THE ALIGNMENT FIELD GUIDE

Best of the Alignment Blog
2010-2015

VIBRALIGN

LEARN FROM AND SHARE WITH THE EXPERTS AT VIBRALIGN

530-G SOUTHLAKE BOULEVARD
RICHMOND, VA 23236
800.379.2250

WWW.VIBRALIGN.COM

TABLE OF CONTENTS

CORRECTABLE ALIGNMENT ISSUES

TABLE OF CONTENTS

SHIMS AND HOLD DOWN HARDWARE

TABLE OF CONTENTS

COUPLINGS AND UNCOUPLED ALIGNMENTS

TABLE OF CONTENTS

PROCEDURE AND TECHNIQUE

TABLE OF CONTENTS

BELTS AND NON-STANDARD ALIGNMENTS

TABLE OF CONTENTS

SAVING TIME AND MONEY

TABLE OF CONTENTS

ADDITIONAL THOUGHTS AND IDEAS

TABLE OF CONTENTS

FOREWORD

The VibrAlign Blog was started in 2010 as a home for informative articles and stories about precision shaft alignment. In less than five years it has become so much more: A thriving online community of experts and enthusiasts.

The stories collected in this book describe how to gather meaningful alignment data, perform difficult moves, avoid common pitfalls, and more. They recount real world situations and present actual data collected in the field. Most were written by the VibrAlign training team; others were contributed by guests. Many have started exciting conversations among our members.

This is a collection of the most useful, applicable, and relevant stories we've published. We hope that you'll read them and discover tips, procedures, and techniques that can be applied to your own practice. Later you can pass that knowledge on to your colleagues and co-workers.

On the road, realigning America,

The VibrAlign Training Team

COMMON ALIGNMENT ISSUES

There are many issues that can (and usually will) be detrimental to your precision shaft alignment. For example, "Soft Foot" occurs when not all feet of the movable machine are sitting flat on the base, or carrying the same weight. "Soft Foot" is likely the most common cause of non-repeatability issues and wasted time.

"Backlash" (which is looseness, or "slop" in the coupling) is another common problem that will cause non-repeatability and an array of confusing data. Other examples are vibration, bolt-bound problems, jack bolt issues, and thermal growth.

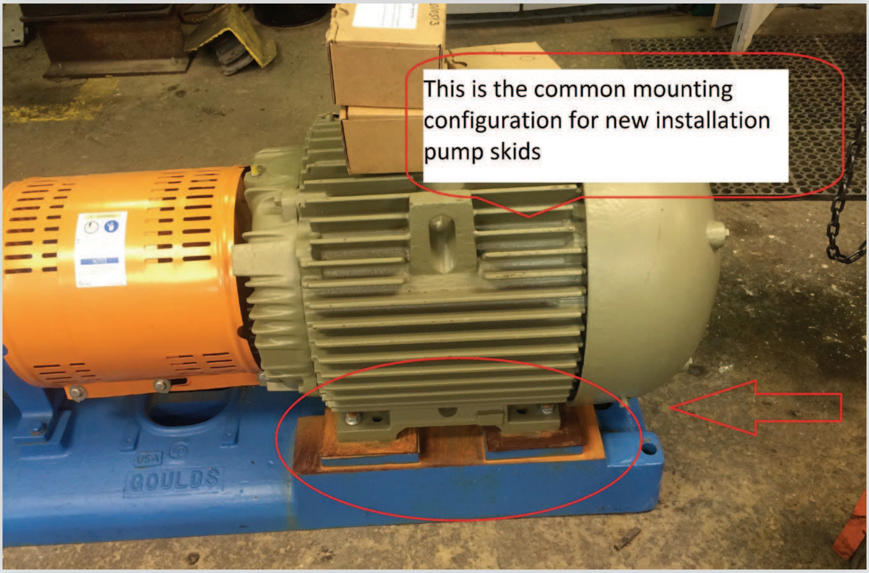
The good news is that all of these issues are correctable and preventable through good alignment practices, careful planning, and proper procedure.

BOLT BOUND PREVENTION

By Mac MacCormack
March 10th, 2015

On numerous occasions I have witnessed brand-new pump skids where the electric motor was already bolt bound. Bolt bound is common in all industries. While conducting the field alignment portion of a precision shaft alignment training class at a chemical plant in southeastern Georgia, I had the opportunity to witness innovation at work to resolve this common issue faced by shaft alignment technicians. (In this particular plant, thermal growth, due to the high process temperatures, would actually contribute to bolt bound situations as well.)

This is where the innovation of Mr. Theodore Moody Sr. and Mr. "Big" Larry Cribbs (names used by permission) comes in. As shown in the following pictures, their modifications to the motor bases makes getting out of a bolt bound situation quick and easy by being prepared ahead of time.



Mr. Moody has drawings for quite a number of pump skids.

WAS SOFT FOOT THE PROBLEM?

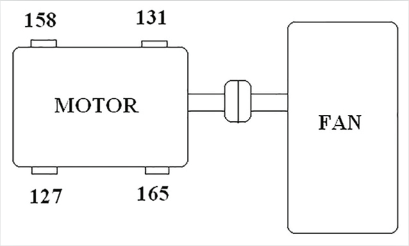
By Patrick Lawrence
August 26th, 2011

We all know what soft foot is, correct? Soft foot is when we are sitting at dinner and the table rocks. Our solution: put a matchbook, folded piece of cardboard or sugar pack under the leg that needs to be raised even with the other three. Now let's eat dinner without our drink spilling.

In machinery alignment the effects of soft foot are much more damaging than spilling your drink…especially if you get free refills. Soft foot will distort and stress the machine's frame, leading to problems. Rotational centerlines on the shafts will not be consistent, leading to problems with coupling wear, rotor air gap, bearing/seal fit and clearance issues. Since lasers were introduced, they have made the measuring of misalignment faster and easier than the old dial days, and our assumption is that the soft foot measurement and correction process is just as easy. Here is a story that will open your eyes.

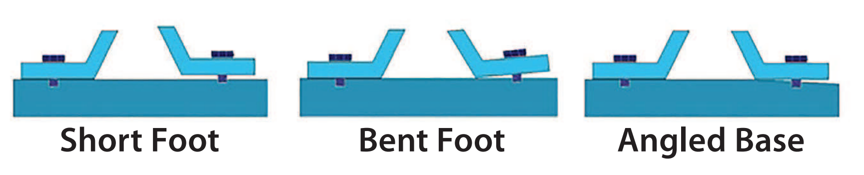
We were called into a foundry to align a blower that was a pain-in-the-neck for several years. The blower was just repaired and the vibration analyst concluded there was an alignment problem. The maintenance supervisor was confused and frustrated because he had just hired an outside contractor who used a laser to align the blower.

We were brought in to correct the problem because the supervisor thought it was a thermal growth problem. The first step was to measure the as-found alignment condition but the values were very inconsistent. It wasn't shaping up to be a usual thermal growth study so we decided to start all over. We loosened all the hold down bolts and here is what we found under each foot.



It *could* be assumed that there was a very bad soft foot problem. But after completing our prealignment procedure and checking for soft foot in two different steps, there was no significant soft foot.

When using a laser alignment system, the heads are mounted on the shafts at the 12:00 position, far away from the feet of the motor. When the foot is loosened, the laser will measure the movement of the shaft and calculate the lift at the foot. Looking at the three soft foot conditions, two of the three will be measured incorrectly: angled base and bent foot. The system sees movement but doesn't know how the foot is lifting. The service company probably saw lift of some value, shimmed accordingly, re-measured and still saw lift then corrected and corrected, hoping for a magical solution. This is quantifying soft foot not qualifying. The best way to correct soft foot is to use a feeler gauge or precut shim to "qualify" if the foot is bent, the base is angled or simply just a short foot.



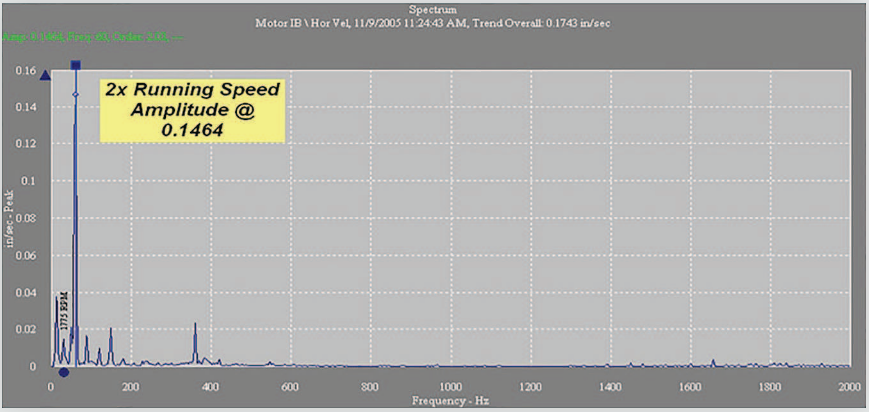
Our solution was to start with 0.125" under each foot and with all feet loose, try to remove one shim at a time to catch any obvious soft foot. None of the shims could be moved, so all the bolts were tightened in sequence. After the bolts were tightened, we went around loosening one foot at a time and used our precut shims to see if we had any bent foot or angled base issues. No issues were found, so we completed the alignment as usual.

Remember, the most accurate and best way to check for soft foot is to use a feeler gauge or precut shims to determine the exact soft foot condition.

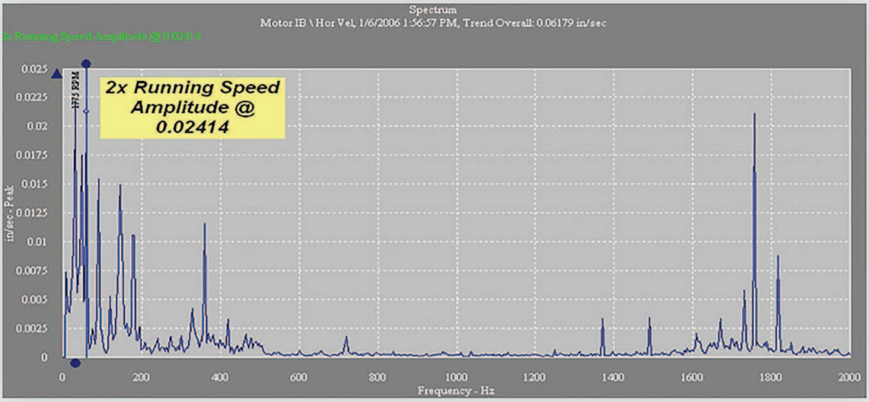
• Short Foot – Shim exactly the value measured.

• Bent Soft & Angled Base – Use a step shim, trimming the part of the shim where it does not fit under the foot to make all the thumb tabs line up. Alternatively, use a Sof' Shoe® shim.

By the way, how did the alignment turn out? Here are the before and after vibration readings: note the level of vibration is now 1/7 the pre-alignment level.



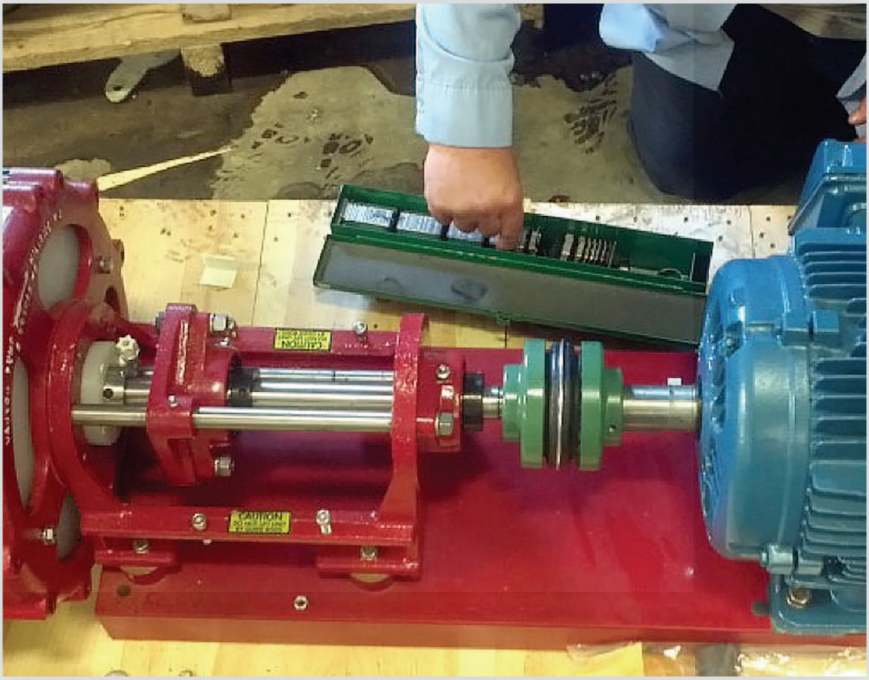
Vibration Before



Vibration After

TROUBLESHOOTING LOOSENESS DURING SHAFT ALIGNMENT

By Patrick Lawrence
July 1, 2012



Everyone has had shaft alignments that seemed to be possessed. Whether you're using a laser alignment system or dial indicators, one set of readings tells you to go in one direction, the next set of readings tells you something completely different. If you're having repeatability problems, something is loose. Is it that simple? Yes!

So what can be loose? When troubleshooting looseness look for unintentional movement– movement you are not controlling. Let's break it down to three different areas: sensor movement, base/foot movement, and torsional movement. Ask yourself these questions as you are stepping through the options.

SENSOR MOVEMENT

- Are the chain brackets tight to the shaft or hub? Are the extension rods tight to the brackets?
- Are the sensors tight to the rods?
- If using magnetic brackets, do the magnets have full contact to prevent them from slipping?
- If mounted to a hub instead of the shaft, is the hub tight to the shaft?
- Is the sensor rubbing on something when positioning the shaft?
- For sleeve bearings, has the shaft come to rest so you know for sure it's in the same spot for measuring?
- Did you bump something out of place?
- Are all the hold down bolts on all pieces of equipment tight?
- For all the above, are you sure?

BASE/FOOT MOVEMENT

- Are the motor feet moving relative to the base?
- Is the base moving relative to the feet?
- Is there debris in/under/around the shims and base?
- Can multiple shims be consolidated into fewer shims?
- Does this sound like soft foot?

TORSIONAL MOVEMENT

- Is there looseness in the coupling?
- Are you controlling it in a consistent manner?
- Are you controlling the backlash in the gearing?
- Are the chain/magnetic brackets tight to the hub/shaft (see above)?

I'm sure you can think of some more. It would be great to hear your suggestions. **Remember that consistent readings will produce consistent results.** Something loose is the number one cause of shaft alignments gone bad.

THE RETURN OF SOFT FOOT

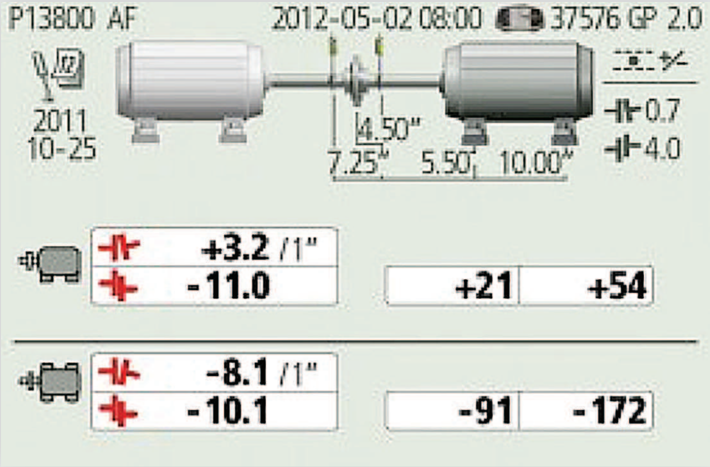
By Brad Case
May 19th, 2012

Previous alignment blog postings have discussed the negative effects of soft foot on rotating machinery reliability and the importance of checking and correcting soft foot before proceeding with a shaft alignment. The question is: "does soft foot need to be checked during an alignment?"

Possibly.

During a recent GO Pro training class, an alignment check was performed on a Goulds 3196 pump, driven by a 20 HP electric motor at 1765 RPM. The pump runs intermittently– only several hours a day.

The initial set of shaft alignment measurements were taken with the following results:



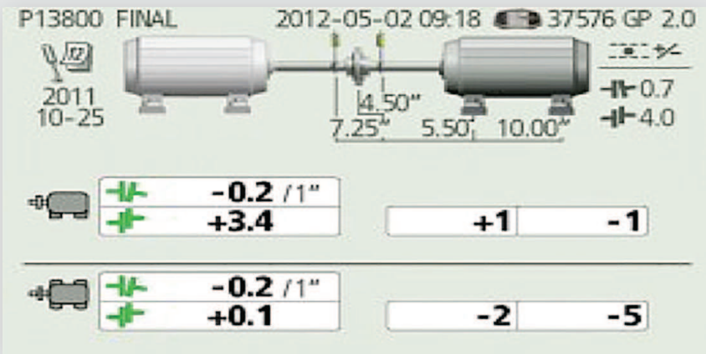
As indicated by the four red coupling values and when compared to the 1800 RPM tolerances on VibrAlign's tolerance table, the alignment was out of tolerance in both the vertical and horizontal planes.

Before making a Verti-Zontal compound move, obvious and final soft foot were checked and found to be nonexistent. The Verti-Zontal compound move was completed including correcting for a bolt-bound condition in the horizontal plane.

As the mechanics where tightening the hold down bolts they noted the right rear foot now had soft foot. Where did that come from?

A 15 mil shim was required to correct the soft foot. After the hold down bolts were tightened, final soft foot was checked and found to be in tolerance (2.0 mil or less).

A light "touch up" to the shaft alignment was required after taking a set of measurements. A final set of alignment measurements revealed a final alignment position of:



So why did the right rear foot develop soft foot during the alignment?

The answer is in the initial alignment results. The horizontal angular misalignment was almost 12 times the allowable angular tolerance, resulting in the rear feet being 172 mils out. Once the rear feet were moved over 1/8", variations in the base or other base-related factors caused the soft foot to mysteriously appear.

When training classes to use our Verti-Zontal alignment process, we stress the importance of performing pre-alignment steps. The first step is to "rough in" the alignment to within 20-30 mils vertically and horizontally for several reasons, one being that the movable machine is close to the final vertical and horizontal position and the aligner is not suddenly surprised by the mysterious appearance of soft foot.

Has this ever happened to you?

NON-REPEATABILITY, A LITTLE MOVEMENT CAN CAUSE A LOT OF HEADACHES!

By James Pekarek
May 23rd, 2013

A recent Fixturlaser GO Basic Training class performed a field alignment on a 100 HP, 3 Phase, 5600 RPM electric motor coupled to a crude oil pump in a refinery. The class decided it would be permissible to use the 3600 RPM setting in GO Basic active tolerance table, which is +/- 0.5 mils/1" angular and +/- 2.0 mils offset misalignment, both in the vertical and horizontal planes.

During the alignment process, we were getting non-repeatable results in both the vertical and horizontal planes. The angular and offset coupling values would change just enough to throw us out of tolerance. After correcting and re-measuring several times, we were getting a little frustrated. Something HAD to be moving.

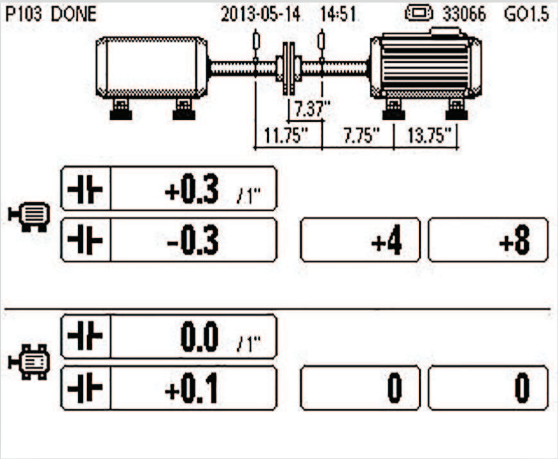
It occurred to me that during the horizontal adjustment phase, the motor shaft was being "held in place" by one of the mechanics to steady it. This is simply the wrong procedure. Even on a heavy electric motor, it is difficult to prevent shaft movement by hand. On some larger 3-phase electric motors, the shaft will roll very freely in the normal direction of rotation, but there will be some resistance in the opposite direction due to "residual magnetism" in the windings and stator.

I tried to steady the shaft myself on the next alignment and had the same results. I did notice, though, that no matter how steady I held the motor shaft during the horizontal adjustment, the shaft was indeed rolling slowly causing the inclinometers to change. Almost imperceptibly, it moved just 1/10th of a degree every couple of seconds. During the process of moving the motor horizontally, this movement would add up to a few degrees of rotation, enough to skew the readings and create inaccuracy. So if the shaft was rolling during the horizontal correction process it was probably "drifting" during the measuring process affecting our repeatability.

Aligning to a close alignment tolerance will be extremely difficult if you have movement in the sensors.

My solution was one that everyone should be doing. We built a “steady rest” from a 2×4 and a steel cylinder to rest the sensors on when rotated to a horizontal plane. With the sensors gently resting on the steady rest, we were able to take the measurements, make the live horizontal adjustments, and follow a bolt tightening sequence without any shaft roll.

The pump came right into alignment on the very next check. This goes to show that shaft movement (sensor movement) during an alignment can cause unexpected and unrepeatable results.



SHOULD THERMAL GROWTH AFFECT ANGULAR MISALIGNMENT?

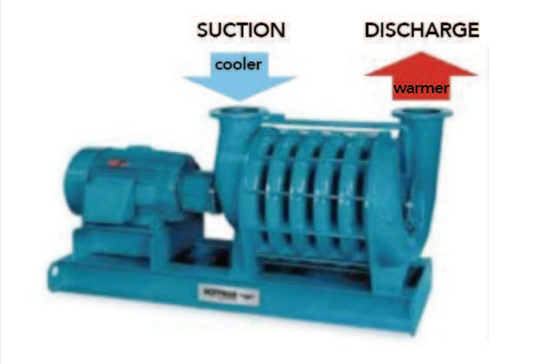
By David Zdrojewski
January 17th, 2012

In my post "How Does Calculating Your Own Alignment Targets Work?" I discussed using a hot check to determine proper alignment targets. Thermal growth is not rocket science. However, it is often misunderstood. I see people causing harm by compensating for thermal growth incorrectly.

Let's look at a simple blower illustration:

If we assume that the blower expands evenly and therefore set the motor high, we could be going in exactly the wrong direction.

Let's take another look:



The temperature change across the blower is not uniform. The discharge end of the blower will expand more than the suction end.

In my next post I will plot out the actual movement and the right compensation.

We really want to create a collaborative blog. Feel free to offer your opinion/question.

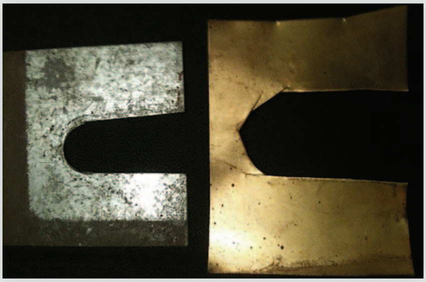
SOFT FOOT AND THE DIRT THAT CAUSES IT

By Tom Shelton
January 15th, 2015

While on the road for VibrAlign ReAligning America, we trainers encounter similar issues at every facility where we conduct our Shaft Alignment Best Practices Training. During our training classes we ask the students what are some of the "pains" that they have regarding the precision shaft alignments that they have attempted in the past. The typical responses are repeatability, movement of the machine while tightening the hold down bolts, etc. These are telltale signs of soft foot. Soft foot is probably the #1 cause of pain when attempting to perform a precision shaft alignment.

Most shaft aligners are familiar with the typical contributors of soft foot such as bent machine feet, bad or rotten machine bases, shim thickness variation, and flexible bases. The one that can be easily overlooked is dirt and debris which are compressible. Compressible materials can trick us into thinking that we have found and corrected a soft foot. As long as we leave all the bolts loose, we may believe soft foot is corrected; however if there is compressible material under the feet or shims, or even between the shims, as soon as you tighten down your hold down bolts and crush the debris you will again have a soft foot.

Obviously, dirt and rust are compressible elements. Some overlooked possibilities are dirty or greasy shims, bent or burred shims and especially a thick coat of paint on the base or even on the underside of the machine feet!



You should take the time to wire wheel the base and feet to clean out any dirt, rust, or debris and always use clean shims with no bent edges or fold lines.

Using new shims is always a best practice. Don't forget to "mic your shims" as part of your process. Shims .050" and thicker can vary in thickness by +/- .005". This variation could add up rapidly if all the shims in a stack were off spec. Last, to eliminate the reintroduction of dirt, minimize the number of shims under each foot. Most aligners will tell you that anywhere from 3 to 5 is the maximum number of shims per stack. A large stack of shims (as shown in the left photo) can create a "spongy" foot. Consolidate shim stacks under the feet as vertical corrections are made.

7 to 8 shims in this stack.
Soft spongy foot!

3 shims in this shim stack.
Solid footing.

In our training we discuss the importance of correcting soft foot. Correcting soft foot is considered to be essential to achieving a precision shaft alignment in an efficient manner. Cleaning under the feet is essential to properly correct soft foot.

VIDEO: CONCEPTS OF SHAFT ALIGNMENT - BACKLASH

By Brad Case
February 17th, 2014

VibrAlign, Inc. has released a new video entitled "Concepts of Shaft Alignment: Backlash." The video describes and depicts how coupling backlash can cause measurement errors and illustrates two guidelines for controlling backlash.

The video series was based on ideas for visualizing alignment created by David Zdrojewski, CEO of VibrAlign. According to Zdrojewski, "Our research shows us that just about half of all millwrights and mechanics performing shaft alignment have never had any training. Although VibrAlign has a staff of expert trainers who are on the road almost every week to train shaft alignment, we understand we still can't reach all the people who need training. That's why we have undertaken to create a video series on the concepts of alignment."

BOLT BOUND? NO ALTERNATE MOVE CALCULATOR? NO PROBLEM!

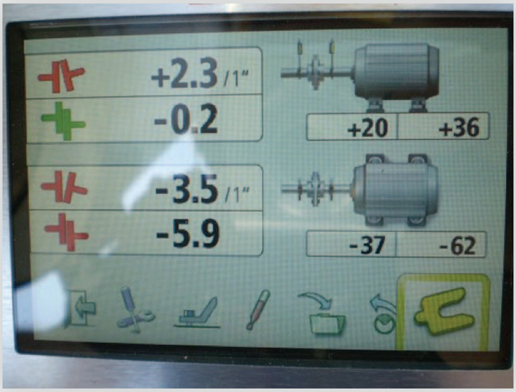
By Brad Case
May 10th, 2013

Previous blogs have discussed several different solutions for solving Base-Bound & Bolt-Bound conditions when performing precision laser shaft alignment (Base/Bound Math and Solving Base/Bound Alignment Problems). Sometimes, though, the solution for a Bolt Bound issue is fairly straightforward and what you need to do is right in front of your eyes on the display unit screen.

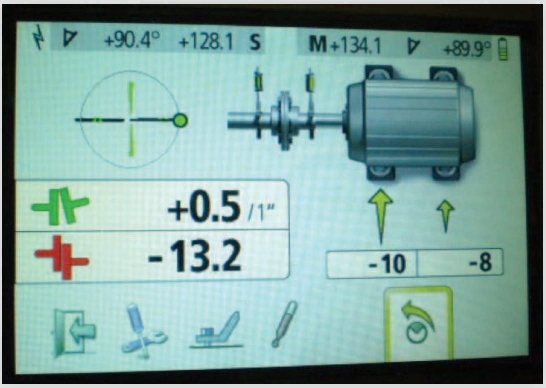
Recently a Fixturlaser GO Pro training class was checking the alignment of a small 3600 RPM, 10 HP electric motor & Durco Centrifugal Pump set. The "As Found" results revealed both the vertical and horizontal angular misalignment to be more than 5 and 7 times the allowable tolerance respectively. The Offset misalignment was not too terrible.

Tolerances for 3600 RPM are no more than +/- 0.5mils/1" angular and +/- 2.0 mils offset misalignment.

After checking for soft foot the class set about to perform a Verti-Zontal Compound Move by first removing shims, as indicated, to correct the Vertical misalignment, leaving the hold down bolts loose, then going live with the GO Pro to correct the Horizontal misalignment.

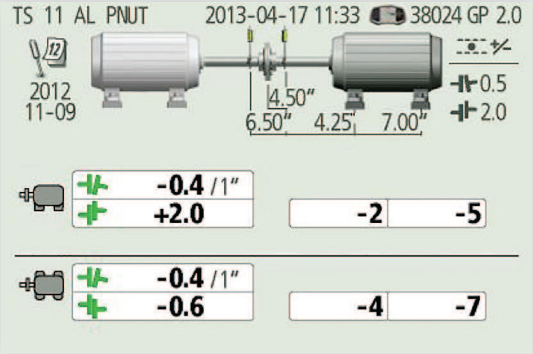


As the motor was moved horizontally the angular coupling value came into tolerance; however the offset coupling tolerance stopped short at -13 mils. There was freedom of movement with the back feet of the motor but the front feet were bolt bound by 10 mils and no adjustment of the motor could get the offset misalignment in tolerance.



Alternate solutions were discussed. The motor/pump base was composite with threaded inserts so using smaller bolts and nuts was not an option. While discussing the option to enlarge the motor feet, a mechanic said "Wait a minute! All we need to do is loosen the pump and move the coupling in the opposite direction the display screen shows we need to move the motor." He was correct.

That is exactly what they did. With one slight push to the front feet of the pump the Offset Coupling Value came in tolerance, and a slight touch up to the rear motor feet brought the Angular Coupling Value back into tolerance.



After tightening all hold down bolts they re-measured with the GO Pro and were finished after one Verti-Zontal Compound Move. Total time from out of the box to final results about 30 minutes!

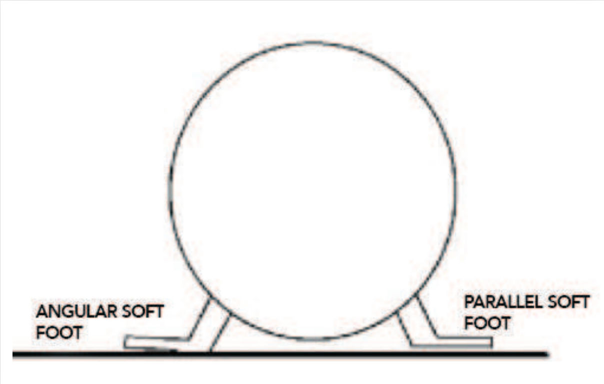
SOFT FOOT–WHAT IT IS AND HOW TO MINIMIZE IT

By Brad Case
June 4th, 2010

Soft foot is a common issue when aligning rotating equipment. It is a major cause of repeatability problems in shaft alignment measurements. In addition to alignment quality and repeatability issues, it can be a cause of machinery vibration, reduce life in electric motors, and cause internal clearance problems in gearboxes and pumps.

But if the proper precautions are taken, soft foot can be minimized and controlled.

The term "soft foot" is the common term used for the improper contact between a machine casing and the baseplate used to support it. It may be either an angular or parallel soft foot, but often it is a combination of the two.



It is often compared to a straight-backed wooden chair, where one leg, being shorter, does not contact the floor, causing a rocking motion in the chair when you are seated in it. While this is a good mental image, soft foot in machinery is a little more complex. While an angular soft foot might make contact with a baseplate or foundation, it does not make a UNIFORM amount of contact. Once base bolts are tightened, the foot tends to bend to conform to the baseplate to which it is mounted.

CAUSES OF SOFT FOOT CONDITIONS

- Twisted or warped machinery foundations or baseplates.
- Twisted, warped, or damaged machinery feet.
- Improper amount of shims under machine feet.
- Dirt, trash, or other unwanted materials under machine feet.
- Dents or other flaws in machine base or machine feet.
- Excessive tension on machine feet due to jack bolts warping the machine feet.

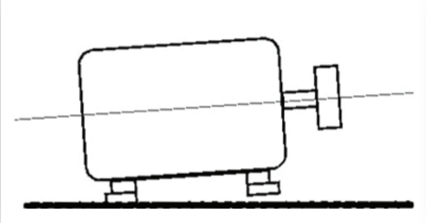
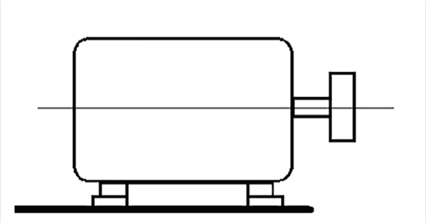
WHAT SOFT FOOT DOES TO YOUR ALIGNMENTS

As stated above, soft foot conditions adversely affect alignment quality and repeatability. Here's how:

Regardless of whether you have:

- an angular or parallel soft foot,
- a bent or deformed shim,
- a bolt hole with a burr,
- a bent motor foot, or
- a deformed machine base,

It can cause the same type of problem. Once you tighten the bolt where the soft foot is, you change the relative position of the shaft. In other words, the position of the shaft changes between tight and loose. If you have used laser alignment tools, you might have noticed that there is sometimes a foot that causes a noticeable change in the vertical or horizontal readings as you tighten a particular bolt. Often, this is the location of the soft foot condition.

Notice that the relative position of the shaft centerline changes due to changes in the position of the soft foot.

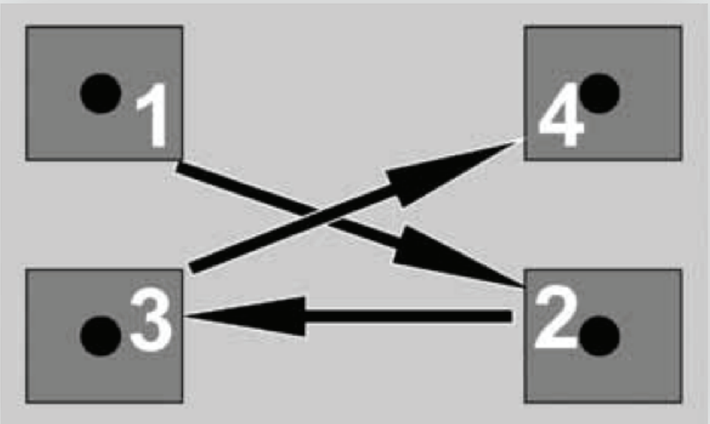
In addition, unless you tighten and loosen the bolts in sequence, the position of the shaft centerline in relation to the stationary machine can change. As an example, if you tighten the inboard left foot first one time, and the inboard right foot the second time, you may take measurements in different shaft centerline locations. Using the straight-backed chair analogy, not tightening in a known sequence causes the movable machine to "rock" into different positions.

STEPS TO MINIMIZE AND CONTROL SOFT FOOT

- Confirm that baseplates and foundations are installed and leveled to specifications.
- Make sure that baseplates and machine feet are clean, deburred and free from dents in the areas to which machinery will be mounted.
- Use clean, flat shims. If you must cut thicker shims from steel stock, be sure they are clean, flat and deburred.
- Once the machine components are placed on the baseplate, rough align, and perform a gross soft foot check of both the movable and stationary machines.
- Leave all foot bolts loose.
- Check one foot at a time, on at least three corners of each foot, with a 0.005" shim or feeler gauge. Correct by shimming with

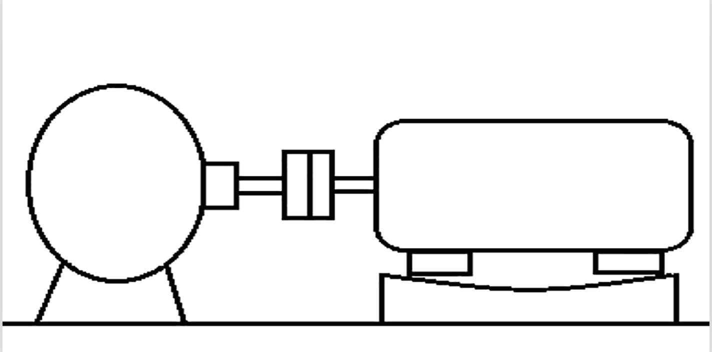
the minimum number of shims possible. If an angular soft foot condition exists, cut one shim in half, leaving the tab in place, to make it easier to reposition.

- Do not attempt to cut several shims to "step" the shim thicknesses under a particular foot. While this might seem like a good idea to increase the amount of contact area, it becomes much more complicated to reposition several shims each time.
- Once gross soft foot has been corrected, tighten each bolt, using a bolt torque pattern similar to the diagram below. The starting point can be any foot, as long as the same pattern is followed EACH TIME the feet are loosened and tightened.



- Once all bolts are tight, loosen one foot, and recheck for soft foot with a 0.002" shim or feeler gauge. Repeat the process of checking each foot at three corners, to identify angular soft foot. Shim to correct as needed. Then retighten the foot and move to the next one. Repeat this process until all feet have been checked and shimmed as needed.

- Tighten foot bolts using 3 passes and following the same bolt torque pattern on each pass. 1st pass tighten to hand tight. 2nd pass tighten the bolts, using a wrench, to around 50% tightness. 3rd pass, complete tightening the bolts. This will minimize the effect of any remaining soft foot.
- Additional soft foot checks can be done using laser alignment tools that have soft foot check capability or with dial indicators. But be mindful that soft foot can not only be in the machine foot – it can also be in the baseplate to which the machine is mounted. In other words, when you loosen the foot bolt, the machine foot may not move, but the base or support underneath it might. This can happen when the foot of the machine you are aligning is thicker than the base or riser onto which it sits. In the example below, if the motor feet are tightened, the base may bend upward to contact the thicker motor foot.



- If the base moves up to contact the motor foot, you may not be able to measure it with a laser alignment tool, or a dial indicator, but it might still cause a soft foot response in the movement of the motor. A shim or feeler gauge is preferred to determine and correct this type of soft foot.

COUPLING BACKLASH – HOW IT AFFECTS ALIGNMENT, AND HOW TO MINIMIZE IT

By Patrick Lawrence
March 24th, 2010

There are three common errors made in shaft alignment—coupling backlash, soft foot and not tightening and loosening movable machine hold down bolts in a proper sequence. Of these, soft foot can be the most problematic, but coupling backlash runs a close second.

Simply stated, backlash is angular movement in any mechanical system between mating parts. Coupling backlash is common, and to a point, desirable in many types of couplings. However, the amount of coupling backlash required for efficient coupling backlash is minimal. Often, excessive coupling backlash is caused by a worn coupling insert.

Coupling inserts should be inspected prior to performing a precision shaft alignment. If the coupling insert is excessively worn, it should be replaced. Signs of wear include excessive tooth wear on toothed neoprene inserts, as well as excessive "twisting" of the insert.
On spider-type couplings, look for excessive compression of the "spider." On grid-type couplings, inspect for excessive wear of the "spring" type inserts, as well as wear of the grids. On shim-pack couplings, look for wear of the rubber bushings, as well as breakage of the shim packs. Less likely, but just as important, causes of backlash can be improper hub to shaft fits, or excessive keyway wear. Occasionally, backlash can be caused by loose foot bolts or other bolted components.

Backlash can cause erratic shaft alignment values in both dial indicator and laser alignment readings. A backlash of greater than 2° of angular movement should be considered excessive, and should be reduced to less than 2° before alignment begins.

Some methods of controlling and minimizing backlash include:

- Replacing the worn or defective components in the system which contribute to excessive backlash, such as worn couplings or inserts.
- Minimizing the effects of backlash by rotating shafts to maintain torque at a consistent level and direction. This can be done by rotating the shafts to be measured in a consistent direction, such as clockwise, or counter-clockwise.
- Utilizing temporary mechanical means, such as duct tape or mechanic's wire, to temporarily override the coupling's ability to experience backlash.

Remember, most mating rotational systems have a slight degree of backlash, which is both harmless, and desirable for efficient operation. But excessive backlash can decrease the accuracy of your alignment. Keep it to a minimum.

VibrAlign sells measurement systems for aligning and positioning machines and machine components. We are also a recognized leader in vibration analysis, balancing, alignment, and training services.

SOLVING BASE-BOUND AND BOLT-BOUND SHAFT ALIGNMENT PROBLEMS

By Brad Case
November 12th, 2012

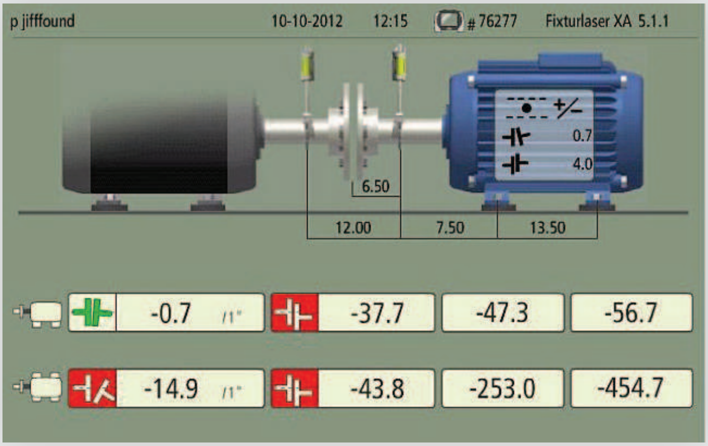
If you align machinery for a living, then more than likely you have encountered machines that are base-bound or bolt-bound.

Base-bound is when the movable machine has to be lowered and there are either too few or no shims under the movable machine feet to accomplish the vertical alignment.

Bolt-bound is when the movable machine is up against the hold down bolts preventing further adjustment in the direction needed to complete the horizontal alignment.

As discussed in a previous alignment blog, the best way to prevent base/bolt-bound conditions is to rough align the machines during installation before piping and other components are connected.

What about machines that have been operating for decades? Case in point, an alignment check of a shredder revealed extreme shaft misalignment in the horizontal plane! Wow! As was feared, the movable machine was bolt-bound.



When bolt-bound, typical thoughts are we have to:

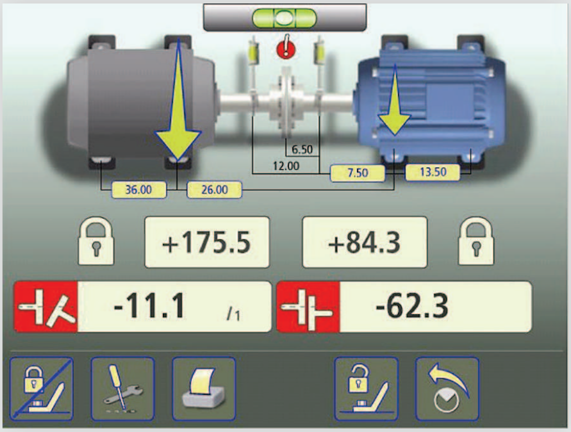
1. Move the stationary machine, hmm that's a lot to move!
2. Drill out the movable machine feet, hmm a 1" larger hole? Don't think so.
3. Use undercut bolts on the movable machine feet, nope that's too much material to remove from the bolts.

So, before you undercut bolts, drag out the hoists, drill motor and other equipment needed to correct the bolt-bound condition, consider alternate moves. When either machine is used as the reference, the other machine typically requires a large move as well to correct the alignment. Alternate moves allow the aligner to change the reference to minimize the movement of each machine permitting the shaft alignment to be completed with much less work and less time.

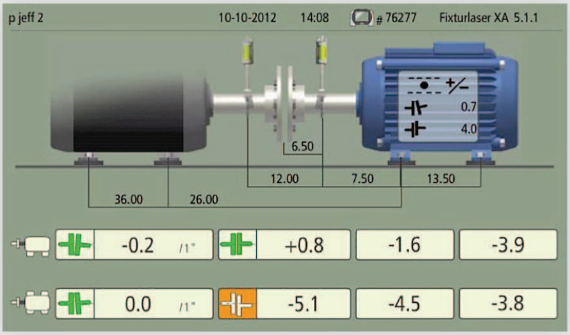
The Foot Lock function in the Fixturlaser XA Pro allows the aligner to easily determine if an alternate move is possible. From the live adjustment screen the Foot Lock icon is pressed. If solving for base-bound, simply rotate the sensors to a vertical plane or leave them in the horizontal plane to solve for bolt-bound. After the dimensions are entered for the stationary machine, open locks appear under the feet of both machines.

Simply press any two locks to close them; the XA will display the corrections necessary to complete the alignment to the new reference. If the adjustment indicated is not acceptable, change the reference by unlocking the locks and closing two different locks.

In the case of this alignment, the best choice with the minimal correction is to lock the outboard feet of each machine.



After the horizontal correction was made and hold down bolts tightened, a new set of measurements was taken followed by a slight vertical and horizontal adjustment. A final measurement was made with the following results.



While not completely in tolerance, a dramatic improvement in the horizontal and vertical alignment was achieved in less than two hours with minimal effort. It was determined a slight soft foot condition, due to rust on the ¼" carbon steel spacer plates under the motor feet, was contributing to the horizontal offset, moving when the hold down bolts were tightened. New plates are to be installed and the alignment fine-tuned.

HOW TO PERFORM A PRECISION ALIGNMENT WHEN NEARBY MACHINES ARE VIBRATING

By Stan Riddle
August 6th, 2014

Equipment rooms can sometimes have numerous machines running all at once-side by side. Often, technicians are required to perform a precision alignment next to a machine which is running. The technicians are right to be concerned about vibration from nearby machines, but the concern can be greatly reduced if certain procedures are followed.

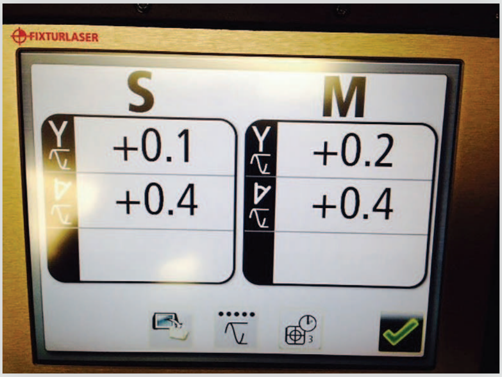
The first is to conduct a repeatability test. Here are a couple of methods to do this:

- Take several sets of alignment readings, and see how much (or little) the numbers change. If the coupling values change by less than one-half of your alignment tolerance, it is safe to assume the machine can be aligned successfully even though the adjacent machine is vibrating.

- use the Repeatability Test function of your laser alignment tool, if it has it. The Fixturlaser NXA has a Repeatability Test, which takes five consecutive measurements of the laser transmitter/detectors, and compares the relative positional changes in both target movement and angular position. Again, if the measured movement is less than one-half of your alignment tolerance, alignment can be completed successfully. Pay attention to the angular movement of your laser tool as well. Excessive angular changes could mean the transmitter/detectors are moving, or that coupling backlash is playing a role in the changes.

Even though you may detect vibration, it could be that the two machine components being aligned are moving in phase-that is, moving up and down at the same time, and by similar amounts.

Think of it like performing alignment in a moving vehicle. The vehicle may be moving, but the machine components are not moving relative to each other.



If you perform a repeatability test, and the movement is greater than your tolerance:

1. Inspect for how the vibration is being transmitted to the machine:
   - Are pipe hangers and vibration isolators working properly?
   - Is bolting tight, including both machines, and their bases and support structures?
2. Can the vibrating machine be shut down while the other machine is aligned? This eliminates the concern about vibration from nearly machines, but may often not be possible. However, with modern laser alignment tools, the measurements can be taken quickly. It may be that the offending machine could be shut down for a couple of minutes without interrupting operations.
3. Can it be done during a changeover, an off-shift, or during a break?
4. Can it be scheduled during a down day?

Lastly, if you have a nearby machine that is vibrating so much you can't perform an alignment, you might want to investigate why THAT machine is vibrating so much!

IS THERE GARBAGE UNDER YOUR BELLY?

By James Pekarek
June 10th, 2014

The belly of your electric motor that is!

During the OJT portion of a training class, at an Omaha NE client, I ran into a most extreme case of soft foot. The customer told me they had a motor/pump set that they could not align no matter what. This was a 100 HP electric motor driving a water pump that supplied water to the top floors of a children's hospital. The class decided to do a simple alignment check when we got to the equipment.

We found the alignment to be close but not quite in tolerance Vertically (Angularity of 0.9 mils/inch, Offset of 9.0 mils) and about twice the 1800 RPM tolerance Horizontally (Angularity of 1.4 mils/inch, Horizontal Offset of 7.8 mils).

The class proceeded to perform the pre-alignment steps, that's when things got weird. Upon loosening the motor hold down bolts, we noticed very loose shim packs and performed an obvious soft foot check.

They found that the shims under all four feet were loose. Hmmm. After removing all of the shims, we measured .030" or more of obvious soft foot at all four feet! One foot had a .065" gap between it and the base!! It was obvious that something was very wrong here. We initially thought that the motor base was warped or perhaps the motor case itself was warped. After examining the whole situation, we discovered there was debris under the motor belly, a lot!

There were large chunks of cement and mortar under the motor case holding it completely off of the baseplate and to top it off the shims were painted down to the base. The photos show the cement we dug out from under the motor.

After tilting the motor to the side, we were able to use a hammer and chisel to remove the cement chunks and shims that were stuck by paint to the base.

After almost an hour of chiseling, we had the motor sitting flat on all four feet and we were able to proceed with our precision alignment.

Lesson learned? Check under the motor belly and make sure there is no garbage!

AFTER SHAFT ALIGNMENT, BACK OFF ON JACKING BOLTS TO REDUCE VIBRATION

By Stan Riddle
September 2nd, 2012

Jacking bolts provide an easy and accurate way to horizontally position a motor during a shaft alignment. However, it they are left tight against the feet, some unexpected problems may occur.

During a recent training class at an Ohio steel mill, we went out to check the alignment on a blower fan that had been experiencing higher than wanted vibration. The shaft alignment was acceptable, but it was noticed that the jacking bolts had been left tight against the motor. The VibrAlign trainer recommended measuring the vibration, then backing off the jacking bolts, and rechecking.

The following reductions in vibration (in inches per second) resulted:

	Before	After
Motor Outboard H-	0.1665	0.1235
Motor Outboard V-	0.0642	0.0667
Motor Inboard H-	0.1574	0.1218
Motor Inboard V-	0.1218	0.082
Motor Inboard A-	0.0934	0.051

While not earth-shattering, it does represent about a 25% reduction in vibration, especially in the horizontal and axial positions, which is the same direction jacking bolts were used–and they were not overly tight to begin with.

If your company's policy is to keep jacking bolts tight, here's a tip:

- Mount a jam nut on the jacking bolt.
- Use a 5 mil shim between the bolt and motor foot, run the bolt up until it lightly pinches the shim.
- Set the jam nut, and remove the shim.

This will prevent jacking bolt-induced soft foot and possibly deforming the stator of the motor, but will still prevent the motor from moving over 5 mils out of the aligned condition.

IS VIBRATION INTERFERING WITH YOUR PRECISION SHAFT ALIGNMENT?

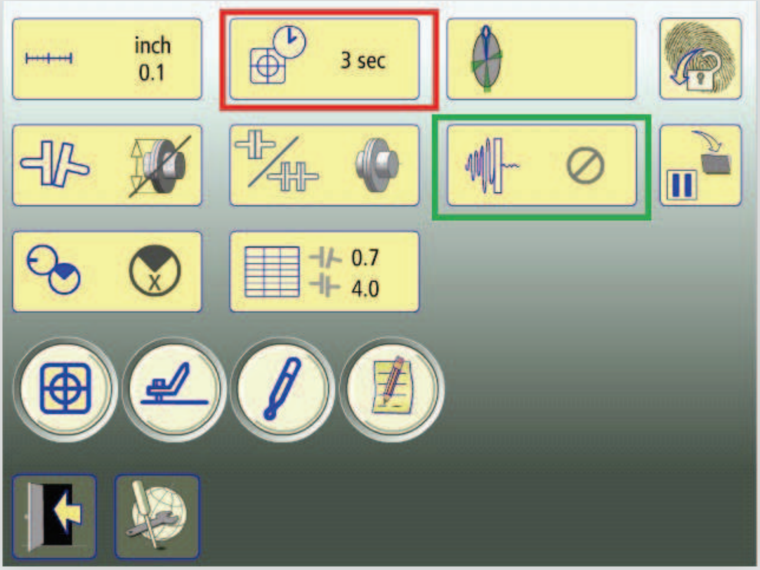
By James Pekarek
July 1st, 2013

During a recent Fixturlaser XA Pro training class, at a Texas petrochemical plant, we were performing an alignment on a 25 HP, 3600 RPM electric motor & water pump. At first the class was having a little trouble bringing the alignment into the 3600 tolerance due to two separate issues.

The first was severe vibration coming from the surrounding equipment causing our coupling and feet values to fluctuate slightly while making the live horizontal correction. This vibration was also causing inconsistent results when two sets of alignment measurements were taken.

The second issue we encountered was the motor was bolt bound by 15 mils at the rear feet when performing the horizontal move portion of the Verti-Zontal Compound Move®. Both issues were easily rectified with a few simple settings in the XA Pro.

To overcome the vibration we did two things. We first extended the sample time setting (outlined in red) from three seconds to eight seconds (after running the built in repeatability test to determine the best setting). We then enabled the level- two vibration screen filter (outlined in green). These two settings effectively eliminated the issues caused by the vibration.

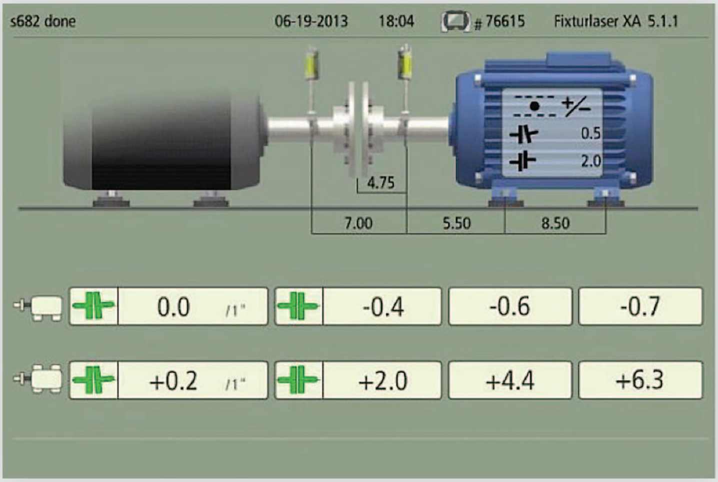


The measurement results then repeated within specifications and the screen filter allowed for the horizontal adjustment with steady values.

The bolt bound issue was easily solved using the Feet Lock Function of the XA Pro to find an alternate solution.

In this instance, the best solution was to lock the rear feet of the motor and the pump. By doing so we were able to move the front feet of both machines in the opposite direction from which the motor was bolt bound. This allowed the horizontal alignment to come in very nicely. The pump front feet only required a 7.0 mil move, which did not introduce any pipe strain.

NOTE: The piping configuration of this particular pump allowed for moving the pump without introducing pipe strain. Always determine if moving a pump will cause pipe strain before doing so.



By combining these three features of the XA Pro, we were able to perform a difficult alignment on a high-speed pump and eliminate fairly severe vibration issues as well as a bolt bound situation.

Happy customer!

COMBINATION SOFT FOOT?

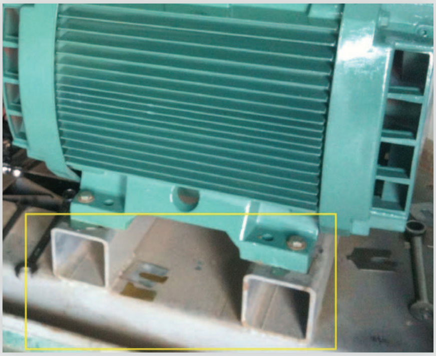
By Brad Case
February 6th, 2014

Any aligner knows that not properly correcting soft foot during a precision shaft alignment leads to frustration and anguish, not to mention wasted time. Soft foot is such a problem there have been numerous articles on The Alignment Blog the past few years about the subject. The articles discuss the many causes of soft foot and correcting "parallel" and "angular" soft foot, but what about correcting "Combination" Soft Foot? Never heard of it? Me neither until recently.

While performing the pre-alignment steps on a 200 HP motor pump set, a customer found obvious soft foot at the motor's rear feet. A 0.005" thick shim fit under the right rear foot to correct the parallel soft foot. However the shim pack was still loose. Further checks with a feeler gauge also revealed an angular soft foot of 0.015"! One leg of a 0.015" thick shim was cut off, leaving the safety tab, and inserted under the foot to correct the angular soft foot. The left rear foot was found to have 0.005" angular soft foot which was also corrected.

So what was the cause of the "combination" soft foot? The sub base, which in this case is structural square tubing under the motor feet.

Structural tubing is not always the best choice for a sub base, as the sides of the square tubing are not necessarily flat and the thinner wall thickness of the tube can deform. In this case it appears the tubing may have deformed slightly when welded to the base, causing the non-flat surface under the rear motor feet.



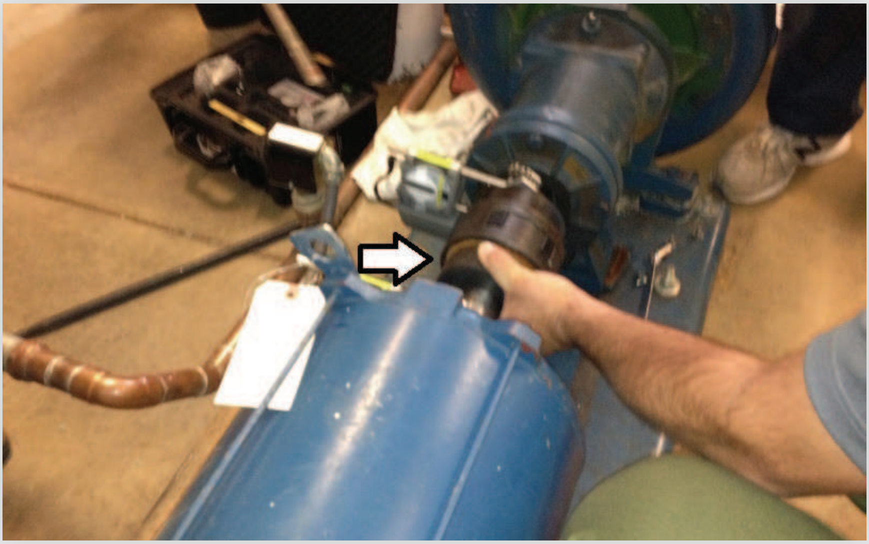
When dealing with soft foot anything is possible. Whatever the type, it needs to be corrected.

HOW TO MINIMIZE THE EFFECTS OF COUPLING BACKLASH WHEN MEASURING MISALIGNMENT

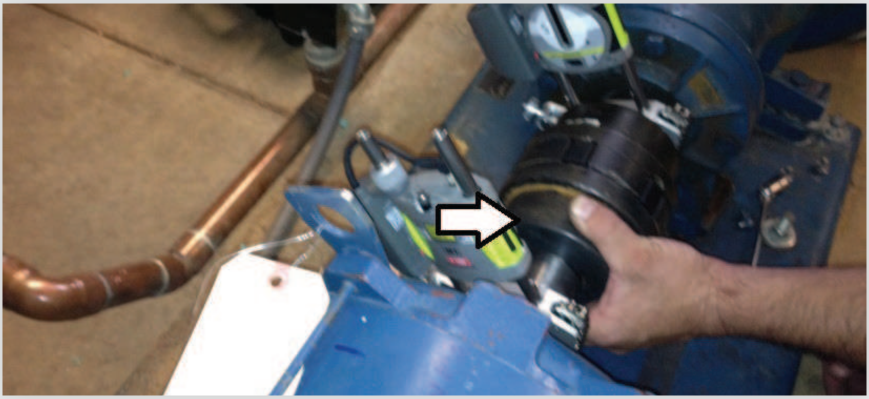
By Steve Gordon
July 24th, 2013

Certain types of flexible couplings are designed to have looseness, creating coupling backlash. Even when installed correctly! Looseness from coupling backlash, if not controlled, will have a negative effect on measurement quality by increasing measurement error and the amount of time it takes to do a precision alignment. So, how can coupling backlash be lessened or eliminated? Check out the procedure below:

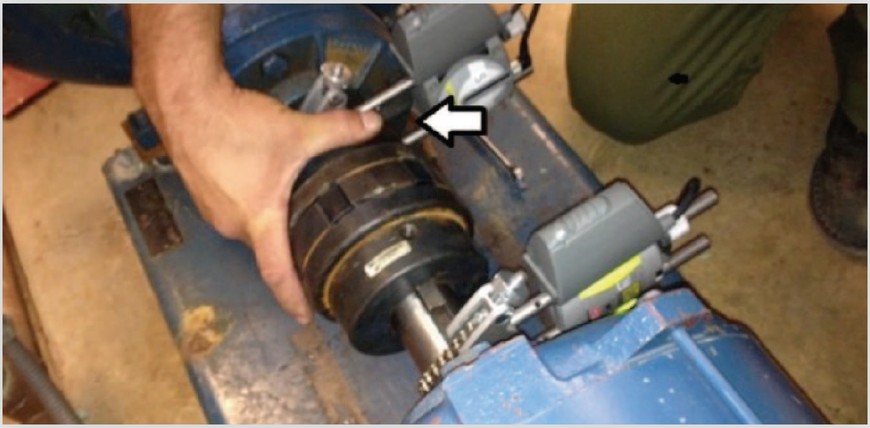
In the direction of rotation, engage the coupling from the motor side and move the sensors to 9 o'clock. Take the first measurement.



Then move the sensors to 11 o'clock keeping the coupling engaged from the motor side. Take the second measurement.



Then rotate the sensor to 3 o'clock to take the third measurement. When the sensors pass 12 o'clock, switch the engagement to the pump (driven) side. This will keep the coupling engaged in the same direction throughout the measurement process.



By using this procedure you will minimize the effects of coupling backlash and increase your measurement accuracy! You will end up getting a precision shaft alignment done faster with less moves.

SHIMS AND HOLD DOWN HARDWARE

Shims, bolts, and washers are necessary tools to hold your equipment in place while making adjustments on your movable machine. But they are not without their own challenges: you must pay close attention when selecting your shim types, shim sizes, number of shims, bolt sizes, bolt quality, and washer quality. After all, these are the tools holding your equipment to the floor.

A LITTLE SHIM CAN MAKE A BIG DIFFERENCE

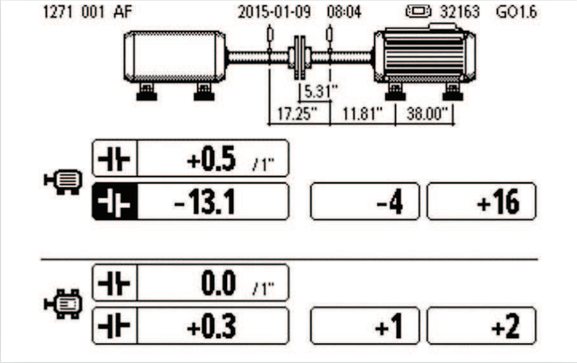
By Stan Riddle
February 9th, 2015

To the casual observer, precision shaft alignment of large machinery may look like "grunt work," a task that only requires a strong back. But those of us who perform shaft alignment know it is moving big heavy machines to within very small tolerances. As such, small movements can often make big differences in alignment quality.

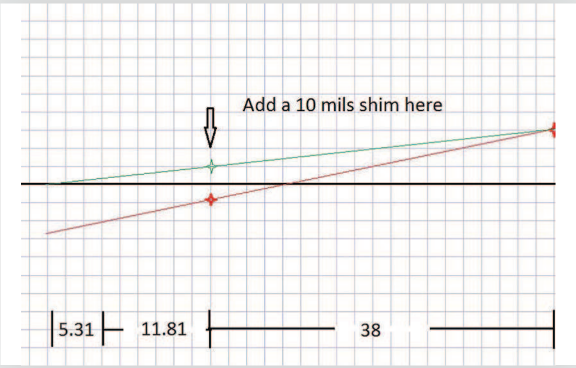
As an example, I recently received an email from a VibrAlign client, with the following problem:

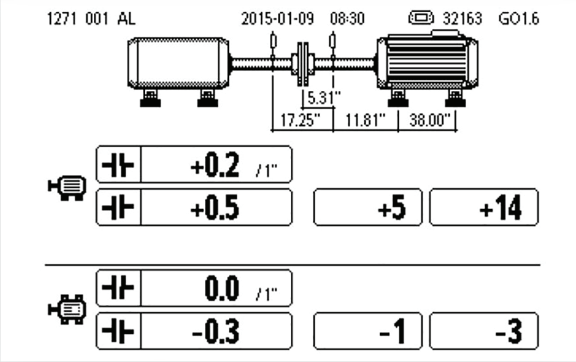
A 400 HP, 1800 RPM motor, driving a gearbox. The motor could not be lowered further, due to being base bound. The customer stated, "If I were to go back, and add 4 mils to the front, would it make a substantial change?"

My answer, "a little, but not enough." However adding 10 mils to the front would make the alignment substantially better.



How could a change of 10 mils, roughly the thickness of 3-4 human hairs, make such a change? By making the front feet number positive. In doing so, the shaft centerlines are much closer at the coupling.





The customer made this one small move, and made the alignment MUCH BETTER! Actually better than the 3600 RPM tolerance.

Remember this rule of thumb. You want your foot values like this:

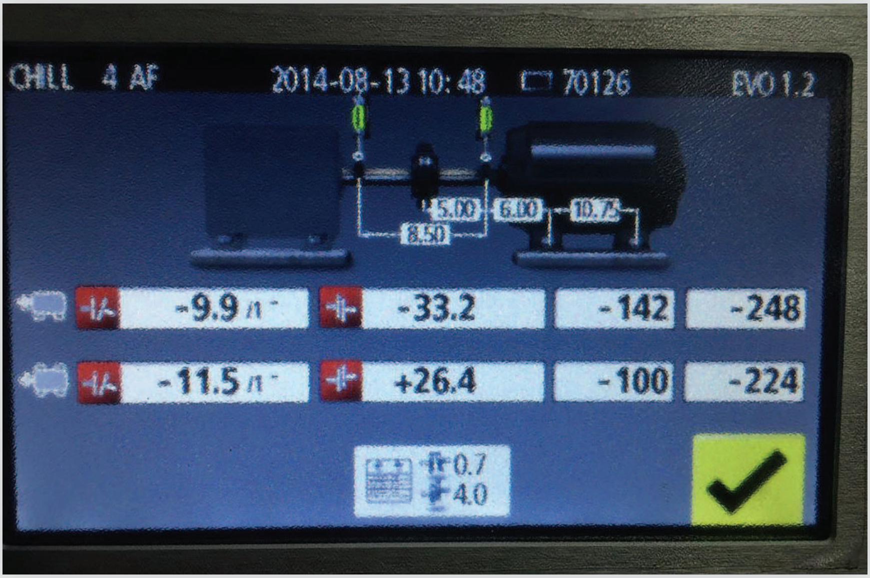
- The back, or outboard feet values, should be the bigger number.
- The front, or inboard feet values, should be the smaller number.
- Both values should have the same sign, such as either both positive, or both negative.

DON'T OVERLOOK "HIDDEN SHIMS" UNDER THE FEET!

By Brad Case
August 15th, 2014

A recent Fixturlaser EVO class performed an alignment check on a 35 HP, 1750 RPM electric motor and chill water pump set.

The initial set of alignment results indicated horrible angular misalignment (14 to 16 times tolerance) and offset misalignment (6 to 8 times tolerance) in the vertical and horizontal planes.



Before making corrections, pre-alignment checks were done which included consolidating the shim stacks under each foot, performing soft foot checks which revealed a 10 mil soft foot on the right front foot that was corrected.

While making corrections using the Verti-Zontal Compound Move, they noticed some movement of the motor when tightening bolts- too much movement, resulting in slightly inconsistent results.

All the mounting brackets, sensor clips, hold down bolts, etc. were tight so they took a closer look at the shim stacks and discovered a number of carbon steel "hidden shims" under 3 of the 4 motor feet.

So why weren't they found during the pre-alignment checks? Several reasons:

First, the shims are much smaller than the motor feet and the properly sized shims. Plus, the shims had no safety tabs so they were hidden under the motor feet.

Second, the pump skid OEM had used shims with holes instead of slots, allowing the shims to spin around on the hold down bolts to where they were really tucked up under the backside of the feet, which was very difficult to see.

Third, the rust had them stuck to the bottom of the feet.

(Shim shown on top of foot for clarity).

Once the old shims were replaced and shim stacks corrected the 10 mil soft foot previously found disappeared and the alignment was completed with another Verti-Zontal Compound Move.

Other issues were also discovered during the alignment.

- The motor was slightly bolt bound which was corrected by using slightly smaller diameter bolts.
- The washers under the hold down bolts were cupped which pulled the rear feet approx. 40 mils to one side as the hold down bolts where tightened.
- Due to the large vertical and horizontal angular corrections the coupling axial spacing closed up, putting the two hubs in contact with each other, causing a bind which prevented horizontal adjustment, and had to be reset.

With all these issues the alignment was still completed in a little over 1 hour and 45 minutes!

Lessons learned? Take nothing for granted! During pre-alignment or when shimming, double check under the feet for "hidden shims" or shims stuck to the underside of motor feet or the base by corrosion, rust, grease, or oil.

So when your laser tool (or dial indicators) shows inconsistent results after making (or during) corrections don't keep chasing the alignment, stop to check out the big picture to find out why.

"MIC" YOUR SHIMS!

By Brian Shanovich
September 20th, 2013

Has this ever happened to you? You're aligning a machine and your laser alignment system ordial indicator calculations tell you to add shims under the motor feet. You do what is expected, re-measure and you still have to add shims! Wonder why? I've heard it before, my laser doesn't work or you calculated wrong. The true culprit is in the shims, and here are three reasons why!

1. Most shim manufacturers buy their stainless steel in coils by the pound, yet they sell their fabricated shims by the piece. This means that if a coil of stainless steel is produced slightly thinner than its "nominal" thickness, then that coil would be slightly longer than one that is on-size, yet they both weigh and cost the same. The only difference is that the thinner one will yield more pieces for the shim manufacturer, saving them money. The problem is, additional shims will need to be used during an alignment to make up for this shortcut, at your expense.

Secondly, most sheets of stainless are cold rolled and have variations in the thickness throughout. It is not economically feasible to measure every shim to check the thickness; the sheets are spot checked at a known sequence. To get the accuracy on 100% of the shims, each one must be measured at various locations on the shim.

Here is a real example that shows this variation. We were at a job site aligning a 200 HP motor and were adding shims to align the machine. We needed to add 250 mils (0.250"); as you can see, the shim measured 246 mils (0.246"). 4 mils less.

We also checked each shim in several locations to make sure the thickness was uniform. If the shim had more than a 2 mil variation, we would discard it. The reason is we have a 2 mil soft foot tolerance and would not want to create an angular soft foot because of shim quality. We also would recommend that you mic all shims 50 mils and thicker. The thicker the shim, the more likely there are variations. We have seen 125 mil shims as thin as 114 mils, 11 mils thinner.

2. Where are most errors made? Human error is the usual suspect. Adding up the different shim values in a stack creates problems as well. When doing an alignment, there should be jobs that are designated to each mechanic. In a two-person team, one operates the alignment tool, the other does the shimming and wrenching. This will eliminate any confusion on the adjustment amount. Also, mic all your shim stacks before placing them under the feet to guarantee the proper amount. I know adding shim values to get the exact amount is hard. Believe me, subtracting is worse! Especially when we recommend a maximum of 4 to 5 shims under each foot. When you mic the stack, you'll be exact!

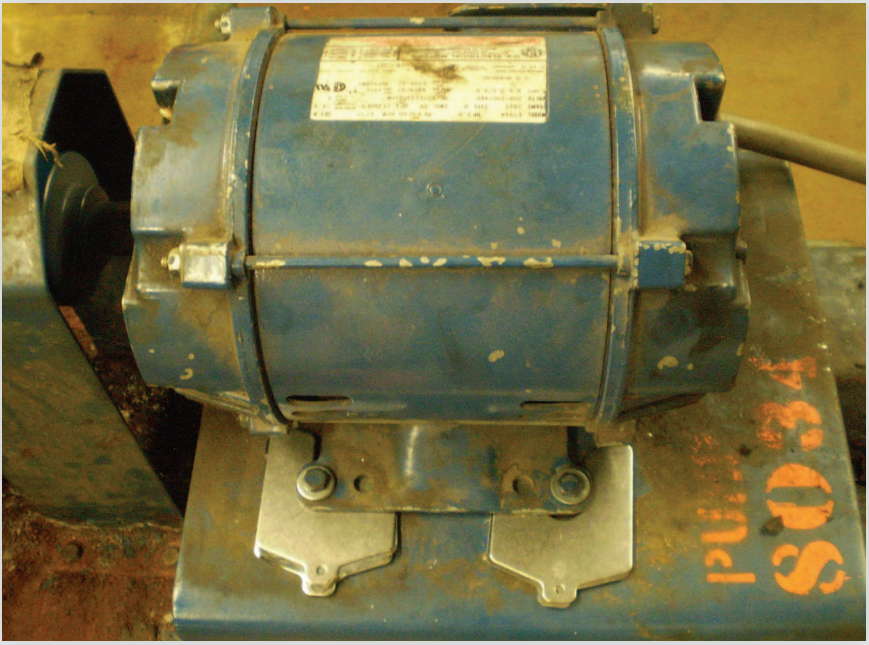
3. Lastly, we also suggest that you replace all old shims. There will probably be burrs, crowns and corrosion on them. In the case of corrosion, if the shim does not have a chemically etched or stamped label, there is no way of knowing the thickness. Also, when you reach my age, the lighter ink stamped numbers are impossible to read. Don't guess, measure for accuracy.

Remember, the better you are prepared to align your equipment, the more efficient and less frustrating the process will be.

WHAT SIZE SHIMS SHOULD I USE?

By Stan Riddle
May 16th, 2013

One of my co-workers recently fielded a call from a customer, asking, "What is the proper way to size shims under motor feet?" In other words, if the foot is 6 by 4 inches square, how big should the shim be?



Excellent question! And one I wasn't sure how to answer. I have always tried to pick a shim that was at least 50% of the area of the foot, and more whenever possible. But I didn't have any empirical data to back it up, so I did a little research.

Some shim manufacturers (Lawton and Accushim as examples) rate their shim sizes by horsepower or frame size of the motor they support. So if you are using a standard NEMA frame motor, you can look up the right size shim for your application.

But, not every machine being shimmed meets NEMA specs. So, according to The Shaft Alignment Handbook (J. Piotrowski):

"The rule of thumb is provide at least 80% contact between each machined foot and its point of contact on a baseplate, frame, or soleplate" (The Shaft Alignment Handbook, 3rd Edition, p.300).

I have always tried for a minimum of 50% contact, while making sure the shim is equal around the periphery of the bolt. In other words, there should be an equal amount of shim all the way around the bolt, except for the slot.

That being said, one would have to consider not only the physical dimensions of the shim and foot, but also factor in the mass of the machine, and dynamic radial and axial forces imparted to the foot during operation of the machine, because a shim in essence makes the foot contact area smaller. So, I blew the dust off my old Statics book, and found out that the modulus of elasticity for 304 stainless steel is about 11.2 million psi, with a Rockwell hardness of 80B. Translated, it's pretty hard, tough, and strong! So, does it really need to be 80%, or even 50% for that matter?

HOW MANY SHIMS?

By Patrick Lawrence
June 13th, 2011

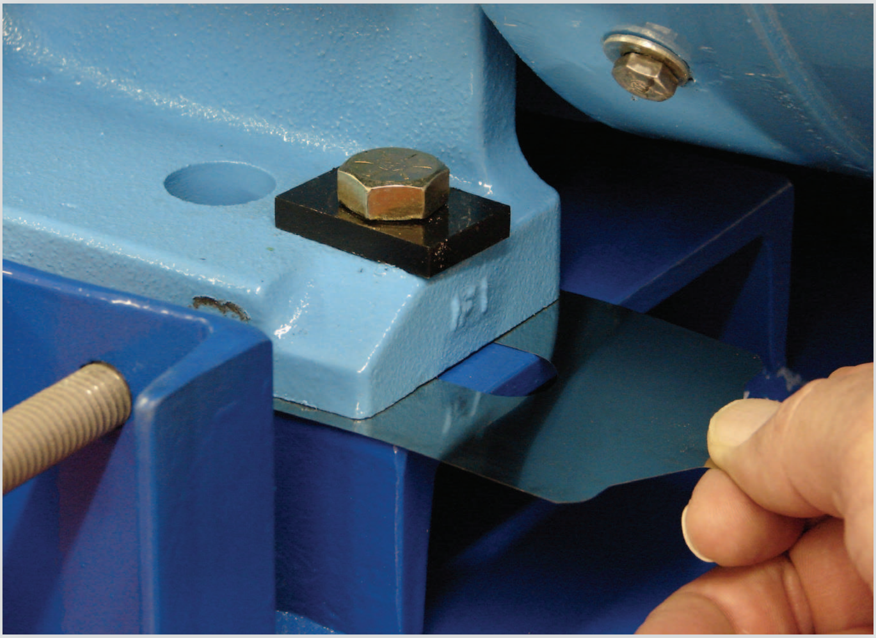
In a recent email to VibrAlign, Mike wrote:

"In using your shims what is the most shims you can place under each foot? I have always been taught to use no more than 5 shims under each foot. Is this true? "

Mike, good question!

VibrAlign's official stance is no more than 4, if possible. However, that's not always possible. So, here's a "real world" answer:

- Use the smallest amount of shims possible.
- They should be flat and straight, free from burrs, slag, or dents.
- Shims should be durable enough to offer stable support. In other words, the shim should be able to support the weight of the machine that sits upon it, without its thickness changing over time. Shims should also be able to survive the elements into which they are used, such as rain, chemicals, caustics, etc.
- Shims should be checked with a micrometer or caliper to verify the thickness.
- Always use the thickest shims possible to minimize the number of shims used under a particular machine foot.
- If shims are bent, damaged, rusty, or otherwise deformed, they should not be used.
- When shim stacks are removed to change the thickness of the stack, care should be taken to carefully measure the entire stack, including the dirt, grit, rust, etc. The shim stack should either be cleaned before re-use, or new shims should be used.



- When shims are placed under a machine foot, they should be carefully slid under the foot until they make contact with the bolt, and then slid back about ¼", to make sure it does not contact the threads of the bolt. This way, when the bolt is tightened, it will not bend the radius of the shim, and deform it.
- Shims should be stored in a neat, clean, and orderly fashion.
- When aligning a machine, try to lay shims on a shop towel, or other clean surface, to minimize the risk of adding dirt or other contaminants under the machine foot.
- When aligning electric motors with cooling fins, the fins make excellent places to place the shims during alignment. The shims can be placed in the fins above the foot under which they will be placed, helping to minimize errors in shimming.

STACKING THE DECK CAN GET YOU IN TROUBLE!

By Stan Riddle
November 13th, 2011

The photo to the right was taken at a recent training class. The maintenance guys at this facility were excellent aligners. They were adamant about getting their shaft alignments to "better than excellent" levels. They believed in preparing the surfaces of the base and the motor before installation. Their company spent thousands of dollars re-working piping and bases to minimize the chance of pipe strain or bolt bound conditions.

They were careful to measure, correct, and record their alignments accurately. They did so many things – so well!

And yet, questions remain…

How many shims do you see? Could the shim stack have been consolidated to reduce the number of shims? Could the thinner shims be "sandwiched" between the thicker ones so they would both be out of the way and not curl up like the ones in the photo? Could the flaking paint have been removed with a wire brush so it does not get between the shims–in essence becoming a partial, enamel shim? How much more work would it have been to go back to the shop, and cut a few pieces of ½" plate to use as one big shim under each motor foot?

You may be saying to yourself, "But you guys at VibrAlign don't know how it is where I work!"

Yeah, we probably do.

And we found out a long time ago that the extra ten minutes it takes to get a few thick, clean, flat shims may well shave minutes, or even hours, off of the alignment process. It will minimize the risk of soft foot, increase your accuracy and repeatability, and cause you to tighten and loosen bolts much less.

Stacking the deck will get you in trouble!

DON'T OVERLOOK THE HOLD DOWN BOLT WASHERS

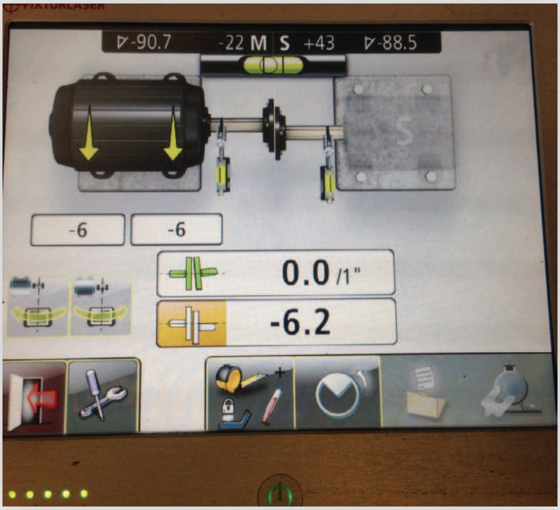
By James Pekarek
January 22nd, 2015

Anyone involved in precision shaft alignment knows that unintentional movement is the biggest contributor to non-repeatable alignment results. Movement can come from several sources: Soft foot, loose bolts, flexible bases, excessive bearing clearances, improperly mounted or loose sensor mounting hardware, etc.

One of the more elusive and least considered sources of movement is cupped washers on the hold down bolts of the movable machine. I see this issue at almost every "Shaft Alignment Best Practices" Training Class I conduct. My clients are usually knowledgeable about alignment and how to get their job done; however, they typically have not considered the condition and QUALITY of the washers under the hold down bolts to be very significant. It is! All too often I see techs and mechanics performing their alignments and never inspecting the washers. This can kill your shaft alignment!

When cupped washers are present, every time the hold down bolt or nut is tightened, it forces the washer to flex down inside the bolt hole of the motor foot, bending it into a slight concave or "bowl" shape. At this point the washer is ruined and should be replaced. Whenever you loosen and re-tighten the bolt, the cupped washer will re-center in the motor foot hole, pulling the motor back underneath itself again. This may only be a very small amount, not even visible, but when using precision laser alignment equipment, the problem quickly surfaces. Each time the affected bolt(s) are tightened, the alignment numbers will skew and it will appear that you have a soft foot problem when, in fact, the washer is the culprit.

In the photos to the right, you can clearly see the cupped washers and in this case a slightly worn (cupped) bolt hole which also contributed to the "unintentional movement."



The cupped washers were pulling our motor 6 mils to the side, moving it out of the horizontal offset tolerance as indicated by the Orange Coupling Icon.

We replaced all the washers at each motor foot with 2 thicker washers and the problem was solved. Our alignment came right in at better than the 3600 RPM tolerances of +/- 0.5mil/1" angularity and +/- 2.0 mil offset.

When performing precision laser shaft alignment, part of the pre-alignment steps should be inspection of the hold down bolt washers to eliminate a potential alignment headache. Even if the washers are not cupped it's a good idea to replace "thin" washers with thicker double stacked washers to prevent the thin flat washers from possibly cupping during the shaft alignment you are about to complete.

BROKEN WASHERS CAN CAUSE HEADACHES!

By Stan Riddle
October 11th, 2013

Recently a customer contacted us about increased vibration on a motor, due to a broken washer. And they wanted to know if there was a specification for washer hardness, and a guide for bolt size to washer size.

There are many standards for bolting (USS, SAE, ASME, etc.), of which washers are an important part. As an example, a structure like a bridge or skyscraper may have a stringent metallurgy requirement, while one for a small industrial motor may not. In industry, the problem is that most purchasing departments specify "washers" – without regard to strength, hardness, malleability, etc.

I have seen broken washers increase machine vibration, since it means that the bolt is now loose. My opinion, and it is only that, is that broken washers are caused by three things:

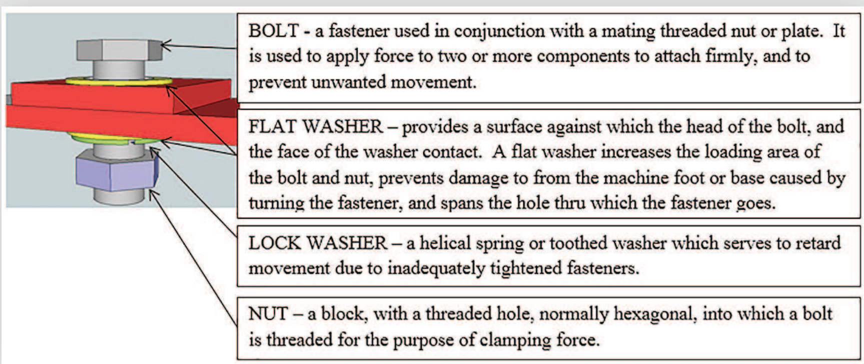
- They are cheap.
- They are improperly sized or installed, including improper sizing, excessive torque, or installing bolts much smaller than the bolt hole it goes in.
- They are deformed or worn, and should be replaced.

Washers should be specified, not just purchased because they are the "cheapest." Hardened washers are available, and can be beneficial. But increasing the hardness of metal normally increases its brittleness as well. Using two standard flat washers may help. Your maintenance or design engineer should be able to help determine the proper application.

Washers are sized. A 3/4” bolt should use 3/4” washers. A 1” washer fits easily on a 3/4” bolt, but is too big to do its job, which is to:

- Provide a flat surface against which the head of the bolt and the face of the washer contact.
- Increase the load area of the bolt.
- Span the diameter of the hole.
- Prevent damage to the machine foot by the turning bolt/nut.

Washers should normally be installed in this fashion.

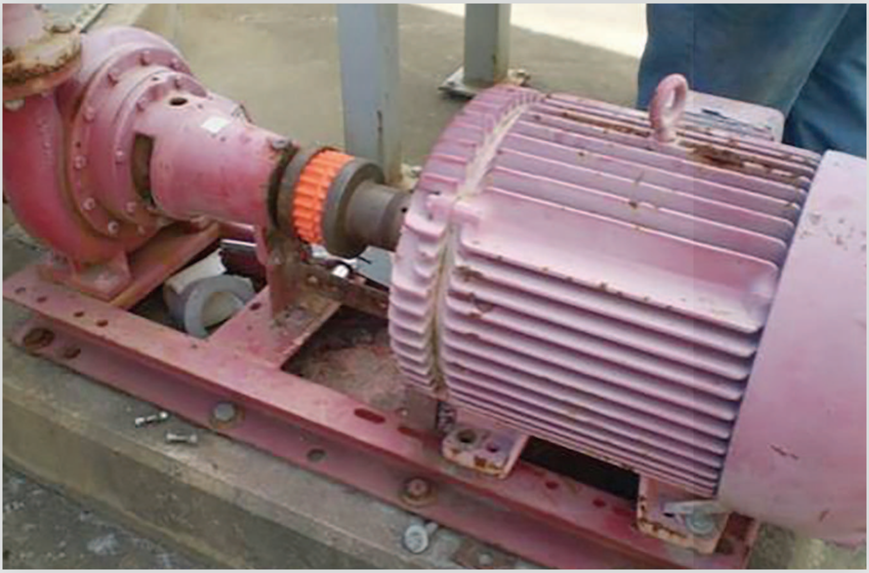


In addition, washers which are visibly damaged, deformed, cupped, or rusted should not be used.

CUPPED WASHERS

By Brad Case
July 18th, 2011

The OJT portion of a recent training class was the alignment of a 3600 RPM electric motor driving a Bell & Gossett Fire Service Water Pump.



As the hold down bolts were tightened (in a cross torque pattern) the horizontal offset would change to approximately 5 mils at 50% torque then 8 mils at 100%. After 2 attempts the same amount of horizontal movement took place. The students were bewildered. The machine had no soft foot, the coupling backlash had been neutralized and there was no other looseness.

Hmmm……what could it be?

The answer…cupped washers under the hold down bolts.

The electric motor feet had fairly large bolt holes with soft steel washers under the hold down bolts. As the motor feet were tightened, the cupped washers "centered" the motor feet holes causing the horizontal offset to change and move out of tolerance.

After replacing the hold down bolts and washers the horizontal offset remained spot on as the electric motor feet bolts were tightened.

One student commented "I never would have guessed the washers could be a problem."

IS IT OK TO UNDERCUT BOLTS?

By Stan Riddle
September 6th, 2011

This is probably one of the most common questions we are asked during our alignment training classes. And the best answer might be, "Sometimes, if you must, maybe!" Let me preach on it.

Undercutting bolts is a method used to align machines that are bolt bound. A bolt-bound condition occurs when the movable machine cannot be moved horizontally to a degree sufficient to align it to the stationary machine. This most often occurs due to inadequately aligning the machines before other items, such as piping, are installed. Undercutting the bolt reduces its shank diameter, allowing a little more room in the motor foot hole for alignment.

The best method to prevent a bolt bound condition is to rough align the machines before they are installed. Slide both machines as far to one side as they will go and mark the base of the foot. Then slide the machines as far in the other direction as they will go and mark that side. Position both machines in the middle of the two marks and align. This gives you the maximum amount of "hole" in both the driver and driven machines.

On machines already in place, this may not be possible. If you must use undercut bolts, please consult your engineering department guidelines. We offer these guidelines as an opinion only:

- Use the Fixturlaser XA's Feet Lock™ program to make a slight adjustment to the stationary machine to move it toward the movable machine. If you do not have the Feet Lock™ program, this can be calculated on graph paper. This will allow the maximum strength of the bolt as designed.

- If you must use an undercut bolt, it is a good idea to use manufactured hardened undercut bolts. They are designed for this application.
- If the bolt does not thread into the base and a nut is used underneath, you may be able to drop to the next size smaller bolt, depending on the mass and start-up torque of the machine. Again, consult your engineering department before doing this.
- If you MUST remove metal from the bolt, and this is approved by your engineering department, bear in mind that removing just the thread diameter will not weaken the bolt's tensile strength. But if you remove additional metal from the bolt shank, you may weaken the bolt considerably. As an example, a ¾" Grade 5 bolt turned to 5/8" will decrease the shear capacity by approximately 30%.

While undercutting a bolt may make the alignment easier, it may cause more problems than it corrects. Make every effort to align your equipment with bolts sized by the designer.

What is your site's policy on undercutting bolts? How are you solving bolt-bound issues?

JACKING BOLTS

By Stan Riddle
July 11th, 2011

Jacking bolts provide a smoother, easier way of moving machinery than using pry bars and hammers. Their use will almost always speed up the shaft alignment process, prevent excessive minor moves back and forth, and generally make the task of shaft alignment much more pleasant.

So why aren't they used more often?

- Expense? Four pieces of threaded rod or bolts, with nuts welded to the base plate, make excellent jacking bolts.
- Installation? Tack weld the nut to the base, and you're done!
- Too far from the jacking bolt to the motor? Use a spacer.
- Can't weld in that area? Drill and tap a metal block, and then drill and tap into the base. Bolt the block to the base.
- Can't do that either? Jacking bolt accessories are available from several companies, including VibrAlign!

- Don’t have time? The time installing jacking bolts can usually be faster than the time chasing a motor back and forth with a dead blow hammer, not to mention repainting all the paint you beat off the motor.

Does this answer some of the questions in your facility?

Here are a few jacking bolt tips:

- After the alignment is completed, back them off. Leaving the jacking bolts on the motor tends to bind the feet, increasing the chances of soft foot as well as the chance of warping the motor frame and increasing vibration.
- When moving a machine horizontally, turn the bolt head one flat and notice the amount of change. This should give you an estimation of how many “flats” you need to turn to get the motor into the correct position.
- Use the jacking bolt you are moving toward as a stop. Set the “gap” amount of movement with a shim or feeler gauge, and then “push” the motor with the opposing jacking bolt until it touches the jacking bolt you “gapped.” This will usually get you very close.
- Use a laser alignment tool from VibrAlign and it can watch the move and you’ll know when you’re done!

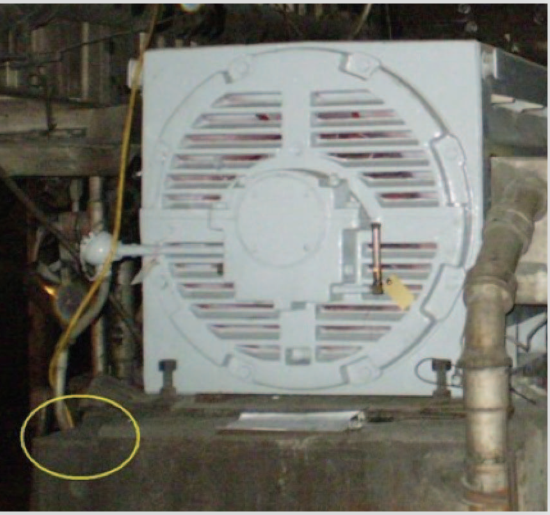
TO TURN OR NOT TO TURN, THAT IS THE QUESTION!

By Brad Case
November 19th, 2011

Bowl mills are used to pulverize coal prior to being blown into coal-fired boilers. They are very large machines with heavy rotating components usually driven by an internal planetary gear set in the bottom of the mill. A typical steam generation power plant will have multiple bowl mills for each boiler in the facility.

During a Fixturlaser XA training class at a coal-fired power plant a discussion developed between two mechanics as to whether their bowl mill shafts could be rotated during an alignment. One mechanic was convinced the mass of the bowl mill would necessitate the coupling being disassembled and the alignment performed with one non-rotating shaft. The other mechanic felt that, though difficult to turn, the bowl mill alignment could be performed coupled up thus saving time, gathering more accurate alignment data as both shafts are rotated eliminating the extra work required when performing an uncoupled alignment. Either way, it's a matter of choice for the mechanic using the XA.

As luck would have it a 700 HP, 1200 RPM electric motor had just been replaced on one of their bowl mills and needed to be aligned to the mill.



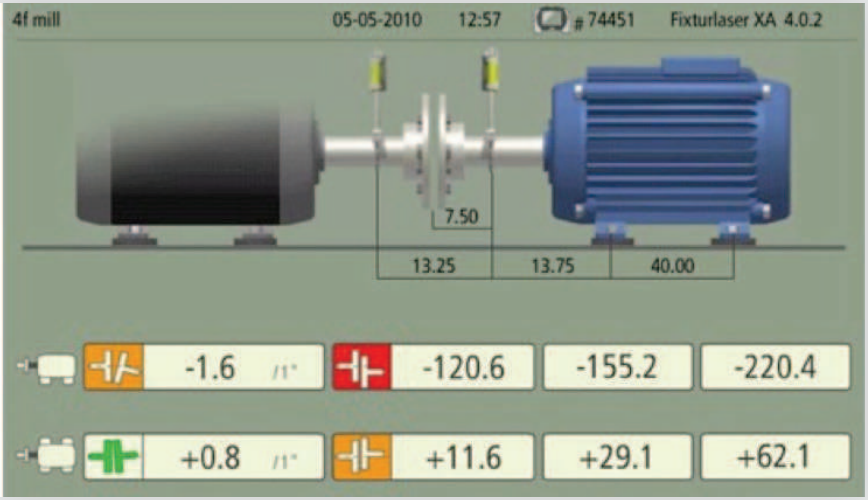
Initial inspection of the motor installation revealed a slight bit of concrete to have been broken off from the left rear and right front corners of the foundation under the outer edges of the motor base. There were no shims under the motor feet. The gear coupling was already assembled so 0.050″ thick shims were placed under all motor feet as a starting point.

The obvious soft foot check revealed the left rear and right front corners of the motor feet to have 0.025″ of angular soft foot, on the outboard side of the motor feet, which was corrected accordingly. The final soft foot correction took an additional 0.005″ under the right foot of the motor.

The Fixturlaser XA was mounted, dimensions entered, and measurements were taken. A 48″ pipe wrench was used to turn the shafts. The measurements were taken near 9, 12, and 3 o'clock. The dual inclinometers of the XA keep track of the position of the sensors, when taking measurements, so precise positioning of the sensors is not required, speeding up the alignment process on large hard-to-turn machines.

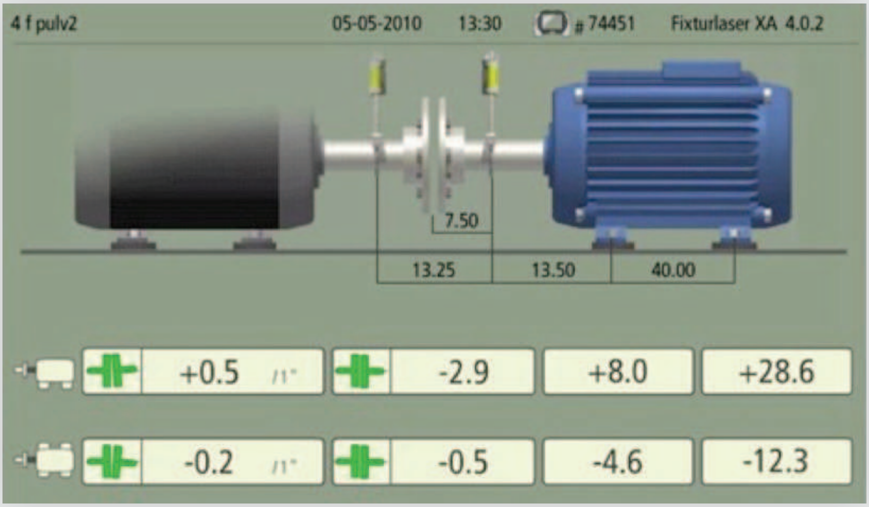
The bowl mill operates at 1200 RPM, with an allowable angular misalignment of 1.0 mil/1" and an allowable offset misalignment of 6.0 mils (1.0 mil = 0.001").

The first set of alignment measurements were taken with initial results of:



The mechanics completed a Verti-Zontal alignment by: 1) loosening the hold down bolts; 2) adding 155 mil shims to the motor front feet and 220 mil shims to the rear feet to correct the vertical misalignment; 3) correcting the horizontal misalignment to within tolerance as indicated by the XA's live screen; 4) tightening the motor feet hold down bolts using a cross torque pattern in 3 passes.

A second set of alignment measurements were taken with final results of:



Time from initial to final results, 33 minutes! The alignment was completed with one Verti-Zontal adjustment and the final coupling values where just shy of 3600 RPM alignment tolerances!

Could this alignment have been completed with the coupling disassembled and by only turning one shaft? Absolutely! However, as is shown, whenever possible, it is to the aligner's benefit to perform an alignment with the coupling assembled so both shafts can be turned even when the machines are "difficult" to rotate. Faster alignments with less work!

Turn baby turn!

COUPLINGS AND UNCOUPLED ALIGNMENTS

The coupling is one of the most important and least understood components of your machine. It must transfer rotational torque from the driving machine to the driven machine. It must also absorb vibration and allow flexibility between the two machines. Some couplings are even designed to act as a “fuse” to prevent a failure on one machine from affecting the other.

There are many coupling types, styles, and sizes (more than most people realize) and each kind has its own application.

IS YOUR COUPLING RELAXED?

By James Pekarek
September 23rd, 2014

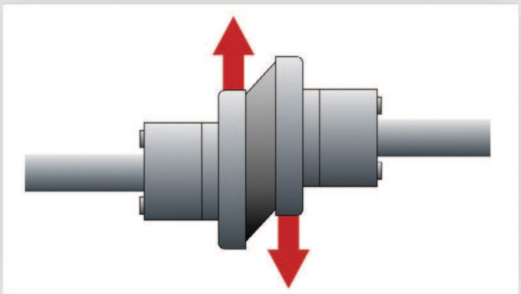
During the OJT portion of a Fixturlaser NXA Pro training class, at a power plant, the students asked me to allow them to perform the precision laser shaft alignment of a 75 HP electric motor to pump without interrupting them or offering any advice. I obliged and let them go on their way.

The first go around they seemed very confident and went about the alignment seemingly without issue. They removed all the old shims, cleaned under the feet, corrected soft foot, took alignment readings, made the exact recommended corrections and re-measured all in proper order. The results were less than perfect.

The horizontal results showed 1.8 mil of offset misalignment and 0.5 mil/inch of angular misalignment at the coupling. This is well within tolerance for 1800 RPM. However the vertical results were a different story. They showed 6.7 mil of offset misalignment and 0.9 mil/inch of angular misalignment at the coupling, which was out of tolerance. Another shim adjustment and a new set of alignment measurements verified they had the motor and pump within 1800 RPM tolerances.

I asked them to start over from the beginning and perform the alignment again in its entirety. They received the same results almost exactly, the horizontal was fine and vertical was out requiring a second shimming sequence. We had lots of time so I asked them to repeat the entire alignment 2 more times. Each time they got almost the same results.

They felt the alignment should have been completed in one Verti-Zontal Compound Move so they asked me to assist and help with the alignment. I knew all along exactly what the issue was. We started from the beginning again and removed all of the shims. We then performed the rough alignment with a straight edge; this is the step they left out each time. When the rough alignment step is skipped and the two machines are significantly misaligned, it creates strain in the flexible coupling element. The two machine shafts are going to be pulled towards each other, taking up any clearances in the bearings, which can be significant depending upon the bearing type and class, which in turn influences the shaft's rotational centerlines.



Performing a rough alignment during your pre-alignment steps will relax the coupling element and allow the shaft bearings to sit in their proper positions while laser alignment measurements are being taken. This will typically allow the alignment to be performed in one Verti-Zontal Compound Move, saving you a considerable amount of time. (Not roughing in will also affect dial indicator alignment measurements).

BALANCE YOUR COUPLINGS

By Tom Shelton
October 16th, 2013

Balancing your couplings is not essential to a great precision shaft alignment, though it is an essential part of a job well done. As part of your prealignment steps/checks, the keyways of the driver and driven machine shafts should be set 180 degrees apart from each other. This will help to correct any influence that is being exerted on the shafts by incorrect key lengths or incorrect set screw lengths in the coupling hubs.

The formula for determining the proper key length is: Length of keyway on hub + length of keyway on shaft divided by 2. Then multiply by .95. (hub key length + shaft key length = X, X ÷ 2 = Y, Y x .95 = proper key length)

Example:
Motor shaft keyway is 5″ long, the coupling hub keyway is 3″ long.

5″ + 3″ = 8″, 8″ ÷ 2 = 4″, 4″ x .95 = 3.8″, the key should be 3-51/64″ long.

In addition to having the proper key lengths, the coupling set screws should completely fill the full depth of the threaded hole on the hubs.

These practices will help you gain the maximum benefit from your precision shaft alignment by minimizing imbalance at the coupling.

FLEXIBLE COUPLINGS AND FLEXIBLE SHAFTS

By Stan Riddle
January 10th, 2013

Most mechanics are pretty familiar with flexible couplings. They are designed with an elastomer, or flexible element, which compensates for slight amounts of misalignment through a sliding motion between the coupling hubs and the insert. However, it is very important to have some idea as to how much the coupling will flex before it begins imparting the forces of misalignment to the shafts, seals, and bearings. This is not always easy to determine simply from engineering specifications by the coupling manufacturer.

I recently fielded a call from a customer of ours who was having problems aligning a refrigerant centrifugal compressor. He stated that he was an experienced aligner, but his shim corrections did not produce the outcome he expected. After some conversation, he stated to me that the machine had a disc-type coupling, and that the compressor shaft diameter was reduced quite a bit just outside of the compressor.

I mentioned to him that I had the same problem with the same type of chiller about 20 years prior, and what I had done was to align the compressor and motor shafts with the disc pack removed. He called me the next day to let me know that after removing the disc pack, he completed the shaft alignment quickly, accurately, and in a short amount of time.

The cause of the alignment problem was not with the measuring tool, but in the fact that, in this particular case, the disc-type coupling was stronger than the small diameter shaft. The coupling would partially bend the shaft instead of the other way around. This in no way lays blame on the coupling or the chiller design. Disc-type couplings work well, and transmit large amounts of torque for their size. But they are relatively stiff.

When it comes to aligning machines with either a disc-type or elastomer "tire" style coupling, pay special attention to your alignment values. If you make vertical and horizontal corrections per the amounts specified by the alignment tool, and your alignment is not close to what you expected it to be, remove the elastomer or shim pack element, then align the shafts with the flexible element(s) removed. If you are unsure as to how to do this, please contact us at VibrAlign. We'll be glad to help.

FLUID DRIVE COUPLING AND HIGH VIBRATION? NO PROBLEM!

By Brad Case
November 6th, 2013

I recently took a call from a customer at a coal-fired power plant in Arkansas. He was performing a precision laser shaft alignment of a 450 HP, 1750 RPM electric motor coupled by a fluid drive coupling to a gearbox on a coal conveyor. Similar to the one pictured.

This conveyor is one of two side-by-side conveyors; each is 60” wide by 500 yards long. The gearbox has a backstop which only allows a clockwise rotation as viewed from the rear of the electric motor. The other conveyor was in operation during the alignment.

Mike, our customer, was using a Fixturlaser NXA Pro, with 12” extension rods which were needed to get the sensors high enough to shoot the lasers past the OD of the coupling.

He was having repeatability issues and said he could feel vibration at the ends of the extension rods. Also, this style of fluid drive is typically treated as an uncoupled alignment and Mike wanted to verify the best way to take the measurements. Shaft Alignment with a Fluid Coupling.

We discussed running the built-in repeatability test of the NXA which tests the vibration levels of the surrounding environment and allows the user to adjust the measuring sampling time accordingly, also turning on the screen filter.

As the gearbox shaft could only rotate one direction and the fluid drive coupling allows the motor shaft to turn independently of it, I recommended using the Tripoint measuring method and simply matching the inclinometer values of the S and M Sensors at each measuring position.

By using Tripoint and taking the 1st set of measurements at 9, 12 and 3 o'clock, performing a Verti-Zontal Compound Move as needed then re-measure at 3, 6 and 9 o'clock, the "shaft turning" required will be minimal.

When he finished Mike emailed me the following.

"Initial Repeatability test @ 3 seconds setting: S Sensor value changed by 20 mils (.020") due to vibration.

Final Repeatability test @ 10 seconds setting to compensate for vibration: S Sensor value changed by 1.1 mils (.0011") M Sensor value changed by 0.7 mils (.0007").

Dimensions: S to M sensor 28.875", Coupling center to M sensor 6.750", M sensor to front motor foot 15.00", Front motor foot to rear motor foot 28.750".

Here are the results in 2 moves:

Vertical Angle; -0.1mil/1", Vertical Offset; +0.8 mil. Horizontal Angle; 0.0 mil/1", Horizontal Offset -0.4mil"

Editor's note: At 1800 RPM max. allowable angle is +/- 0.7mil/1" and max. allowable offset is +/-4.0 mil.

Even with high vibration levels in the area this shaft alignment was easily corrected after compensating for the vibration. It's always a good practice to run a repeatability test at the beginning of the alignment as it only takes a few minutes to do so, which ultimately can save you hours and a lot of frustration during the alignment!

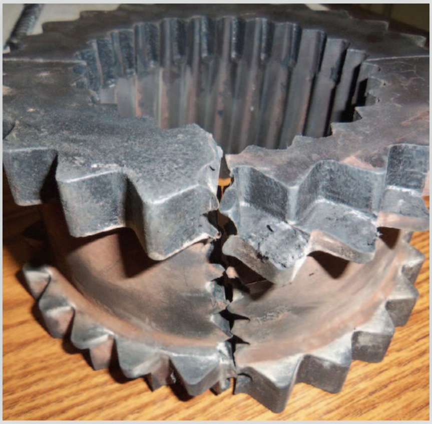
COUPLING ALIGNMENT TOLERANCES VS. SHAFT ALIGNMENT TOLERANCES

By Stan Riddle
October 8th, 2014

A coupling alignment tolerance and a shaft alignment tolerance are different things - VERY different things!

- A Coupling Alignment Tolerance is often (but not always) the maximum amount of misalignment the coupling will operate at before premature failure.
- A Shaft Alignment Tolerance is the maximum amount of misalignment the shafts can tolerate before they begin to transfer radial and axial loads to the bearings, seals, gears, and other affected machine components.

Here are a couple of photos I took of failed coupling inserts. These were taken during some of our training classes. In each instance, I was told that the shafts were aligned to the coupling alignment tolerance. On one, the offset misalignment was about 18 mils. On the other, the angular misalignment was about 3 mils per inch.



While the couplings did transfer power for a brief time, the loads from misalignment, along with frequent starts, caused them to fail before their time. It's not the coupling's fault. It is a lack of understanding of the differences between coupling misalignment and shaft misalignment. And the coupling, seals, bearings, and productivity pay the price.

In our quest to Realign America we want to start an alignment movement! We need to accept the fact that the allowable misalignment for the coupling, and the allowable misalignment for the shafts, are two different things. And we need to start calling precision alignment "Shaft Alignment," not "Coupling Alignment"!

Who's with me?

WHY SHOULD I ALIGN A FLEXIBLE COUPLING?

By Stan Riddle
September 29th, 2011

In a recent training class, a mechanic asked, "Why should I worry about aligning a flexible coupling? I thought the reason we used flexible couplings is because they didn't have to be aligned." That's a great question, and one that deserves an honest answer.

Let's pick a commonly used coupling, and look at its alignment specifications: T.B. Woods Sureflex Coupling (with an 8JE insert).

- Cost – about $40.00 for the sleeve, or insert.
- Maximum RPM – 4500
- Parallel misalignment – 0.020 in.
- Angular misalignment – 0.094in. (about 0.012"/inch)

MAXIMUM RPM AND ALLOWABLE MISALIGNMENT
(Dimensions in inches)

Sleeve Size	Maximum RPM	Types JE, JN, JES, JNS, E & N			*Type H & HS		
		Parallel	Angular	Y	Parallel	Angular	Y
3	9200	.010	.035	1.188	-	-	-
4	7600	.010	.043	1.500	-	-	-
5	7600	.015	.056	1.938	-	-	-
6	6000	.015	.070	2.375	.010	.016	2.375
7	5250	.020	.081	2.563	.012	.020	2.563
8	4500	.020	.094	2.938	.015	.025	2.938
9	3750	.025	.109	3.500	.017	.028	3.500
10	3600	.025	.128	4.063	.020	.032	4.063
11	3600	.032	.151	4.875	.022	.037	4.875
12	2800	.032	.175	4.688	.025	.042	5.688
13	2400	.040	.195	6.688	.030	.050	6.625
14	2200	.045	.242	7.750	.036	.060	7.750
16	1500	.062	.330	10.250	-	-	-

Based on the manufacturer's recommendations, this coupling can tolerate a fairly substantial amount of misalignment. And, since the insert is relatively inexpensive, why go to all the trouble of precision alignment?

Because we don't align couplings – we align shafts! The coupling sleeve, or insert, can tolerate that amount of misalignment; but, the bearings, seals, shafts, gears, and so on, cannot!

The coupling insert will bend or flex, but it also resists bending. It would prefer not to be flexed at all. And when it is flexed, it requires a good amount of energy to counteract that force. That energy manifests itself in:

- Increased heat due to friction
- Increased radial and axial loading on the bearings, seals, gears, and shafts.
- Premature wear, and eventual failure, of these components, including the insert.

Think of it this way. Take a wide rubber band, and place it across the ends of your index fingers. Stretch it until it just begins to straighten out. You could hold it there for a long time. Now, stretch the rubber band until just before it breaks. It won't take long until your knuckles start hurting. It's still the same rubber band, but it requires much more effort to keep it stretched.

So to answer the question, "Why should I worry about aligning a flexible coupling?" - You shouldn't worry about it at all. But aligning the shafts to a precision alignment value is extremely important. And it you align the shafts, the coupling will "go along for the ride."

You'll increase the life of your machines, and your couplings!

FOOT TOLERANCES VS. COUPLING CENTER TOLERANCES

By Patrick Lawrence
May 4th, 2012

Let's jump back into it–foot tolerances vs coupling center tolerances. It's a hotly debated topic in some circles. I'm no great debater but let's take a look at this from the two sides we hear most often:

Argument 1: You're Crazy

We all know tolerances are expressed at the coupling center. The calculated values at the feet have nothing to do with the quality of the alignment. Alignment tolerances are expressed as an angle and offset in the vertical and horizontal planes at the point where the two shaft centerlines intersect. Why in the world would you continue to 'correct' an alignment when it is already within industry accepted tolerances? We know how difficult these pieces of equipment can be to align. Tempting fate and continuing to adjust the equipment just for a thousandth of an inch here or there is ludicrous. It does nothing to substantially increase the reliability of the equipment. Furthermore, shooting for values at the feet that are, say, 0 ±0.002", just shows a lack of understanding of the geometry involved in shaft alignment. Didn't you read 'Don't Look at Your Feet'?

Argument 2: You're Lazy

The idea behind foot tolerances is to drive you to a precision state. If there's a correction that can be made, why not attempt it? Who cares if you're in tolerance? Why not leave it in as great condition as we can before starting it up—this may be the only chance we get for a while. Putting in a little extra effort goes a long way. We are using accurate measuring tools, following an effective procedure and have taken great care in our prealignment steps to remove sources of measurement errors. Part of the reason we take great care in those prealignment steps is so we can tweak the equipment and get an appropriate response. So what if it takes an extra set of moves to get there? If we're honest with ourselves, most of the equipment we align is relatively easy to move around. Now get off your duff and help me pull these shims out!

Well, maybe I wouldn't make a great politician but these are pretty much the conversations when this topic comes up.

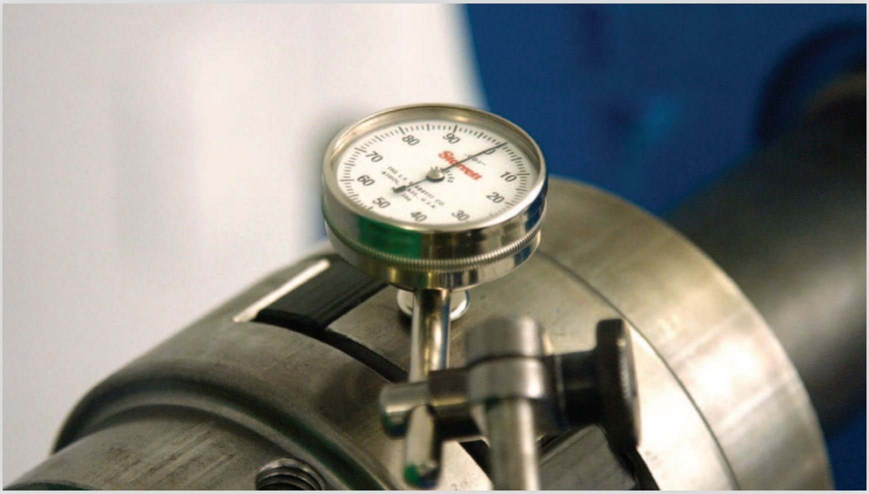
COUPLING OR SHAFT RUNOUT

By Stan Riddle
October 3rd, 2013

On rotating machinery, runout is defined as the degree to which a shaft or coupling deviates from true circular rotation. Every shaft or coupling has a center of rotation, or centerline. Any stray from concentricity is considered runout. If runout is severe, it can cause many problems with equipment, such as:

- Excess vibration
- Seal wear
- Bearing damage

Runout can be easily overlooked during the alignment process, regardless of the tool being used to measure for misalignment. But it is easy to check for runout before the alignment process begins.



Use a dial indicator and magnetic base. Zero the indicator on the outside diameter of the coupling hub. Slowly rotate the shaft to look for runout, and measure the amount.

Then move the indicator to the shaft adjoining the coupling hub. Measure the same way. If the hub and shaft travel by approximately the same amount, the runout is probably due to a bent shaft.

To confirm, measure the shaft in different places. The bend normally decreases the closer the indicator is moved toward the bearing. In this case, if the runout is excessive, the shaft should be replaced.

If runout is measured on the coupling hub, but not the shaft, the runout is probably due to either a casting or machining error (such as the hub being bored out of center). In this case, the coupling hub should be replaced, but the shaft should be OK.

In addition, axial runout of coupling hubs should be checked as well. This can often indicate either a damaged hub, or one that was not bored concentrically, but at an angle.

Most engineering manuals recommend no more than 2-3 mils of runout. On machines rotating at 3600 rpm or faster, this number should be cut in half (1 to 1 1/2 mils).

A quick check for runout can identify machinery problems, increase reliability, and extend component life.

UNCOUPLED SHAFT ALIGNMENT – IT DOESN'T NEED TO BE DIFFICULT

By Brad Case
October 13th, 2014

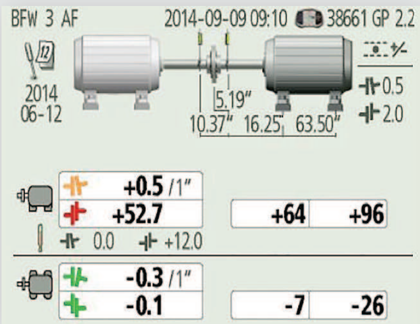
The night before the OJT portion of a recent Fixturlaser GO Pro Training class, at a Combined Cycle Power Plant, the shim packs of the disc type coupling between a 3300 HP electric motor and fluid drive began to fail. The machine was shut down before any damage could occur and was waiting for our class the next morning. Talk about good timing for a shaft alignment training class! (Note: The other end of the fluid drive was coupled to a boiler feed pump.)

As the coupling was disassembled the shim packs fell apart.

Disc type couplings are fairly "rigid" flexible couplings that can influence the rotational centerlines of each machine, so the class performed the shaft alignment uncoupled.

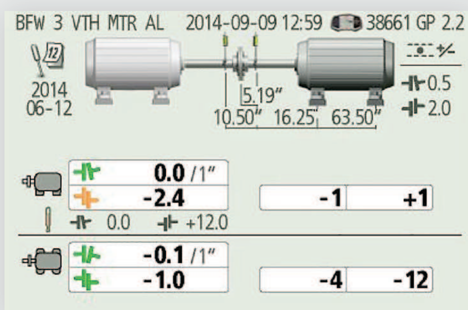
The motor operates at 3525 RPM and needed to be set 12 mils higher than the fluid drive to compensate for vertical growth in the drive. 3600 RPM was selected in the GO Pro tolerance table and +12 mils entered as the vertical target for the motor shaft centerline.

The initial set of results showed why the coupling failed prematurely. The vertical offset was more than 26 times the allowable offset tolerance of +/- 2.0 mils. You can see how the excessive vertical offset misalignment bent the shim packs, when viewed from on end, causing failure at these areas after thousands of cycles of excessive flexing.

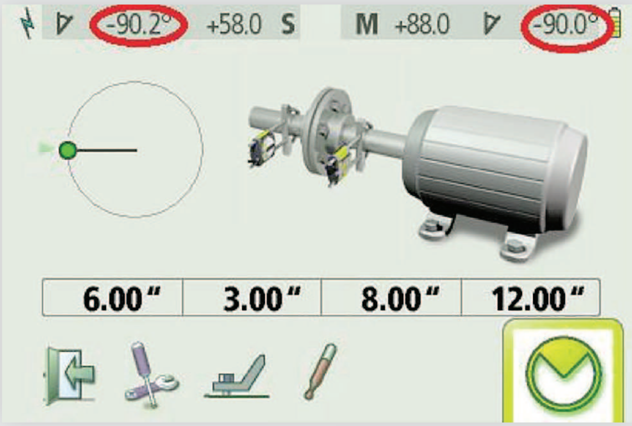


The uncoupled alignment went pretty much to plan and was completed in a couple of Verti-Zontal Compound Moves.

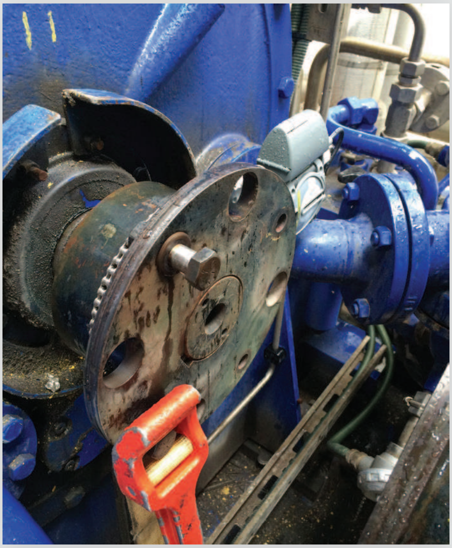
When performing an uncoupled precision shaft alignment with any of the fully digital Fixturlaser Laser Shaft Alignment Systems, there are no special programs or settings that are needed, just a few simple steps to follow when taking the alignment measurements.



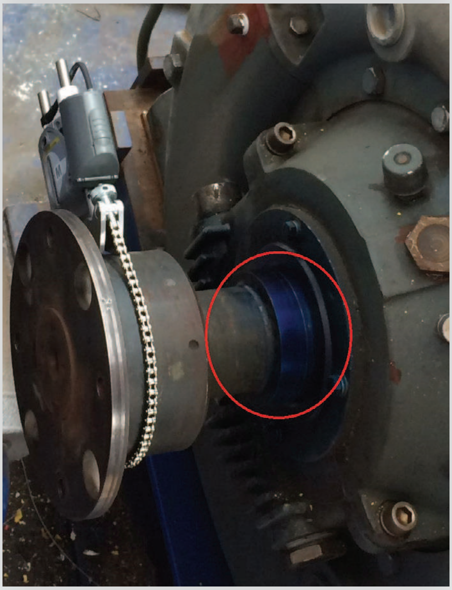
First, before registering a measurement, match the inclinometer values of the M & S sensor, at the top of display unit screen, within .2 to .3 degrees as shown in this example below.



During our alignment the motor shaft (with M Sensor) was the more difficult to turn of the two and was rotated first to each measuring position using a strap wrench, then the inclinometer value for the M Sensor was noted. The fluid drive shaft (with S Sensor) was then easily rotated by hand to match the S Sensor inclinometer value to that of the M Sensor and the measurement taken. Note: The shafts don't need to be rotated together and it is ok to break the laser beams.



Second, if one of the uncoupled machines turns freely, just the weight of the sensor can cause the shaft to turn when the sensors are in a horizontal plane. You can use a steady rest to rest the sensor against or counterbalance the weight of the sensor to keep the shaft from turning. In this case the mechanics simply hung the strap wrench on a bolt threaded in the coupling hub opposite the sensor.



Third, when the electric motor has sleeve bearings, the magnetic center of the electric motor shaft (rotor) needs to be reset before reassembling the coupling when finished. As is shown in the following photo, the exposed motor shaft had been painted with machinist blue beforehand and scribed to indicate the correct axial shaft position for the magnetic center. Some motors will have an indexing pointer and groove machined on the motor shaft to indicate magnetic center.

Of course, as with any precision shaft alignment, all "Best Alignment Practices" should be followed by taking all measurements in the same direction of rotation, checking for soft foot, replacing cruddy rusted shims with clean shims (new if needed) and by keeping the total shim count under each foot to 5 or less shims.

ALIGNING UNCOUPLED MACHINES

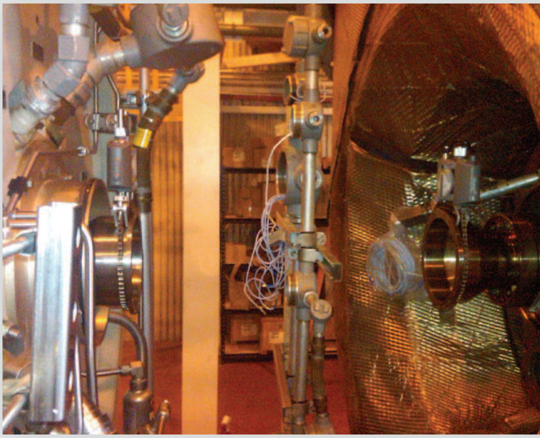
By Stan Riddle
December 11th, 2012

Normally, it is faster and more accurate to perform shaft alignment while the machines are coupled together. This offers several benefits such as:

- Keeping the relative angular positions of the shafts the same allows the technician to align the true shaft rotational centerlines.
- Coupling Gap is less likely to change while adjusting the movable machine, since the insert normally keeps axial spacing intact.
- If the machines are coupled, time is not wasted separating the coupling, removing the insert, re-packing grease, etc.

However, there are occasions when the coupling might need to be separated as part of the alignment process.

Here are three examples:



- When the shafts are so misaligned as to cause shaft deflection, or bending, when the coupling is connected. This is normally detected when the coupling does not easily assemble. The easiest way to minimize this is by roughing in the alignment with a straight edge before mounting the laser alignment tool.
- When the flexible coupling has sufficient stiffness to deflect, or bend the shafts during the process of rotation. Some flexible couplings are less flexible than others as part of their design, so a stiff coupling is not necessarily a bad coupling. Some examples of stiff couplings are disc- pack and tire couplings.

- Long, narrow shafts which extend several inches from the inboard bearing can deflect even when the coupling is not abnormally stiff.

If your laser alignment tool has built-in inclinometers, in the sensors, an uncoupled shaft alignment should not be difficult. Use the inclinometer values to set both sensors to the first measurement position, and collect your initial measurement. Rotate one sensor to the second position, then rotate the other sensor to the second position, matching the inclinometer values for each and measure. Repeat this process for the third measurement. Make sure to check your inclinometers before each measurement.

A simple method of detecting whether or not the coupling should be removed for the alignment is simply by monitoring the coupling values. After performing the pre-alignment steps, measure the misalignment, then shim/move to correct the misalignment as indicated. Re-measure. If the values are not very close to being in tolerance, and if you have carefully taken your measurements, suspect that the coupling stiffness is influencing the shaft's rotational centerlines. Re-measure for misalignment, this time with the shafts uncoupled, and see if the measurement changes.

Once the machines have been aligned, re-couple the shafts, and re-measure your alignment. Your values should not change more than 1-2 mils.

ELECTRICAL PIPE STRAIN?

By Tom Shelton
November 6th, 2014

Precision shaft alignment of rotating equipment is an essential part of any solid preventive maintenance program. To accommodate aligning any type of machinery you must be able to move one of the elements of the machine to achieve a precision shaft alignment. There are many limiting influences that could cause you to not be able to move some part of a machine. Some common examples are bolt bound/base bound condition, pipe strain, structural interference, etc…

Recently I was with the maintenance crew of a fresh water supply system in a major city. These guys were familiar with shaft alignment and the importance of aligning their pumps and motors to keep the people of the city happy and supplied with clean water. The crew had been using Fixturlaser Laser Shaft Alignment equipment for many years and had recently upgraded their systems by purchasing a NXA Pro system. As is the case with most of our customers, upon purchasing the NXA the customer opted to have a trainer from VibrAlign come on-site and give them some updated training in shaft alignment best practices. During the hands-on portion of the training we went to one of the many pump stations that the maintenance crew is responsible for.

Upon initial inspection of the motor/pump sets to be aligned, we discovered a major road block. Two of the motor/pump sets could not be aligned, without some structural work, as the electric motors could not be adjusted vertically or horizontally due to the rigid conduit and the junction box severely restricting movement. In other words the motor had severe "electrical pipe strain." Also, the pumps could not be moved as the piping was rigid and very close.

Two other electric motors took a little encouragement from a come-a-long to give some room from the conduit/junction boxes for the motor to be moved.

Be mindful of ALL of the influences that could affect your shaft alignment or limit the ability to align a machine.

Take time to look at possible influences that could limit movement or cause distortion in the machine components. Sometimes machines are not alignable without major work.

Remember though, once you have fixed it, you won't have to do it again and with a proper alignment the frequency of failure of that machine declines substantially.

The conduit is rigid and directly attached to the motor with no freedom of movement.

The junction box is against the breaker panel. On this one we were able to pull the breaker panel far enough away to align the equipment. It still needs to be modified

Plenty of clearance here.

And here.

PROCEDURE AND TECHNIQUE

Every mechanic has his or her own way of doing things, and every machine is different. That being said, there are correct general procedures that will apply to almost any machine alignment.

By following proper procedures, you will save time and money.

ADJUSTABLE MOTOR PLATE ALIGNMENT USING THE VERTI-ZONTAL ALIGNMENT PROCESS

By Matt Rybalt
February 18th, 2015

Recently while visiting a client's site, we were asked for alignment advice regarding an electric motor coupled to a mixer. The customer shared that the electric motor sat upon an adjustable base plate with adjustment bolts (jack bolts) in the vertical and horizontal planes.

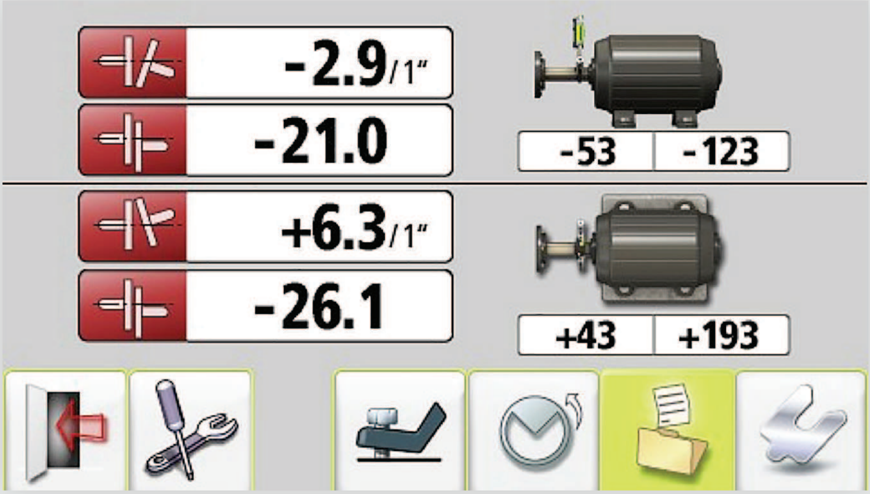
Despite the base plate having vertical jack bolts, VibrAlign's typical instruction in this application is to simply add/remove shims for the vertical adjustment. Shimming at the motor feet was not possible due to an obstruction blocking the right side motor feet. Challenged by this barrier, we decided the vertical jack bolts were a viable alternative for making vertical corrections.

This particular motor & mixer operates at 3560 RPM with a history of costly seal and bearing failures. To complicate matters, this production function needed to be operational in less than 90 minutes, making both precision and efficiency critical variables.

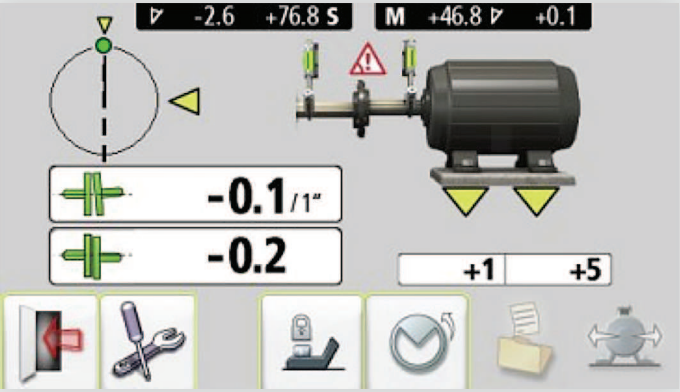
After an initial inspection, we loosened all the vertical jack bolt jam nuts, easing the tension on the base plate. This allowed us to measure each adjustment point for soft foot. Through this process we identified that the base was not flat and thus when the back left bolt was torqued it resulted in deflection (soft foot). We vertically adjusted this isolated foot, which subsequently resolved the issue.

After completing the remaining Pre-alignment steps, we set up the Fixturlaser EVO alignment system, selected the 3600 RPM tolerance and measured the motor shaft condition.

The initial results indicated severe misalignment with the vertical angle more than 5 times tolerance, the vertical offset was almost 11 times tolerance, the horizontal angle was more than 12 times tolerance and the horizontal offset was 13 times tolerance!

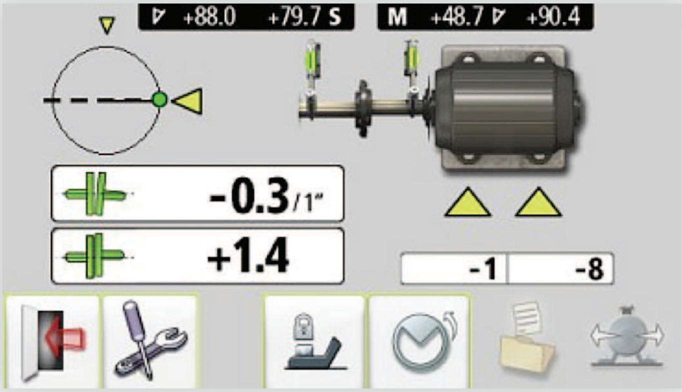


We began the Verti-Zontal correction process and because of the vertical jack bolts, bypassed the shimming screen straight to the live screen. Using the EVO live screen with the sensors in the vertical plane allows you to perform vertical adjustments on this type of machine while simultaneously observing the motor shaft position.

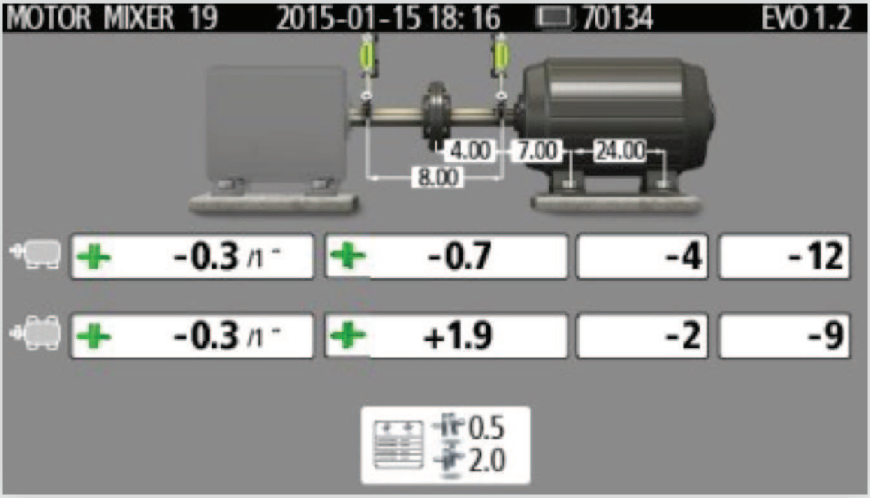


Through this process we identified that a half turn of the vertical jack bolt was a change in position of roughly 5 mils (.005"). Staying focused, we were sure to account for the same allotted torque on both the inboard and outboard feet vertical jack bolts. We also discovered and compensated for roughly .005"- .010" of excessive gap displacement at each foot.

Next we made our horizontal adjustments utilizing the horizontal jack bolts.



Lastly, we evaluated our vertical alignment figures to assure there was no unintended movement. Once confident in the alignment condition, we torqued the jam nuts utilizing a cross- pattern tightening sequence and re-measured for final confirmation.

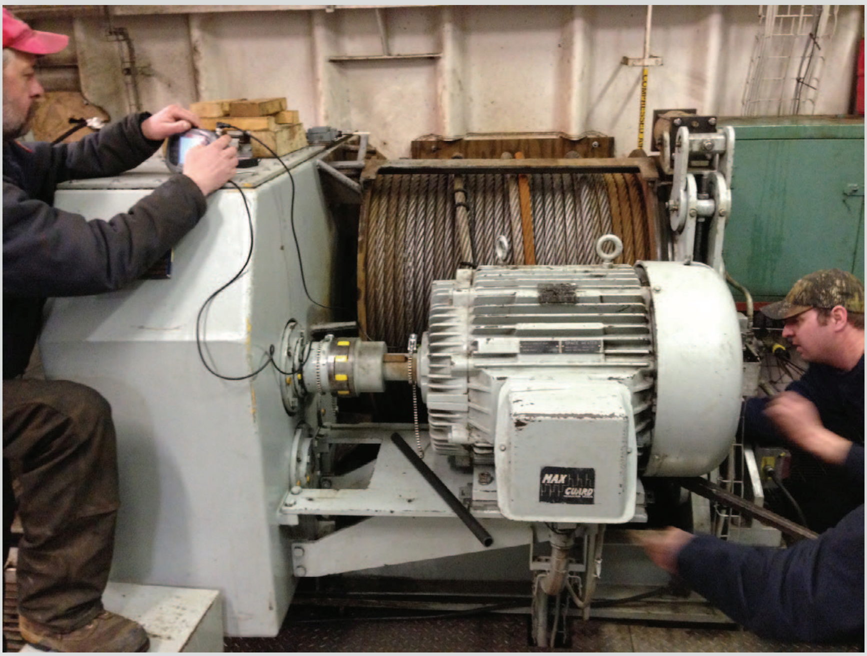


All in all, 3 specialists spent 50 minutes working on the machine. This is proof that with an effective precision shaft alignment tool and efficient alignment procedure, you can help correct/prevent rotating asset failure while working with (not against) production.

THE IMPORTANCE OF PROPER ALIGNMENT TECHNIQUE AND BEING AWARE OF MOVEMENT

By James Pekarek
April 17th, 2013

During the OJT portion of a Fixturlaser GO Basic Training class, with the Army Corps of Engineers, the class aligned two electric motors driving large winch gearboxes on a dredging barge. These winches are used to move the barge into position during dredging operations.



The class wanted to rotate both shafts to perform the alignments, so to take the alignment measurements, we momentarily disengaged the winch drum from the gearbox, rotated the gearbox and motor shafts to each measuring position and then re-engaged the drum to take the alignment measurements. We could have treated this as a non-rotating shaft alignment and broken the coupling loose to do so. However more accurate misalignment data is obtained when both shafts are rotated.

During the second winch gearbox alignment, we were struggling to keep the horizontal coupling values in tolerance. The coupling values would be near perfect during the live horizontal correction using the Verti-Zontal Compound Move® and then be more than 2 times out of tolerance upon the recheck. The vertical alignment remained spot on. Hmm, something must be moving?

After some analyzing and carefully watching the dual inclinometer values for the sensors, I noticed that during the "live" horizontal correction, the motor coupling and sensors were very slowly moving 5-6 degrees up and down with the movement of the barge sitting on the water in the river. The winch was coupled to some large positioning booms outside that were swaying very slightly in the passing wakes. This was happening too slowly to perceive with the eyes or even feel, but the inclinometers did in fact pick up the movement which was causing a "false" misalignment condition.

We then disengaged the winch drum and held the sensors in place with a steady rest fixture while performing the live horizontal adjustment; the alignment came in perfectly and the recheck confirmed a perfect alignment both vertically and horizontally. Our customer is very happy with the Fixturlaser GO Basic and they are excited to begin aligning the other rotating machinery on their boats.

WHAT THE VERTI-ZONTAL COMPOUND MOVE MEANS TO ME

By Stan Riddle
December 4th, 2012

VibrAlign's Verti-Zontal Compound Move is a shaft alignment process to allow the aligner to make both vertical and horizontal alignment corrections with a single measurement, or spin of the shafts. It's touted as making shaft alignments faster and more accurate.

But here's what it means to me – it makes shaft alignment EASIER!

- If I can roll the shafts only two times – once to measure and correct, and one more time to confirm and store the corrected alignment, it is faster. On a small pump, it's not a problem to rotate the shafts numerous times. But sometimes the rotor is 15 tons, and it must be rolled using a 6-inch nylon strap and a spud wrench, all attached to a 50-ton bridge crane. Less rotation means less times I worry about damaging something by this process.
- If I have to lie down on the motor, with an eye bolt stuck in my belly, to tighten and loosen the foot bolts, it means I don't have to do that as many times.
- If I have to tighten and loosen the foot bolts each time with a "knock wrench" and an 8-pound sledge hammer, it means much less hard manual labor.
- It means much less tightening and loosening of the bolts.
- It means much less climbing up and down cooling towers to make adjustments and re-measure.
- It means fewer times shimming, hammering, prying, lifting, sweating, and so on.

Faster is better. Accuracy is better. And easier on me is better!

I enjoy millwright work – I really do. But it can take a toll physically over 30 years or so. And if the Verti-Zontal Compound Move makes it easier on me and the machinery, I'm a fan!

THE MOUNTING QUESTION??

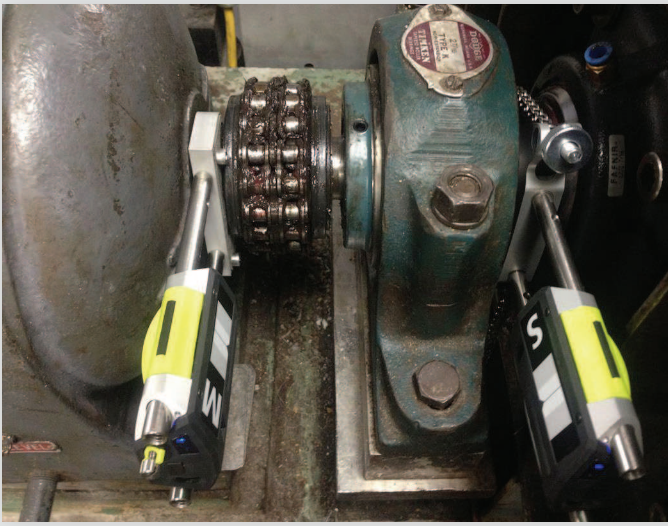
By Tom Shelton
May 16th, 2014

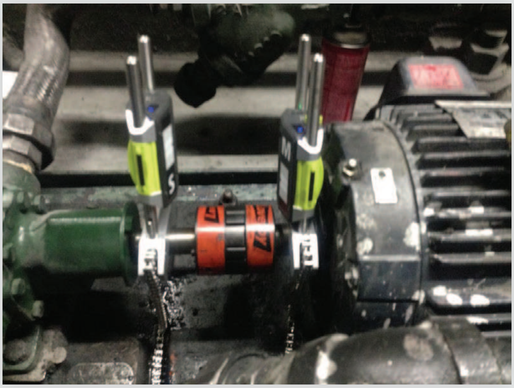
One of the frequent questions that we are asked is "Where do I mount the sensors?" The answer is that you must mount them to the rotating elements of the driver and driven machine in a location that provides a solid footing for whatever mounting apparatus you need to use.

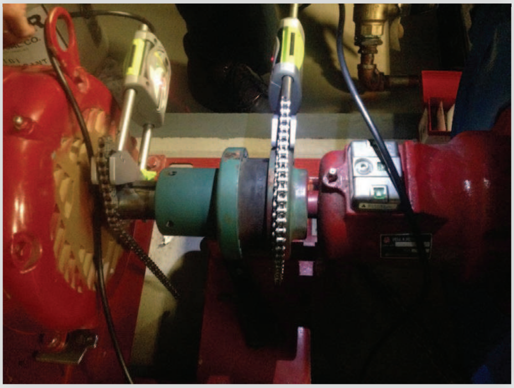
The sensors also must have a clear "line of sight" for the projected laser beams. What that means is that the options are limitless, as long as the rotational centerline of each machine is represented independently and the mounting brackets are not going to shift during the alignment process.

Again, the sensors must be able to "see" each other. There are many situations where creative placement is necessary. They can be mounted on the coupling hubs or shafts or a flywheel, even a brake disc. Look at the pictures below; these are just a few of the numerous applications, from our training classes, of the equipment that you have to work on every day in the field.

If you ever encounter an interesting mounting problem, give us a call and a picture. We would be glad to help!







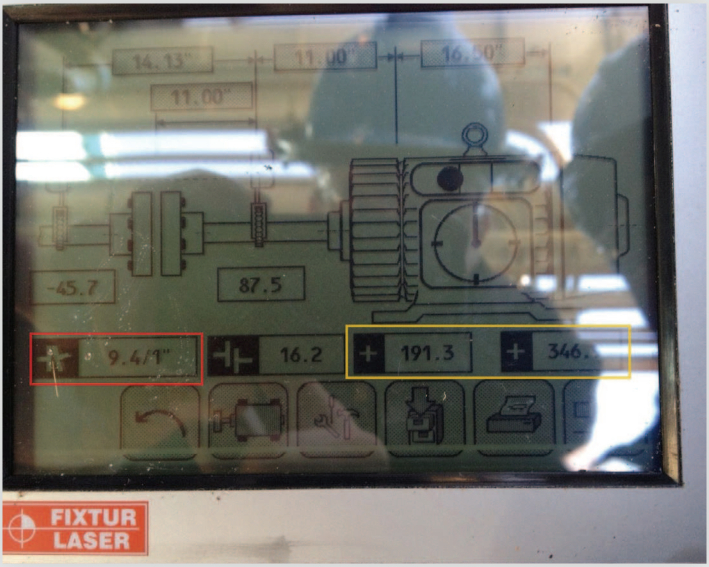
IN SHAFT ALIGNMENT, LOW CAN SOMETIMES MEAN HIGH!

By Stan Riddle
January 16th, 2013

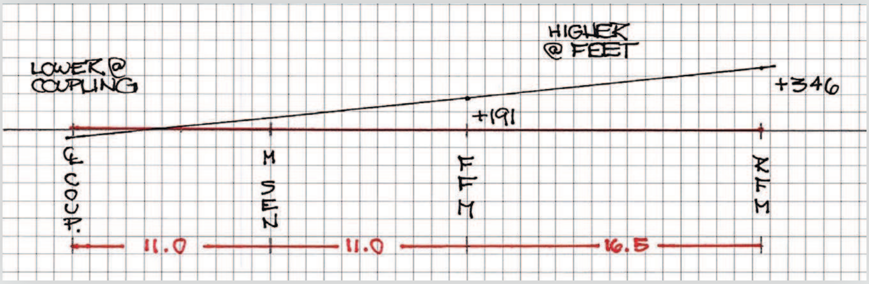
A customer in the northeast US was concerned that his laser wasn't working properly. He called into our office stating "the motor shaft is a ¼ inch low at the coupling, but the laser shows I need to remove a lot of shims from the motor feet – both front and rear." His thought was something must be wrong with his laser.

I asked him to rough in the machines with a straightedge until it was pretty close then re- measure with his Fixturlaser Shaft Alignment System. He did, and called back to tell me the offset at the coupling was fairly close (slightly low), but the vertical foot values showed the motor front feet were +191 mils (too high) while the rear feet were +346 mils (too high)!

I asked if he had a smart phone (which he did), and if he would take a photo of the screen, and send it to me. Sorry for the glare, but hopefully you can make out the position of the front and rear motor feet outlined in yellow.



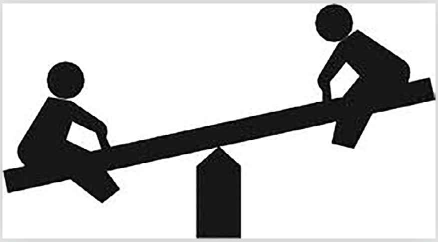
I did some good old-fashioned plotting on graph paper, and a little math, and came up with a good answer:



His Fixturlaser Shaft System was working fine, and here's why.

- The motor was too high, but much higher at the rear feet than the front feet.
- The slope, or difference between the front and rear feet, was 155 mils over 16.50", or 9.4mils/inch – exactly what the angular coupling value shows (outlined in red in the first photo).
- The length of the motor shaft from the front feet to the coupling center was 22 inches. So as the slope of the motor shaft keeps moving towards the coupling center, it's getting closer and closer to the stationary machine's reference rotational centerline (zero), until it finally goes to the negative side. In this case 16 mils low at the coupling center.

Think of it as a see-saw. When one end is higher, the other end is lower. In our case, the fulcrum would be the front motor feet.



Happy customer –
good learning experience.

THE ALIGNMENT TRIANGLE

By Stan Riddle
December 18th, 2013

No, it is not the place where good shaft alignments get lost – never to be seen again! It is a way of thinking about locating machinery feet so that the shafts are in alignment, even when the feet of the movable machine may be a few thousandths up, down, left, or right of perfect. Shaft alignment is about aligning the shafts, not the feet.

Think of the shafts as two straight lines – one stationary, representing the stationary machine, and one movable, representing the movable machine.

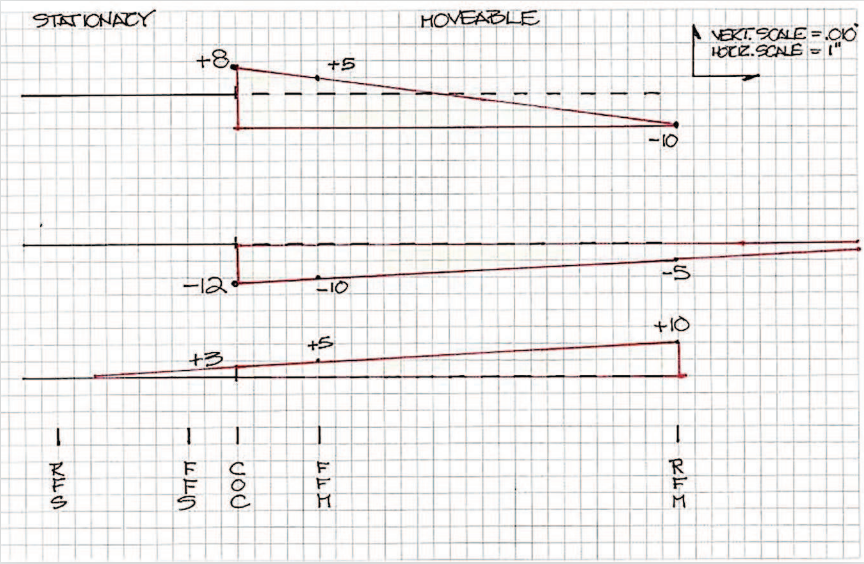
Examine the three graphs below:

The vertical scale is 1 block = 5 mils (.005") and the horizontal scale is 1 block = 1 inch

In the top graph, the movable rear feet are 10 mils low, and the movable front feet are 5 mils high, but the result at the coupling is 8 mils high.

In the middle graph, the movable rear feet are 5 mils low, and the movable front feet are 10 mils low, but the result at the coupling is 12 mils low.

In the bottom graph, the movable rear feet are 10 mils high, and the movable front feet are 5 mils high. The result at the coupling is 3 mils high.



Simply put, the "triangle" formed by connecting the foot positions to the reference line should point toward the coupling, not away from it. Remember this simple rule of thumb;

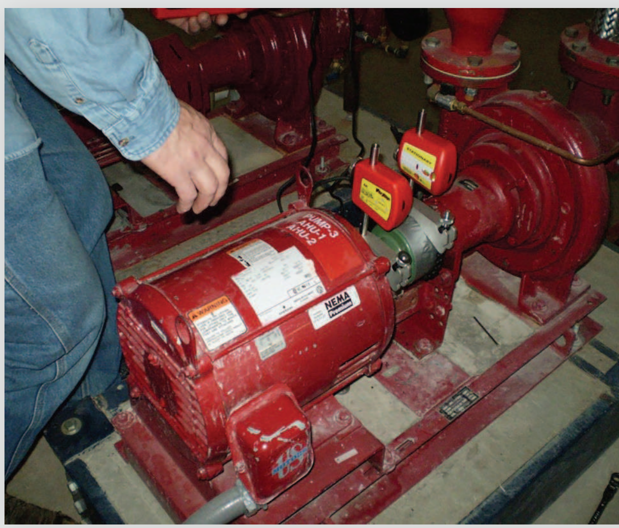
- The value of the movable rear feet (outboard) should be bigger.
- The value of the movable front feet (inboard) should be smaller.
- They should both be the same sign. In other words, if one is a positive value, both should be a positive value. If one is a negative value, both should be a negative value.

SHAFT ALIGNMENT OF SMALL MACHINES

By Brad Case
August 13th, 2012

The VibrAlign Training Faculty sees a lot of different machines during our training classes across the USA. The one statement that we hear repeatedly from mechanics and millwrights is, "I would rather align a 500 HP motor & pump set than a 10 HP one." We agree!

While small machines are easier to physically adjust during a shaft alignment, their small size presents another set of alignment issues. The electric motors are typically lightweight, the mounting feet are a thin stamping, the bases are rather flimsy when compared to larger and heavier machines, and there are no jacking bolts to control the horizontal adjustment.

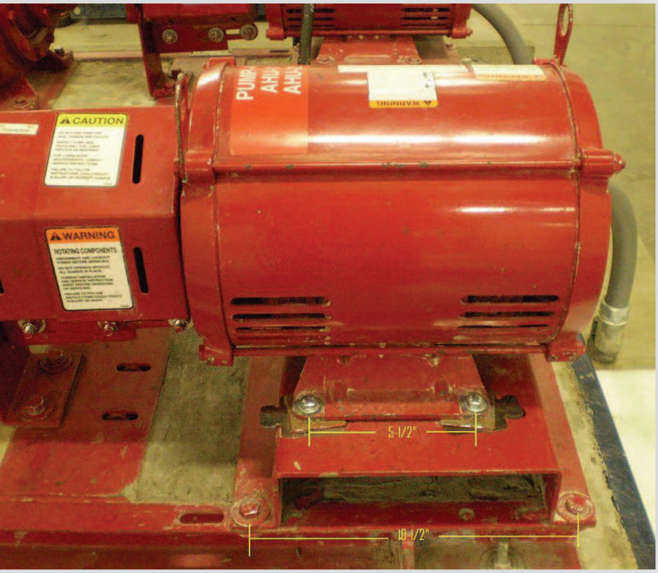


What does this mean for the aligner? Well, his/her alignment technique will need to be excellent and a "light" touch is also needed while making the live horizontal adjustment. After roughing in, soft foot absolutely needs to be corrected and a cross-pattern bolt tightening sequence with three passes needs to be followed to minimize movement of the motor. This, however, may not be enough.

During an alignment of a 10 HP motor/pump set during a training class the vertical alignment corrected easily. However, the horizontal alignment was extremely "sensitive" and would not stay in tolerance when the hold down bolts where tightened. The bolts where checked for cupped washers which were okay.

The problem? – the distance between the motor feet was only 5-1/2". The slightest movement at the feet caused the horizontal alignment to move out of tolerance at the coupling.

The solution? – move the sub-base! This application has a motor sub-base bolted to the pump base with a bolt spacing of approximately 10-1/2".



So for this motor alignment we adjusted the Verti-Zontal Compound Move slightly.

After getting results, the vertical alignment was corrected by shimming the motor feet and re- tightening those hold down bolts. The sub-base bolts were then loosened and the horizontal alignment adjusted and the bolts re-tightened. It took two modified Verti-Zontal adjustments to get the alignment in tolerance. By the way, when making the horizontal adjustment you don't need to change the feet dimensions, just move the motor the direction indicated until the coupling values are in tolerance!

Pretty cool, huh?

ORGANIZING YOUR SHAFT ALIGNMENT JOB

By Patrick Lawrence
October 12th, 2012

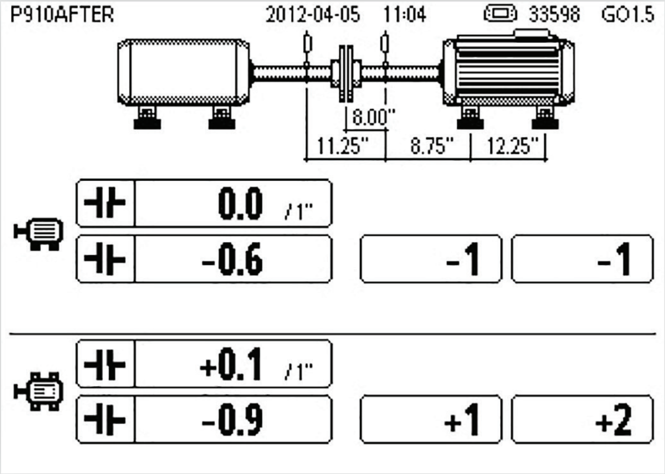
One of the great things about being out and about with other shaft alignment professionals is seeing how they get work done. Two recent shaft alignment training classes had some great examples of how to stay organized.

During an alignment on a gas compressor a few weeks ago, these guys pictured below, had to manage shims at twelve different feet! They each had their shim piles they were adjusting. The XA Pro told them how to adjust during the Verti-Zontal move and they were using calipers to check the thicknesses. I dared not say a thing for fear of confusing the math! Patience and attention to detail is what led to this compressor alignment being completed in one move.

How much time do you waste walking back and forth from the job to the shop? I was in awe of these shaft alignment tools, in the following photo. I've been asked before what to pack in your tool bag but this takes the cake! These guys either roll this to the job or transport it with a little fork lift they have. Either way, it's at every job. Shims, cleaners, dial indicator accessories, pry bars, persuaders of different sizes, wrenches–looks like it's all there!

CAN PRECISION SHAFT ALIGNMENT BE TOO GOOD?

By Stan Riddle
April 3rd, 2014



A shaft alignment tolerance is simply that – an allowable, minimal amount of alignment. There are many different tolerance tables for shaft alignment. At VibrAlign, we have a good alignment tolerance, based on many years of experience and engineering. Other alignment tools have their own tolerance tables. Many technical and trade organizations have their alignment tolerance values. Coupling manufacturers and machinery manufacturers have tolerances for alignment as well.

Some facilities specify an alignment tolerance of "as close to zero as possible." With today's extremely accurate laser alignment tools, you can get VERY close to zero. But to do so, you will probably spend an inordinate amount of time achieving an unnecessary goal.

Many years ago, I aligned a baghouse fan for a power plant. And quite honestly, I wanted to show off – and get "all zeroes" on the alignment. I spent an entire day on this fan, shimming and moving very carefully, until I got repeatable "zeroes" for angularity and offset at the coupling.

We started this fan, and almost immediately heard a loud "growl" from the motor, which also started overheating. When the inboard motor bearing got to 180 degrees, it tripped out. I uncoupled the machines, unwired and removed the motor, and disassembled it. The bore in the inboard end bell was 0.0005'l oversized, which allowed the inboard bearing to slip in the end bell.

So the brand new motor was re-bored, reassembled, re-wired, and re-aligned. But this time, the alignment was left about 2 mils misaligned on the horizontal offset. And it ran smoothly for years.

By trying (and achieving) "perfect" alignment, I can only suppose there was little to no pre-load on the bearing. If I had left it misaligned by only a couple of mils, the bearing probably would not have slipped, and I would not have spent an additional day in repairs and additional alignment.

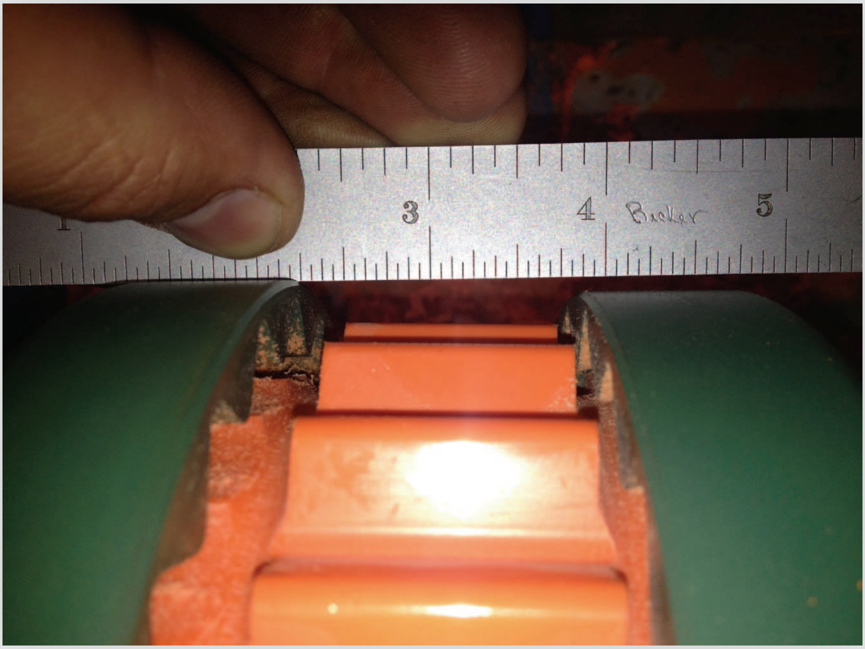
Modern laser shaft alignment tools are not about how close to zero you can get the alignment, but how quickly you can complete the job, while doing it accurately, repeatedly, and easily.

WHAT TO DO WHEN THEY WANT TO RUN THE MACHINE NOW!

By Stan Riddle
June 18th, 2014

I frequently hear statements similar to these in training classes:

- We just straightedge it in, and align it when we have an outage.



- Don't be so picky. It IS a flexible coupling.
- They won't give me time to align it properly.

My answers are something along these lines:

- I doubt they'll let you go back and align it properly! There will be another "fire to fight" by the time the outage gets here. And there may already be damage to the insert, bearings, or seals before you do get to align it. So, align it now.
- It IS a flexible coupling, but not infinitely flexible. As a matter of fact, many are not very flexible at all. Much of the force transmitted

by the coupling to the shafts will move right to the bearings and seals, damaging them. So, align it now.

- They will give the electrician's time to wire it back up, won't they? So you may be able to align it before the electricians finish wiring it up. So, align it now.

Few things irritate me more than when a company spends thousands of dollars for a precision laser shaft alignment tool, only to NOT USE IT because they are in too big a hurry for immediate gratification! If they would only allow a few extra minutes to align it properly, they could avoid misalignment-related problems. The coupling insert won't need replacing every few weeks (just like last time), the seals won't start leaking again after a few months (just like last time), and the bearings may not retire until after you do.

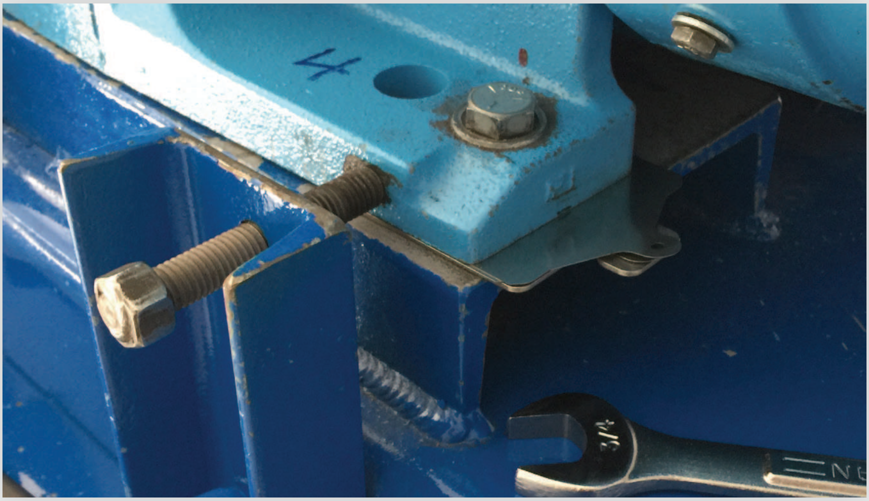
Believe me – as a millwright for over 25 years I've been in your shoes. It's frustrating when you want to do the job right, but are overruled when you try. Sometimes the best way to prove it is to go along "chewing up couplings" until someone takes notice.

However, I hope you will be your own advocate. Stress to your management and to production that just a few more minutes aligning it "by the book" will increase the life of the machine exponentially, reduce future costly unscheduled downtime, lower cost in fewer wasted parts, and generally, make everyone's life at work more pleasant.

USE YOUR HEAD NOT YOUR HAMMER!

By Tom Shelton
October 2nd, 2014

Many of our classroom discussion topics relate to problems in the field when attempting a precision shaft alignment of rotating equipment. One such topic is how to move a piece of equipment horizontally that does not have jack bolts already mounted on the base. The obvious answer is to mount a set of jack bolts to your equipment or use a Horizontal Alignment Tool Set with portable jack bolts. If neither option is possible then it is time to employ creative means to move your machine.



One thing is certain, DO NOT directly hit the motor or machine foot! This means don't use a hammer or brass bar to hit the foot or machine directly. If the only means to move a machine is this type of force, use an intermediary device to soften the blow. Otherwise, direct consequences will occur that may not be immediately evident.

When blunt force, such as a hammer blow, is applied to a motor or any part of a machine that contains bearings, the damage you inflict will cause premature failure. When a bearing receives a substantial blow, it can be possible to crack or at least leave pitting on the race where the roller and race are in contact. Other damage that can occur would be a cracked or bent motor frame. This is easy to do and hard to fix.

There are as many creative ways to move a motor as there are mechanics moving motors. Be creative! Safe, and creative. I personally have used pry bars, port-a-powers, and made base modifications to keep from using a hammer. One example of base modification is to drill a ½" hole in the base approximately 1" from each foot of the movable machine. I then inserted a pinch bar in the hole to pry against with a small pry bar. This did not undermine the structural integrity of the base and the horizontal correction was easily completed. You are not usually trying to a lift a heavy weight, only slide it a few thousandths!

IF a hammer is your only option, use a piece of wood, a hammer handle, or brass bar and place it against the machine foot, then hit that instead of the machine. This is not the recommended method of moving a machine. USE YOUR IMAGINATION and BE SAFE.

THE FASTEST WAY TO DO AN ALIGNMENT

By Tom Shelton
May 23rd, 2014

According to our resident alignment training “philosopher” Stan Riddle, “The fastest way to complete a precision shaft alignment is to take your time.” This doesn’t mean to take numerous breaks; what he is telling us is to stop and think!

As Industrial Mechanics, usually in a production environment, we tend to try and complete a job as fast as possible. This is primarily due to the pressure of down machines and the cost of production downtime. When we do an alignment we sometimes try to take shortcuts to save time and labor. This type of action usually ends up wasting more time than if we had followed a specific plan, step by step.

VIBRALIGN has spent many years in developing a training program to show you the essential steps to complete an alignment with minimal moves and in minimal time utilizing Fixturlaser Alignment Systems. While it is up to you as a mechanic to look at all aspects of a job, the essential, absolute steps you must perform are:

1. Rough align your machines.
2. Eliminate obvious soft foot.
3. Establish a tightening sequence for the hold down bolts.
4. Correct final soft foot. (Residual Soft Foot).

At times we are instructed to “Go out and check” an alignment. If we find that the machines are not aligned to within the correct tolerance, would it be acceptable to just loosen up the movable machine feet and put some shims in or take them out to correct as the laser system illustrates?

Experience tells us that if we have to loosen any hold down bolts we might as well start at the beginning. Remove the shims, clean it all up and start from scratch. More often than not, the result of trying to shortcut the process ends up wasting valuable time. Following the essential steps will result in the most efficient alignment process. Take a shortcut and you will likely send yourself back to the beginning of the process to start again.

Remember, “The fastest way to do an alignment is to take your time.”

PROPER MOVEMENT SEQUENCE FOR SHAFT ALIGNMENT

By Patrick Lawrence
June 14th, 2010

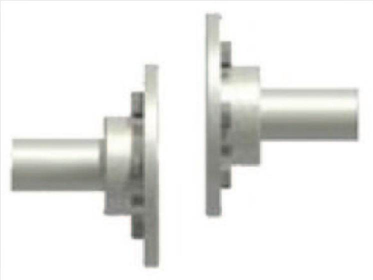
One of the most important factors in successful shaft alignment is utilizing a proper sequence of moves. Understanding and utilizing this methodology will drastically decrease the time required to align shafts, and improve the effectiveness of your efforts.

First, be sure to perform the proper pre-alignment steps, such as minimizing soft foot and backlash. If you are unsure of these steps, please visit the Pre-alignment section of VibrAlign's Alignment Resource Center.

Shaft misalignment occurs when the shaft rotational center of one machine (usually a fixed machine) does not align with the shaft rotational center of another (movable) machine. The goal of shaft alignment is to correct this misalignment and make the shafts collinear. The two machines are almost always misaligned in a combination of angular and offset positions:

- Vertical/horizontal angular misalignment, where the shafts are not in the same vertical/horizontal plane.

- Vertical/horizontal offset misalignment, where the shafts are parallel vertically/horizontally, but not collinear, or in the same line.



After measuring the shaft positions to determine the angular and offset misalignment, the first step in correcting the machine is to correct the vertical plane. Whether you're using indicators and have graphed the solution, or using a laser system that did the math for you, correcting the vertical plane first allows for greater flexibility when making the horizontal move: once the vertical alignment is completed, you should theoretically be able to move the movable machine as far as the hold down bolts will allow and still be aligned vertically. This is why it is so important to correct the vertical misalignment first.

The next step is to make the correction in the horizontal plane. Much like with adding or removing shims in the vertical plane, sliding the machine towards or away from you will correct both the angular and parallel offset misalignment together.

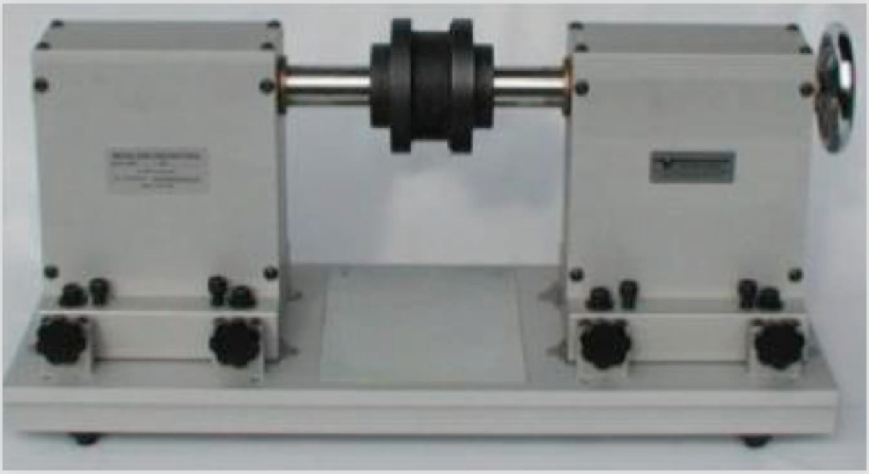
Once the correction moves are complete, tighten the hold down bolts at the feet and re-measure to confirm your work. Most alignments should be accomplished in one or two complete moves.

PRACTICE DOES MAKE PERFECT IN SHAFT ALIGNMENT

By John Visotsky
October 22nd, 2012

Practice and repetition are key components to becoming good at anything. Precision shaft alignment is no different.

It is a rare day when an important alignment project develops, all pre-alignment conditions are perfect and the machinist is given all the time in the world to do the alignment. The machinist might even have the latest and greatest laser alignment system. Since that situation never really happens and chances of a mistake are likely, we should consider this Aristotle quote: "We are what we repeatedly do. Excellence, then, is not an act, but a habit."



Picture courtesy of V-Tek Associates - www.vtekassociates.com

Having a good repeatable machine trainer is an excellent way to maintain competency and ensure success when going to the field. A real trainer must be repeatable, must be able to create conditions found in the real world such as base-bound/bolt-bound conditions, axial float, soft foot or non-rotating shaft. Most importantly, a well-designed, repeatable trainer can be used to practice the alignment procedure and also allow the user to become more familiar with the alignment process and alignment instrument and develop excellent habits.

Many times companies just take an old motor/pump skid and try to use that as a trainer. They typically have been junked for a reason and don't make the best trainers. Others try to build their own and in my experience they either do not get around to it or if they do, it is not very repeatable or does not allow the user to set up various misalignment conditions.

A trainer that can best simulate real machine conditions will help the machinist become an expert in shaft alignment and this can only happen with practice, practice, practice!

START LOW TO USE ALL OF THE SENSOR/DETECTOR RANGE

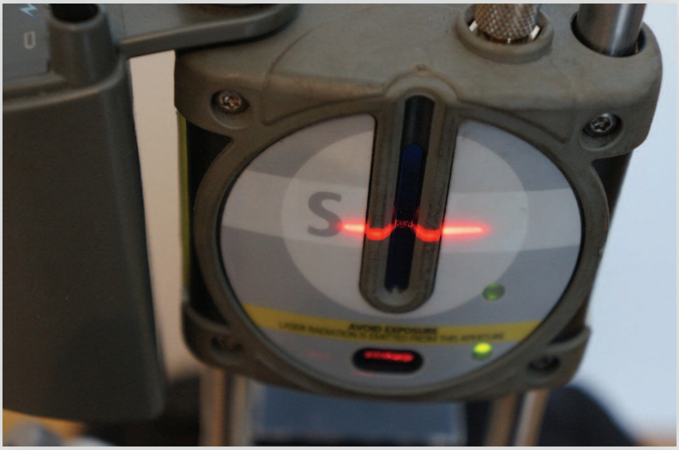
By Richard Talley
August 14th, 2013

During a recent cooling tower shaft alignment, using a Fixturlaser XA Alignment System, when we started taking our initial set of measurements the laser beam went slightly off the "S" sensor detector, even in 60 degrees of rotation.

Normally when the laser beam travels off the detector I use the laser beam to perform the rough alignment, by adjusting the motor while watching the beam to set it halfway back to the center of the detector. The rule of thumb is to adjust the motor's rear feet when looking at the laser beam striking the "S" detector and adjust the front feet when looking at the laser beam striking the "M" detector.

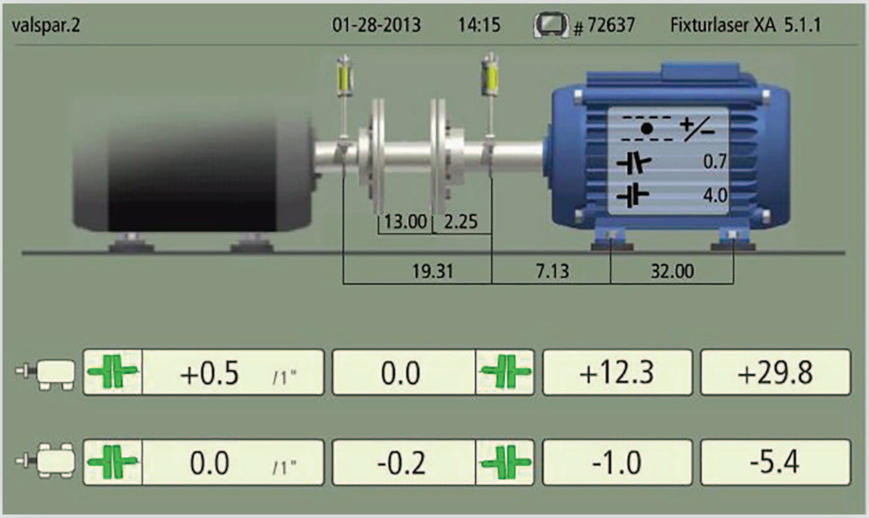
This method works great but in this case the laser beam only went off the top of the detector slightly so instead of starting with the beam in the center of the detector we simply adjusted it lower on the detector and started from there. The laser beam stayed in the 30mm detector and we used the measurement results to perform the alignment. The "S" Sensor setup and final results can be seen below.

Normal Sensor Set-up



Modified Sensor Set-up

Final Results



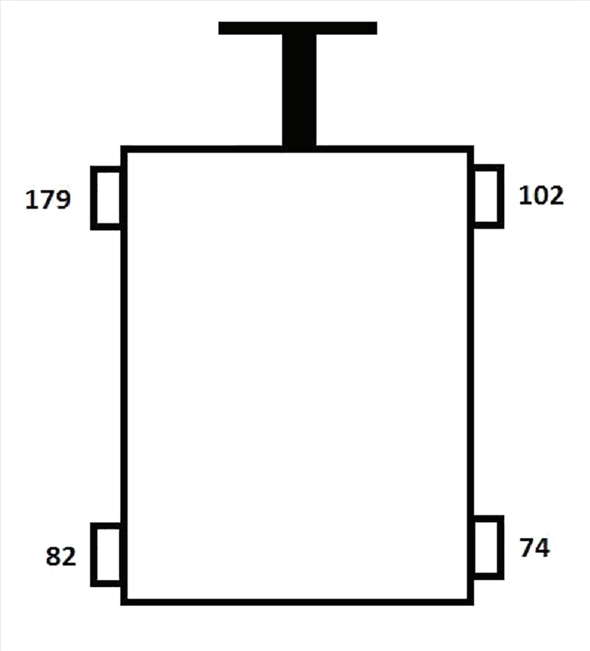
WHY DO PEOPLE STRUGGLE WITH ALIGNMENT? PART 2

By James Pekarek
March 26th, 2014

In my previous blog entry "Why do people struggle with alignment? Part 1," we discussed the importance of not only micing, cleaning, and consolidating shims but also noting the total amount of shims under each foot of the movable machine.

The motor-pump set we performed an alignment check on had the following amount of shims under each foot of the electric motor. We discovered drastically different total thicknesses of shim packs under all the motor feet. Most noticeably they were different from side to side.

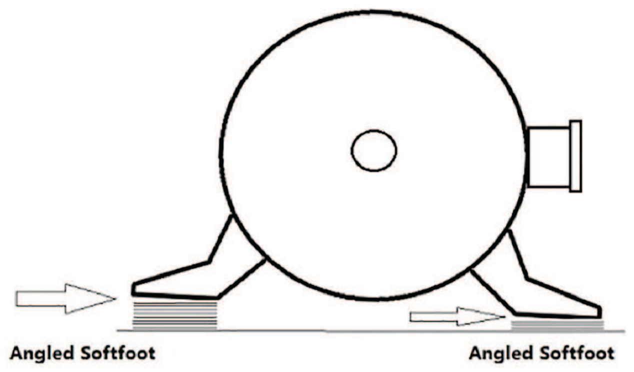
While you don't necessarily expect the front and rear feet to have the same amount of shims the two front feet and two rear feet should be "relatively" close to each other. These are the shim stack totals we initially found.



So why is this wrong? Is this wrong?

For starters and most importantly, this may induce an angled soft foot as shown in the drawing below. Angled soft foot is different from regular soft foot and creates different problems. Also, you don't want to "ASSUME" that the left front foot has 77 mils more shims under it than the right front foot to correct soft foot when previously aligned. You want to identify the type and location of the soft foot for yourself.

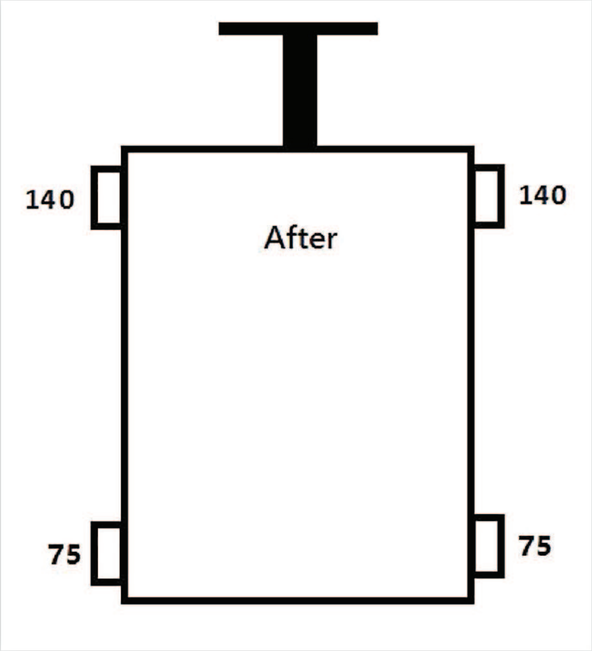
If this induced angled soft foot is allowed, the motor case and feet will distort when the hold down bolts are tightened, potentially closing up air gaps on electric motors as well as bearing clearances on all types of drivers. In addition, the rotational shaft centerline will be changing as well, yielding inconsistent alignment results.



So how did we resolve the shim issue?

First, we measured the total of the shim stacks under both front and both rear feet. Measuring the total shim stack is preferred over adding up the values marked on each shim as this will give you an exact total thickness. Adding the values on each shim will not be as accurate unless you mic the actual thickness of any shim that is 50 mils and thicker due to manufacturer's tolerances.

We then averaged the shim stacks between both front feet (140 mils each) and both rear feet (75 mils each), this maintained the position of the motor shaft while rotating the motor case to a "level" position. At this point, the motor feet were relatively flat with the base and we had a known position to start from and continue with the "Pre-Alignment" steps for this alignment.



So, if you find yourself getting inconsistent results (frustrating) from your laser alignment tool, stop and take a breath, back up and start resolving the issue by checking fundamental items such as soft foot, looseness, and backlash. And most importantly, do not assume anything when it comes to precision shaft alignment!

TROUBLESHOOTING GUIDE FOR BASIC ALIGNMENT

By Billy Stanley
October 27th, 2013

When you are using a Fixturlaser Alignment System and you are not able to get it aligned in three tries, here are a few things to look for.

1. Ensure that you start with a clean base and have checked for soft foot.

2. Do not use more than 4 shims under the machine feet.

3. Check for run out on the shafts and coupling.

4. Ensure that you have the proper key length & put them 180 deg. apart.

5. Use the proper procedure for tightening bolts. (X)

6. Try and use new bolts (bolt stretch can cause an issue).

7. Ensure that your sensors are installed properly and not cocked at an angle. (/ \ )

8. If there is a lot of residual vibration in the area then you might want to switch your machine from EXPRESS measuring method to TRIPOINT for better results.

9. Always double-check your measurement before you install it in the machine.

These are a few things that I have run into in the field so I hope this will help you.

I perform Reliability Centered Maintenance work at the mill and since we started precision laser alignment, I have seen the work orders, that I write, go from replacing pumps & motors, to replacing coupling elements for normal wear. So keep Realigning America moving forward.

BELTS AND NON-STANDARD ALIGNMENTS

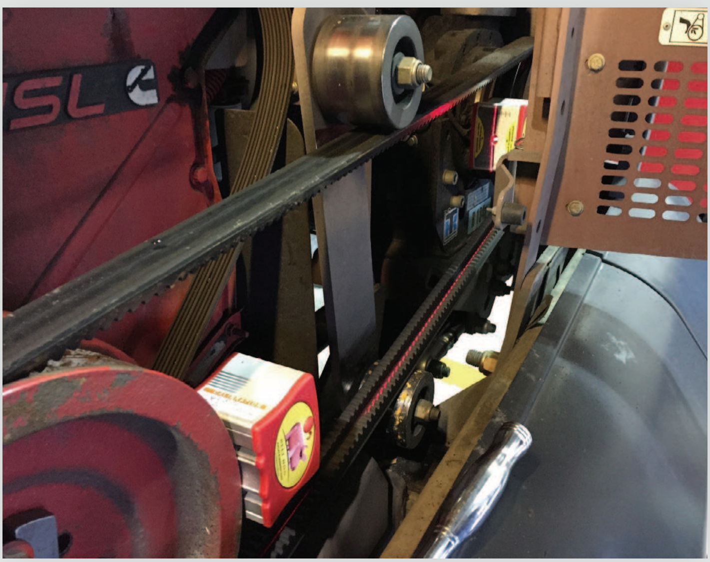
Not all alignments are horizontal shaft-to-shaft alignments. Other machine types call for other alignment procedures. Vertically mounted machines require their own alignment technique, while others have specialized couplings. Some machines are belt-driven and have no shafts or couplings at all.

For each unique challenge there is a unique solution. The following pages present many “non-standard” situations you may come across.

BELT HOGS FOR BUSES?

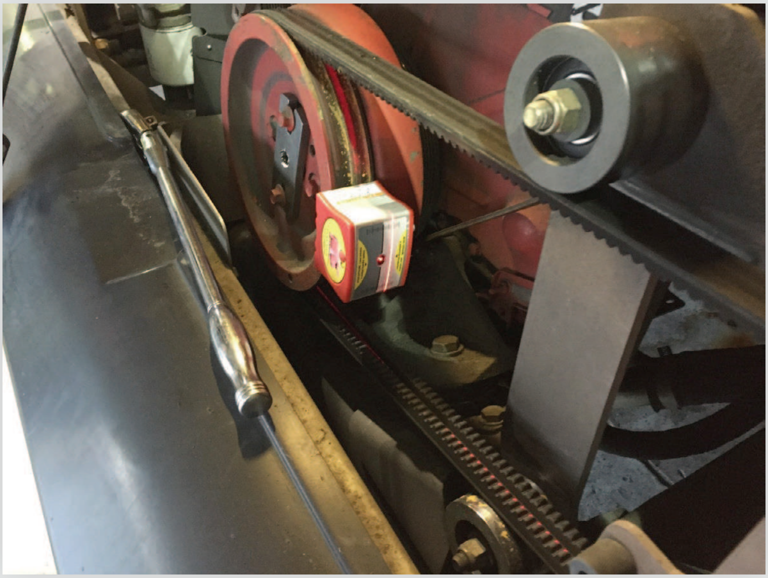
By Steve Gordon
January 6th, 2015

A creative application for the VibrAlign Belt Hog sheave alignment tool has paid off for New Flyer of America and one of its customers, King County (Seattle, WA) Metro Transit Division Fleet Engineering and Vehicle Maintenance. New Flyer is a major manufacturer of heavy-duty buses in the U.S. and Canada.



The Belt Hog is used to align the pulleys that drive the AC Screw Compressor.

Before using the Belt Hog, New Flyer was having to "warranty thousands of belts" because of premature failure. King County Metro was trying to reduce the number of "Road Calls" from bus breakdowns in its 1,400+ bus fleet. The Belt Hog has proven itself with New Flyer, King County and most importantly, its riders, as belt failures and related "Road Calls" have been substantially reduced.



This highlights a creative use of a great laser alignment tool by maintenance professionals who build and maintain these assets with the goal to increase the mechanical reliability.

V-BELT ALIGNMENT OF A VARIABLE PITCH SHEAVE TO A FIXED PITCH SHEAVE

By Stan Riddle
January 31st, 2013

Variable pitch sheaves are used frequently in air handlers. They allow the design engineer to increase or decrease the speed of the driven machine. In doing so, they allow for:

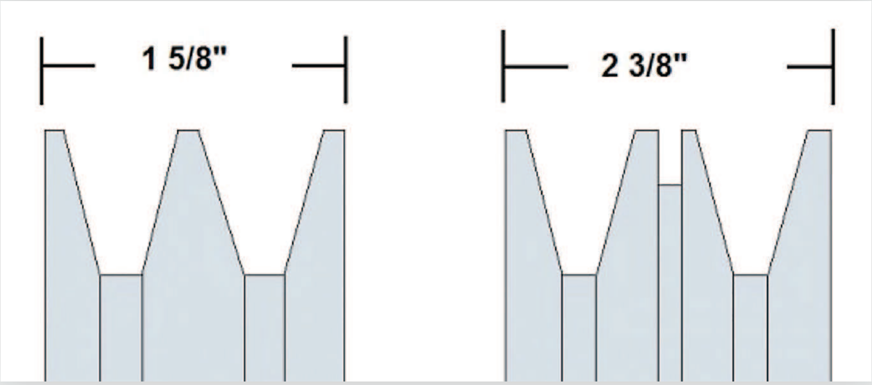
- Changes in amp draw of the motor, to maximize efficiency,
- Increase or decrease static pressure and air flow.

Normally, the design engineer will specify the use of a variable pitch sheave on the driver, and a fixed pitch sheave on the driven machine.

When used with a single belt design, proper sheave alignment is simple, if a good sheave alignment tool is used. However, when multiple belts are used, as they often are, proper sheave alignment can become more complex. A variable pitch sheave can be adjusted to make the diameter of the sheave bigger or smaller. However, this also makes the width of the sheave wider or narrower, depending on the adjustment.

We recently fielded a customer call who was attempting to perform a sheave alignment on an air handler, using a VibrAlign Belt Hog. The motor had a variable pitch sheave, but the fan sheave was fixed. He stated that he could align one belt, but not the other.

Here's why he was struggling.



The width of the fixed diameter sheave is 1-5/8", but the width of the variable pitch sheave is 2-3/8". So, only one set of grooves could be aligned, meaning the other was out of alignment.

The answer? Split the difference.

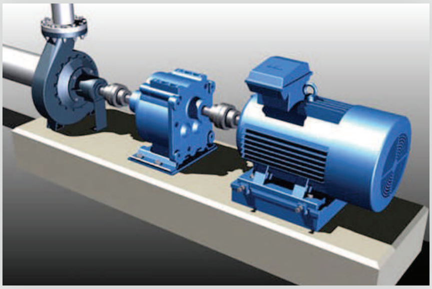
2 3/8" – 1 5/8" = ¾" ÷ 2 = 3/8" offset on each groove.

It is important to note that this will probably not align the sheaves sufficiently to eliminate wear on the sheaves and belts. Nor can it be eliminated. It will, however, make the belts wear evenly.

Variable pitch sheaves are normally used to balance a system out, and achieve proper static pressure and speed. Once that is determined, the variable pitch sheave should be replaced with a fixed pitch sheave of the proper diameter to match the desired speed and pressure. Once both sheaves are fixed pitch, proper alignment can be achieved.

MACHINE TRAIN SHAFT ALIGNMENT TRICKS

By Stan Riddle
September 10th, 2014



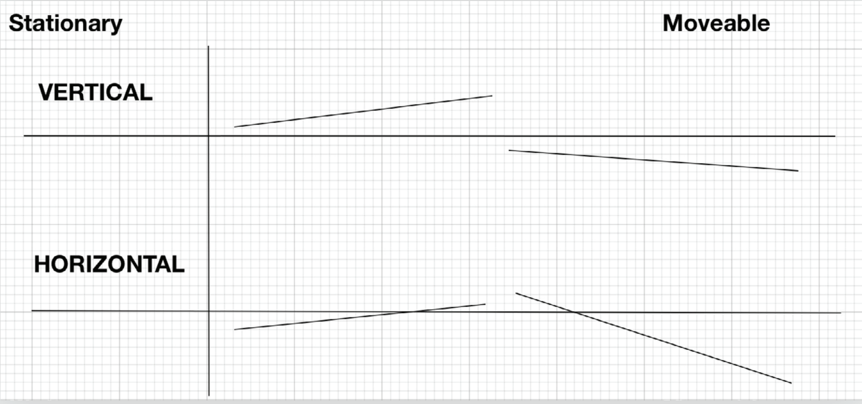
Simply stated, a machine train is when three or more machine components are coupled together, acting as one. Machine train alignment can sometimes be a complicated task. Some laser alignment tools can measure machine trains of up to several machines, simplifying the move options. Whether you have a machine train program or not, by using some common sense guidelines, a machine train can be aligned easily and successfully.

Trick #1: Work From the Stationary to the Movable

Usually, the best way to align a machine train is to work from the stationary machine to the movable. Once the first movable machine is aligned to the stationary machine, the “movable” machine now becomes “stationary.” In the image above, align the gearbox to the pump. Once this alignment is completed, the gearbox becomes the stationary machine, and the motor becomes the movable.

Trick #2: Graphic Visualization

Graphing the alignment allows you to “see” what the alignment looks like. This helps the aligner see move options. In this graph, we can see that lowering the gearbox will improve the alignment to both the pump and the motor. Some tools, such the Fixturlaser XA and NXA,



have machine train programs which can do this for you, as well as calculate options on the moves.

Trick #3: Minimize Angularity

If angularity is excessive, as you progress from the pump to the motor, the chances of being bolt-bound increase substantially. To prevent this, keep your angularity as small as possible.

Trick #4: Take your Time

A machine train alignment can be complicated, depending on the number of machines in the train. By taking your time, observing the alignment, and remembering that you are aligning many components into one "machine," you will complete the task with much less frustration and error.

MACHINE TRAIN SHAFT ALIGNMENT-TO MOVE OR NOT TO MOVE

By Brian Shanovich
September 17th, 2012

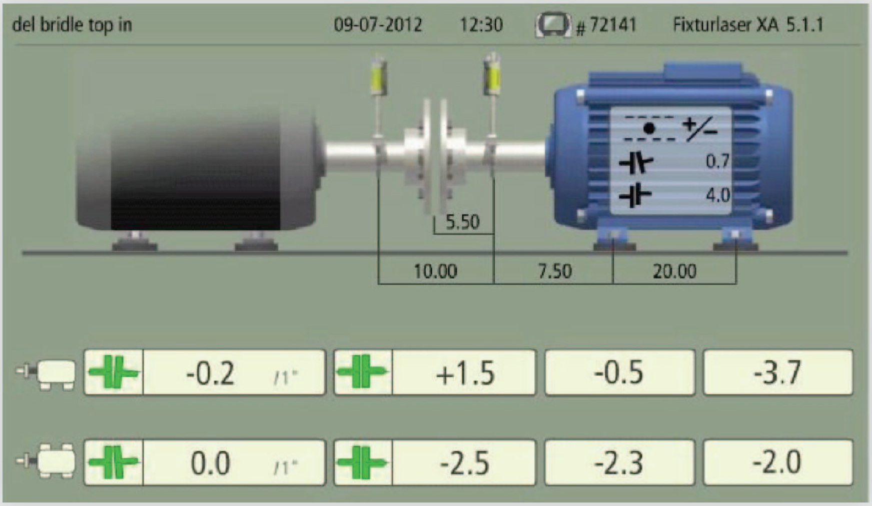
It is always the question with machine train shaft alignments: what needs to be moved? The best way to approach a multiple machine set shaft alignment project is to know where everything is and where everything needs to be.

This particular auxiliary generator set has 10 pieces of rotating equipment to align. An induction motor in the middle with five pieces going to the north and four pieces going to the south, all rotating at 1800 rpm.

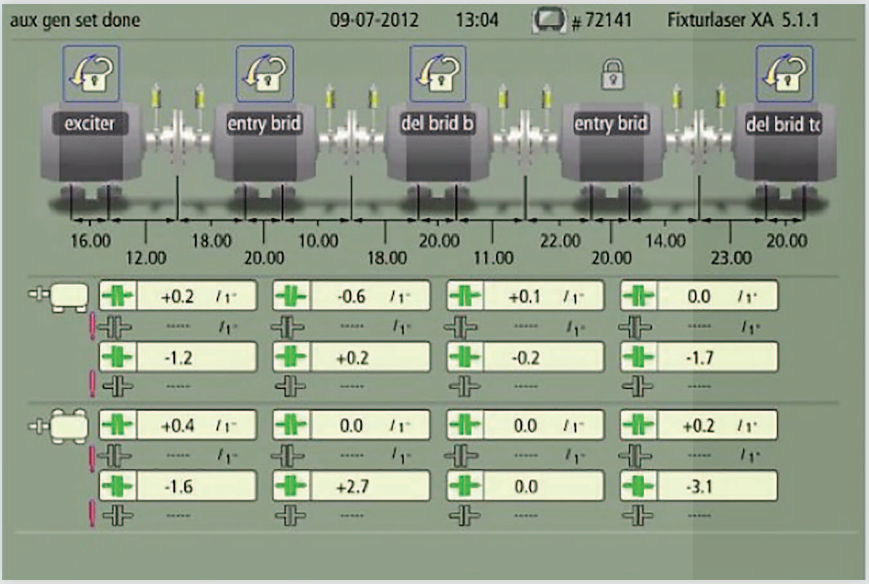
This assessment is tackled by measuring the alignment condition from the induction motor to the first piece north. After this is measured, then the remaining pieces going north will be measured by using the Machine Train program. With the Fixturlaser XA Pro, we can make the machine template with machine names and dimensions and store it in the XA's memory before the shaft alignment conditions are assessed. When the alignment assessment is needed, just recall the saved file from memory and measure the rotational centerlines from machine to machine.

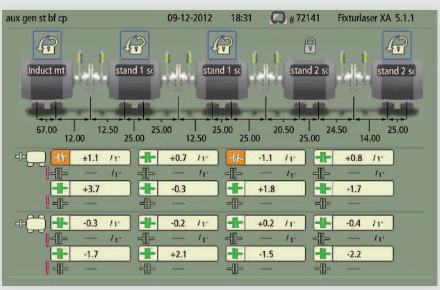
The Results

The induction motor to delivery bridle top generator alignment is clearly within the 1800 rpm tolerances of 0.7 mils/inch angularity and 4.0 mils offset.

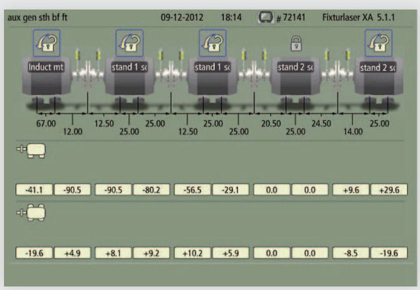


As for the remaining pieces of equipment, the results again meet the correct shaft alignment tolerances.





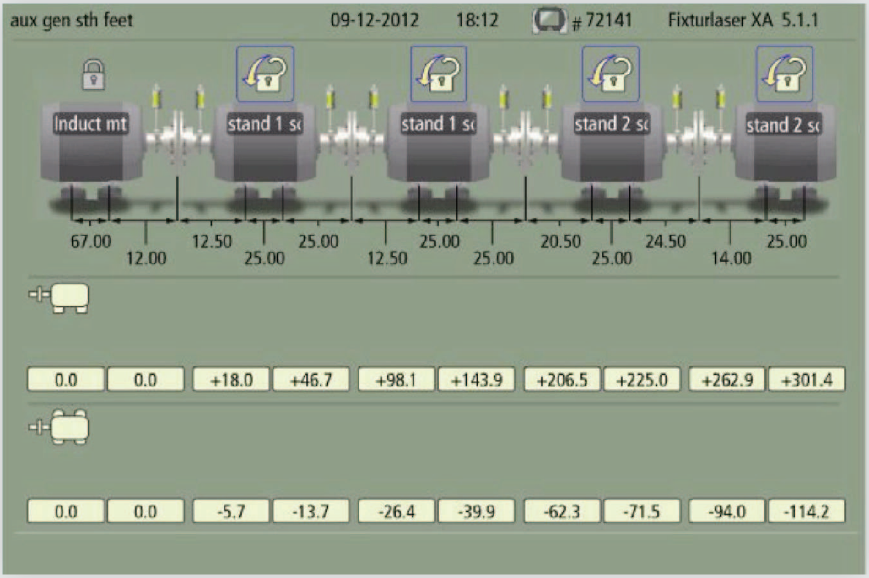
Best Fit coupling Values



Best Fit Foot Values

Now the south generator set needs to be assessed. Remember the induction motor has a shaft that connects to both the north and south stands. After measuring across four couplings, the results are a bit more interesting. The XA Pro has a default "Best Fit" solution that is displayed after the measurements are completed. There are two machines out of alignment (designated by orange values), both Stand 1 and Stand 2 Front Screw Down Generators. The best fit solution has the Stand 2 Front Screw Down Generator with the least amount of correction (shimming less than 90 mils). Let's not forget that the induction motor is also coupled with the north generator set and that is completely within tolerance. If the induction motor is moved, the north generator set will be out of alignment. The best solution (not necessarily the 'best fit') is to select the induction motor by touching the lock over the induction motor, and now the assessment can be done to see if there is enough movement both vertically and horizontally to meet the alignment specifications.

As seen in the report below, if the induction motor is now the "fixed" machine, the vertical and horizontal values are recalculated to show the corrections needed in this scenario. The farther away from the fixed machine, the more the correction. The horizontal adjustment will be easily met with a correction at the back foot of Stand 2 Rear Screw Down Generator (far right) of 114 mils. The vertical correction could be more dubious; but, there were over 500 mils of shims at both of the Stand 2 Front and Rear Generators and over 300 mils of shims for both of the Stand 1 Front and Rear Generators.



In conclusion, a machine train alignment can be completed with much less frustration if the proper tools are utilized. It is always better to see where you are before you start moving equipment around–plan your work then work your plan.

UNDERSTANDING THE NEED FOR OFFSET SHAFT ALIGNMENT

By Tom Shelton
January 22nd, 2014

While at facilities across the country I noticed a lack of understanding regarding the need for precision alignment of offset shaft-driven rotating equipment. I myself have seen electricians and mechanics alike becoming frustrated trying to determine the cause of speed fluctuations and vibration in offset shaft-driven equipment. Typical response is that the cause is electrical until proven otherwise. While this may be true in some instances, the cause for others may be excessive angular misalignment of the driven and driver machines.

An Offset Shaft, or Cardan Shaft as it is typically called, is a drive shaft, with u-joints, used to transfer power from a motor (driver) to a piece of equipment (driven). Offset denotes that the shafts of the driver and driven elements are not "inline" with each other. There can be any number of u-joints in a drive shaft assembly. A "single Cardan" shaft means there is a u-joint at each end of a shaft. A "double Cardan" refers to three or more u-joints in a shaft. A "single Cardan" shaft is what you will most likely encounter in the field.

There are two parts that must be understood, proper phasing and angularity of the input and output shafts.

1. Phasing refers to the position of the yokes that are part of the shaft. The two ends, or yokes, must be positioned parallel, or in line with each other. Failure to do this will cause the driven machine to speed up and slow down twice for every revolution of the driver. This will not only cause runability problems, but will cause high vibration issues.
2. The angularity of the input (driver) and output (driven) shafts in relation to the main shaft element must be equal at each end of the shaft. There are industry guidelines to establish the maximum allowable angle between the shaft and the yokes based on speed and load. The best place to get the proper information is from the machine manufacturer.

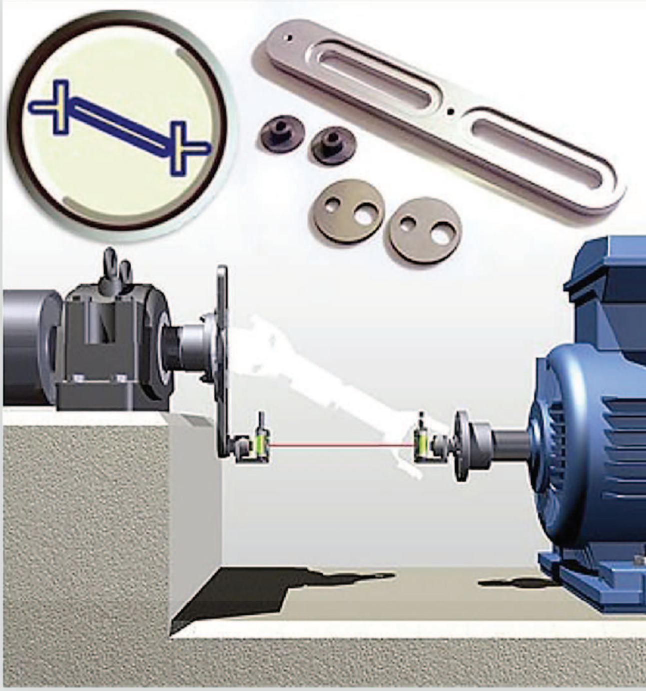
#2 is the alignment part of the job. The driven machine and the driver, when aligned correctly, will place the shaft ends in the correct position. That is, the angle of the yokes on both ends of the shaft will be equal when the driven and driver are on parallel planes in the vertical and horizontal axes. If you do not align the driver and driven machines, the speed of the driven machine will fluctuate. The worse the angular misalignment, the worse the speed fluctuation.

Offset Shaft alignments require specific shaft alignment equipment. Fortunately VibrAlign/Fixturlaser has you covered. The Fixturlaser XA is capable of doing this type of alignment using a special bracket set and alignment program.

After removing the Cardan Shaft the special Offset Fixture mounts across the coupling flange of the driven machine. One laser sensor is mounted on the precision rotating turret of the Offset Fixture with the other mounted on the driver. Misalignment data is collected by rotating the sensor on the Offset Fixture and the shaft/sensor of the driver.

Angular misalignment between the driven and driver machine shafts is displayed on the results screen for both the Vertical and Horizontal planes. (Example results shown in millimeters.)

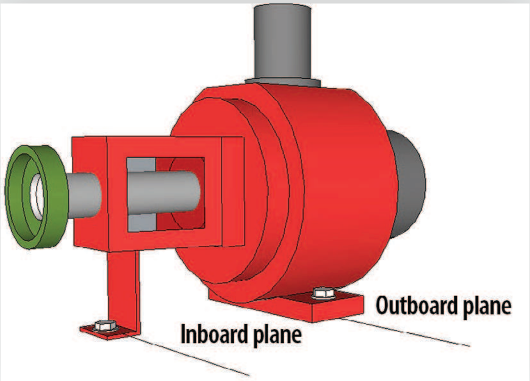
Vertical and Horizontal corrections are made as needed. When the Vertical and Horiztonal angular alignment is in tolerance the driven and driver machine shafts are now parallel and the angle of the yokes on both ends of the shaft will be equal.



ALIGNING MACHINES WITH 3 or 6 FEET

By Stan Riddle
February 28th, 2013

Some machines are not manufactured with a typical 4-footed configuration. Precision shaft alignment can still be easily accomplished on these "non-typical" machine configurations, if you remember a couple of simple rules.

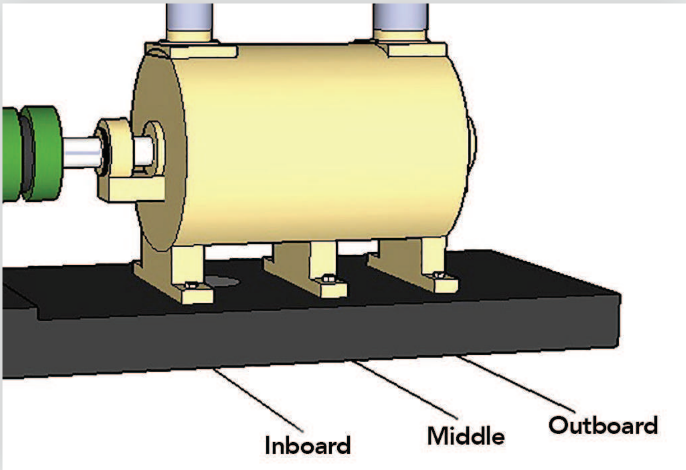


When aligning a machine with three feet, like this example, remember that you are positioning machinery in two planes:

The inboard, or drive end, and the outboard, or opposite drive end.

The outboard end will be treated as usual, and the inboard end will simply be shimmed and/or adjusted at the one foot.

When aligning a machine with six feet, another foot plane is introduced. The inboard and outboard feet will be treated the same as a four-footed machine configuration, but the middle feet (plane) can be corrected using this method:



After the inboard and outboard feet shim corrections have been made, simply use a feeler gauge to determine the amount of shim required to “fill in” under the middle feet. You can snug the inboard and outboard feet before making the shim correction to the middle feet.

On large machines, you may want to add an additional 2-3 mils of shim under the middle feet, to compensate for any “sag” due to weight.

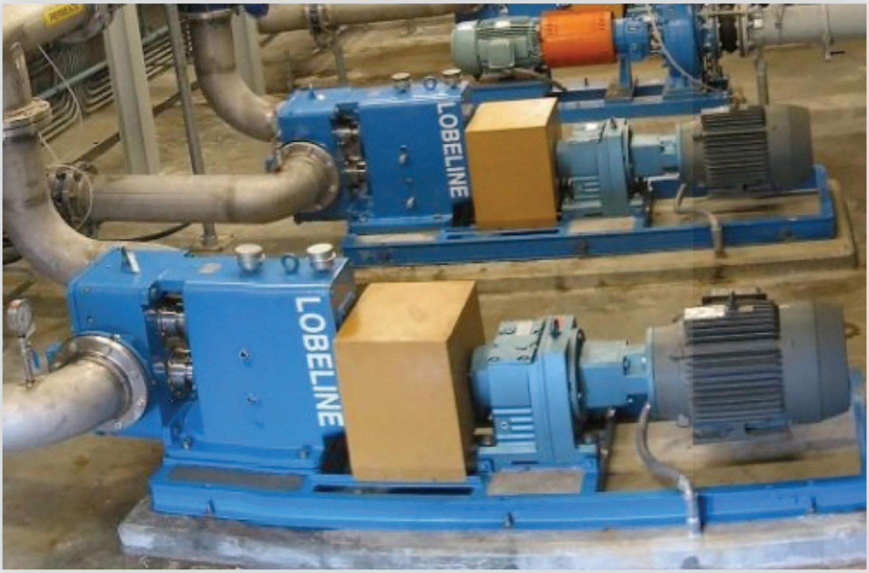
Some laser shaft alignment tools can calculate the middle feet shim requirement based on the distance from the center of the coupling to the middle feet. However, this calculation is based on the assumption that the base is completely flat, which often it is not.

On a “standard” machine configuration, the four feet establish a “plane.” But when two additional feet are introduced, you should not assume they are in the same exact plane.

SOFT FOOT CAUSED BY A C-FACE MOTOR

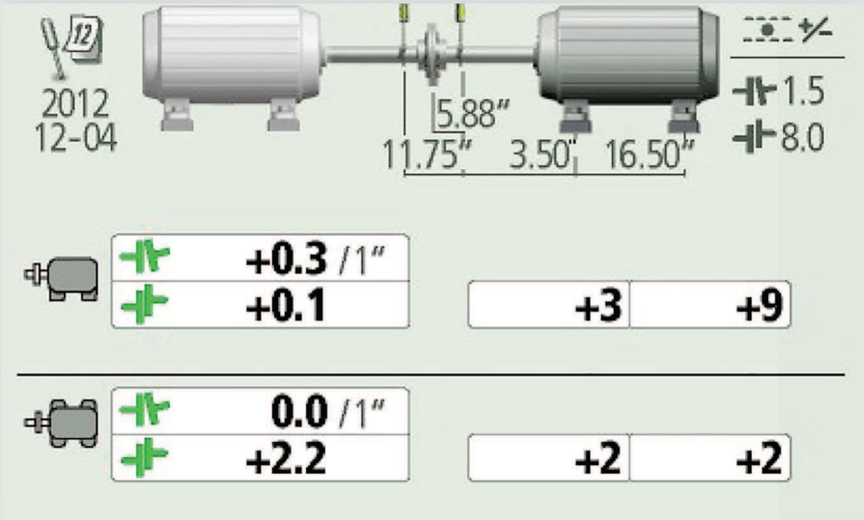
By Chris Troutt, BRI
February 12th, 2013

Our service group received a call from a water treatment plant in the western US for assistance to align a gearbox with C-face motor to a rotary lobe pump. After numerous failed attempts and multiple hours of frustration they had determined the gearbox to be Bolt-Bound.



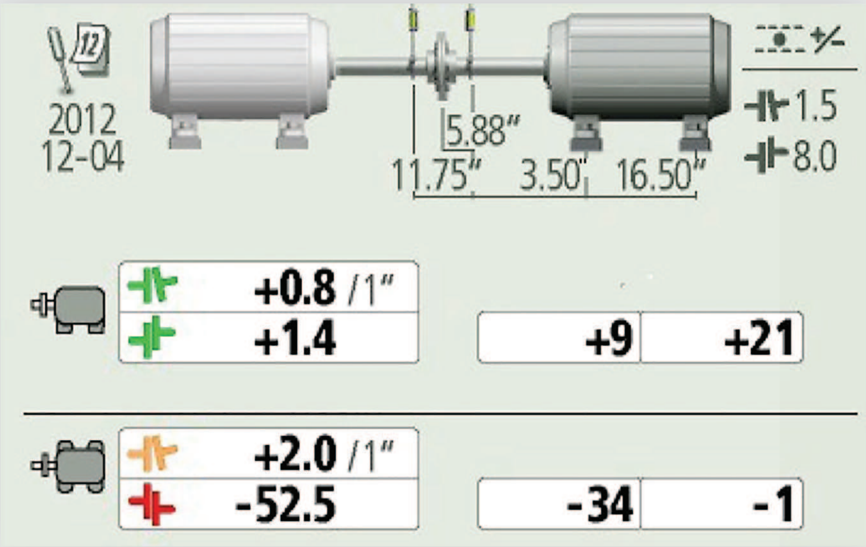
We were asked to bring turn down bolts and perform the final alignment. We packed up our Fixturlaser GO Pro and undercut bolts then headed out for some in-the-trenches training.

The Initial GO Pro readings found the gearbox to be within tolerance in the vertical plane, but out of tolerance in the horizontal plane with an angular misalignment of 2.0 mil/1" and offset misalignment of -52 mils at the coupling center.



We loosened the foot bolts and our tech immediately found soft foot at the feet on the low - speed side of the gearbox. We decided that the soft foot was caused by the gearbox rocking back and forth due to the overhung load of the C-faced motor. Knowing soft foot to be the undoing of many good alignments, we devised a way to keep it to 2.0 mil or less. We loosened the gearbox feet bolts just enough to allow for side-to-side movement of the gearbox, which kept the soft foot under 2.0 mils.

We utilized the live reading for our horizontal correction and left it "live" while we tightened the feet down in a cross torque sequence looking for any gross changes indicating the return of soft foot. It took us only two turns of the shaft to accomplish the alignment, but still accomplished it to an 1800 RPM tolerance in under 30 minutes!



We were also asked to align another rotary lobe pump and accomplished the shaft alignment in short order as well, since we had deduced a way to handle the soft foot. Both alignments took our techs less than an hour and a half, total time.

So in the end the gearbox was not bolt bound, but had soft-foot induced by the overhung load of the C-face motor causing reading inaccuracies. This inaccurate data cost our customer many man hours and 4 machined bolts, which of course weren't needed.

Being vigilant for soft-foot needs to carry through the entire alignment, not just during the "pre - alignment steps." If soft foot is not controlled, it will hamper even the most seasoned alignment technician.

THE SHAFT ALIGNMENT NIGHTMARE

By Stan Riddle
April 10th, 2013

Sometimes precision laser shaft alignment is a quick, neat, orderly maintenance task. And sometimes, it is not! Occasionally, everything that can be wrong IS wrong.

While teaching a Fixturlaser GO Pro training class in Illinois, the class went into the plant for some "hands on" shaft alignment work. The machine chosen was a 25 HP motor coupled to an overhung centrifugal pump. This pump was chosen because it had experienced numerous coupling, bearing, and seal failures. And so it began.

During a quick pre-alignment inspection, these problems were found:

- The pump front support foot was broken at one of the bolt locations.
- The pipe support was loose, and not supporting the weight of the discharge line.
- The flexible joint connector on the suction side of the pump was misaligned.

- The shafts had been running about 3/8" out of alignment in the horizontal plane. That's 374 mils of offset misalignment or about 93 times the 4.0 mils maximum allowable offset misalignment for 1800 RPM!

So, they went to work.

- The mechanics adjusted the discharge pipe hanger.
- They re-positioned the pump to alleviate the pipe strain on the suction flange.
- The motor base riser was cut loose with a grinder.
- A spare pump front support foot was not available, so it was decided that the foot would be usable as it was.

- The riser and base were ground smooth, and all mounting surfaces were cleaned with a brush to remove dirt and paint.
- The riser (with the motor still bolted to it) was repositioned, and tack welded into place. A rough alignment was done with a straightedge. The mechanics noticed that the motor was sitting too high, so the pump was shimmed a little vertically on the inboard feet.
- The riser was welded into place, positioned by using the GO Pro.
- The final precision shaft alignment was completed.

The next day, the maintenance managers commented that the pump had never run so smoothly. But there was one problem. The new oil seal was leaking, because it had been running in such a misaligned condition.

So, the moral of the story is? Just about everything that could be wrong, from a shaft alignment standpoint, was wrong. But, through a little patience, persistence, and using some common sense, all these problems were repaired in a couple of hours. And replacing the oil seal will alleviate the remaining problem.

DO VERTICAL PUMPS NEED ALIGNMENT?

By Brad Case
September 15th, 2011

Yes? No? Maybe? Yes!

You may have heard this in the past…"We can't align our vertical pumps since there is no adjustment due the 'machined fit' between the electric motor and pump housing. Plus it has a rigid coupling!"

You may want to rethink this one.

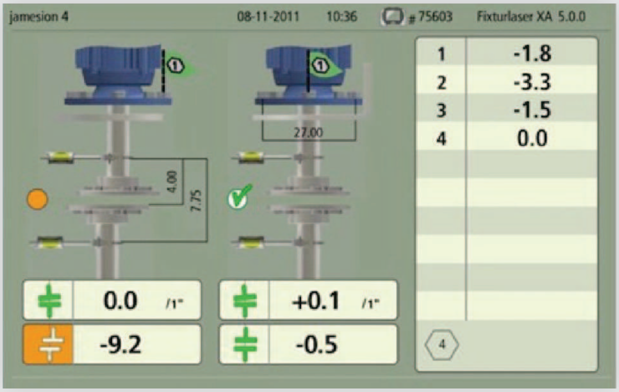
The OJT portion of a recent training class involved a large vertical Floway pump driven by an 800 HP GE electric motor, rotating at 1200 RPM, utilizing a rigid coupling with a piloted fit.

Since we didn't want the coupling and shaft stiffness to influence the alignment readings, the decision was made to remove the coupling bolts and rest the impeller in the pump bowl, treating the pump as a non-rotating shaft. The other option was to loosen the coupling bolts just enough for an approximate 0.050" gap between the coupling hubs, which would still allow pump shaft rotation but would have eliminated the coupling stiffness issue.

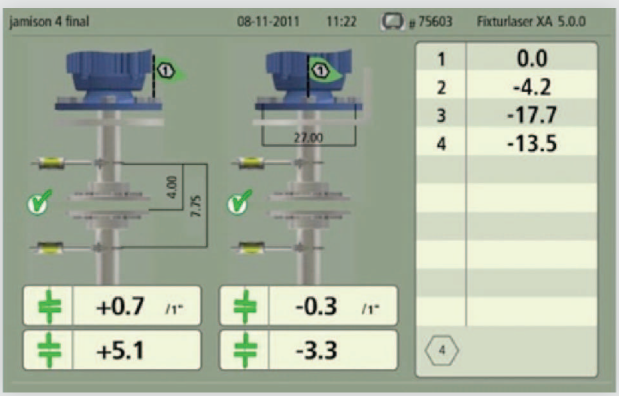
In this case the class wished to practice a non-rotating shaft alignment using the Fixturlaser thin magnetic brackets.

The sensors were mounted and alignment measurements were taken. The thin magnetic bracket with the S sensor on the pump shaft was moved to each measurement location, then the motor shaft with the M sensor was rotated to the same position before the measurement was registered. Note: When using the Vertical Alignment program in the XA, a bolt in the motor mounting circle is labeled #1. The alignment measurements are then registered with the sensors first pointed at the #1 bolt, second at 90 deg. and third 180 deg. from the #1 bolt.

For 1200 rpm, the allowable angular misalignment is +/-1.0 mil/1" with an allowable offset of +/-6.0 mils at the coupling center. The initial alignment results revealed the offset misalignment (as viewed from 90 deg. to the #1 bolt) was out of tolerance. The other coupling values were within tolerance.



The four motor hold down bolts were loosened with the XA monitoring the moves in real-time and the motor was pushed from right to left (as viewed from 90 deg. to the #1 bolt) to correct the out of tolerance offset misalignment. Yes–there was clearance in the “machined fit.” The motor hold down bolts were tightened and a fresh set of alignment measurements were taken and the results analyzed.



All coupling values were now in tolerance. 46 minutes from “As Found” to “Final”!

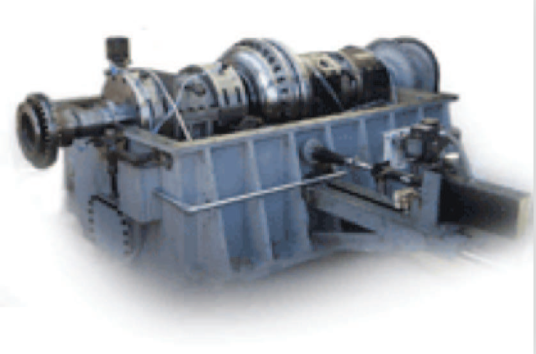
SHAFT ALIGNMENT WITH A FLUID COUPLING

By Steve Matthews
June 17th, 2012

Last week, a customer asked me how to do a laser alignment on a fluid coupling. This question comes up occasionally, so I thought it would be a good subject to address here on thealignmentblog.com. First, it would be helpful to define "fluid coupling." Fluid couplings transmit power from a driving shaft to a driven shaft on the principle of hydrodynamic power transmission–the shafts are not connected mechanically. In fluid couplings, two bladed wheels face each other: a pump wheel on the driving side, and a turbine wheel on the driven side. The cavity or "working circuit" is filled with a fluid. The rotation of the pump wheel causes the movement of the fluid which drives the turbine wheel. These coupling types are referred to by many terms such as fluid couplings, fluid drives, fluid drive couplings, hydrodynamic couplings, hydraulic couplings, clutch couplings, etc.

Fluid couplings have many uses in a variety of industries. For the purpose of a shaft alignment discussion, we will focus on two basic types. Type 1 in which the shell is supported only by the shafts, and Type 2 in which the shell is supported by a set of bearings in a housing.

Type 1 Fluid Coupling



Type 2 Fluid Coupling

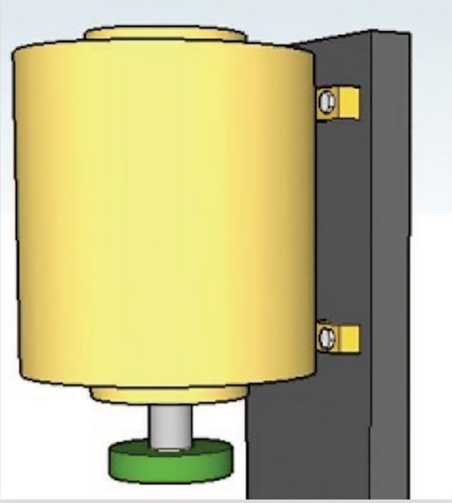
For fluid couplings supported by their own shafts (Type 1 picture), the shaft alignment application is a standard horizontal alignment of two shafts. The challenge is fixturing. As seen in the picture, the very simple solution is to use extension rods so that the laser alignment system sensors extend far enough above the fluid coupling shell to take measurements. Magnetic fixtures attaching to the coupling (shell) generally do not work for these applications. In this picture, submitted by a customer, you can also see that they use a magnetic base as a steady rest for the laser heads. This alignment is often done in the same way you would do an "uncoupled" alignment because the shafts will rotate independently. Remember, with fluid couplings there is no mechanical connection between the shafts. The customer who submitted this photo does this alignment as a coupled alignment because they have a pin or bolt that is used to connect the two shafts so that they rotate together.

Fluid couplings supported by bearings (Type 2 picture) are a different application. In this case, the fluid coupling is considered an independent machine element. It will be connected to the driver with a mechanical coupling, and to the driven with a mechanical coupling. Therefore, the fluid coupling itself is not the alignment to be done. The alignment is from the driver to the fluid coupling input shaft, and from fluid coupling output shaft to the driven machine. This can be done as a machine train application but more likely it would be done in sequence – first aligning the fluid coupling to the driven machine (possibly a gearbox), then next aligning the driving machine (Motor) to the fluid coupling drive.

Precision alignment is particularly important for fluid coupling machinery for different reasons than mechanical couplings. Proper alignment is imperative to ensure performance (transmission of rotational speed), and to ensure proper sealing so that the hydraulic fluid does not leak from the shell.

SHAFT ALIGNMENT OF A VERTICALLY-ORIENTED MOTOR WITH FEET

By Stan Riddle
July 22nd, 2012



Vertically-mounted motors that are coupled may need alignment, whether they are C-faced or not. In cases where the motors are not C-faced, the shaft alignment is treated as a horizontally-mounted motor, with a couple of exceptions.

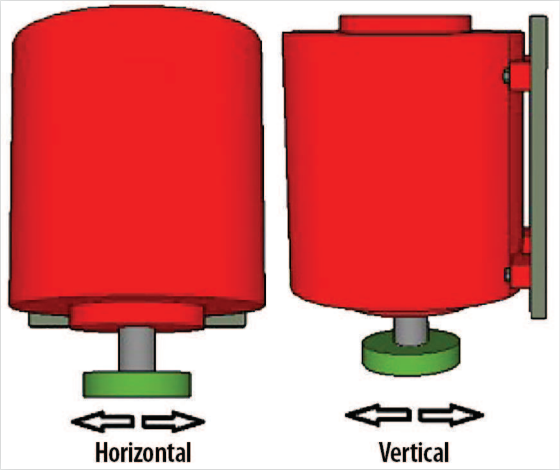
Here's a quick walk-through on a Fixturlaser GO Pro.

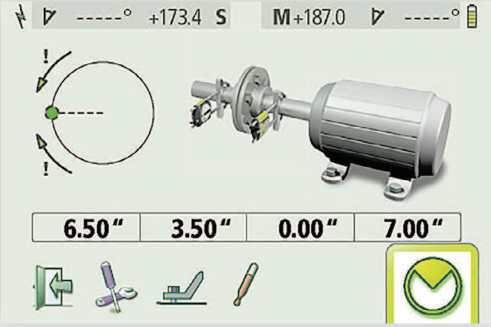
1. Inclinometers cannot be used, since they cannot detect changes in the shafts as they are rotated (they work against gravity). In this configuration, they are always horizontal.
2. The Live Mode function should not be used when making corrections in what would normally be thought of as the vertical correction. This is due to the fact that as the motor bolts are loosened, the motor tends to lean away from the baseplate.

Step 1 – Mount your laser tool to the shafts. Choose horizontal alignment. Select the proper speed and insert your dimensions as you would normally.

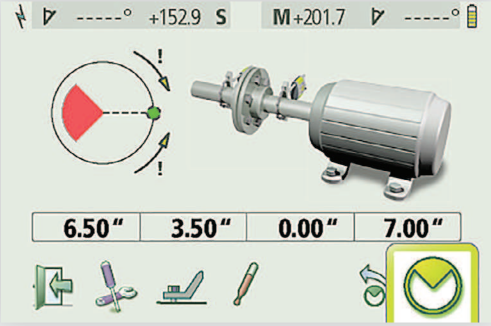
Step 2 – Select the Toolbox and select the icon to turn inclinometers off (see image at right). After this alignment is completed and saved and you have returned to the Main Screen, the inclinometers will go back to normal operation.

Since your inclinometers have been disabled, you must find another point of reference. The easiest way to picture this is that in the case of this shaft alignment, "vertical" is in the direction of the feet bolts, and "horizontal" is parallel to the base plate. An easy way to use this reference is by using a square to sight vertical and horizontal directions.

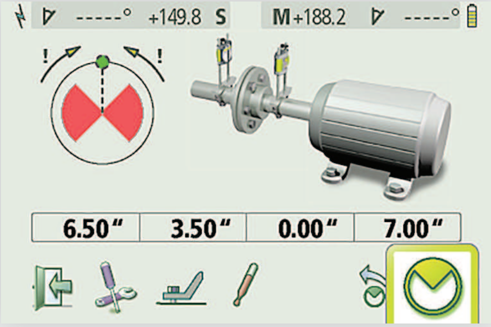




Step 3 – Measurements will be taken in Clock Mode. The first measurement will be taken at the 9 o'clock position. To orient yourself, picture yourself above the motor, leaning over the top. 9 o'clock would be on your left. Take the first measurement here.

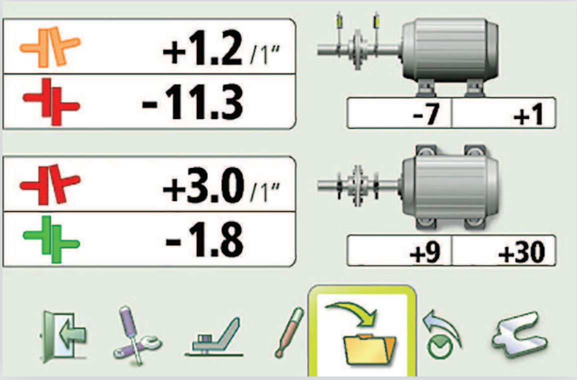


Step 4 – Rotate the shafts 180° to the 3 o'clock position and take the second measurement.



Step 5 – The final reading will be taken with the shafts rotated to the 12 o'clock position.

Measurements are now complete.



Step 6 – Add or remove shims to correct the vertical as given on the results screen.

Gently snug the feet bolts and rotate the shafts to the 9 o'clock position. Live Mode can be used to monitor the horizontal moves.

Re-measure.

Facing an alignment problem that is out of the ordinary? Know of any other applications where this same method will work?

ALIGNING MACHINES MOUNTED ON CHOCKS

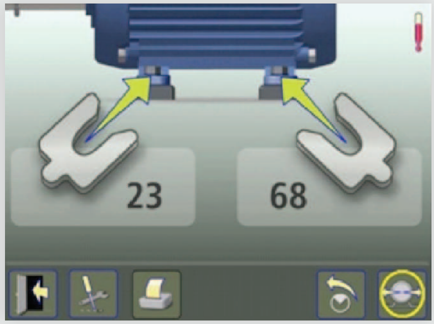
By Brad Case
October 27th, 2011

"Our large machines use adjustable chocks, instead of shims, for correcting the vertical alignment; can we use the VibrAlign Verti-Zontal Compound Move with our Fixturlaser XA when correcting the misalignment?"

Absolutely!

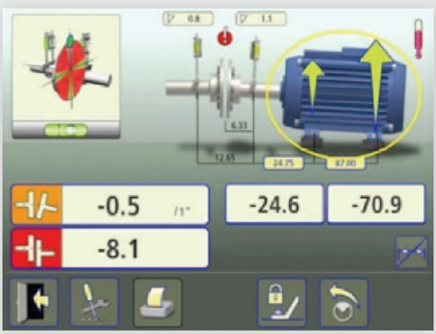
Adjustable chocks are typically found on large machines such as the engine-compressor sets used in the gas compression industry. The chocks are used in place of shims at the equipment feet and require the alignment technician to perform the vertical adjustment "live."

The Verti-Zontal process is modified slightly by taking the three alignment measurements from top to bottom (12 o'clock, 3 o'clock and 6 o'clock, for example) vs. side to side (9 o'clock, 12 o'clock and 3 o'clock) as when aligning a "shimmed" machine. After the results are analyzed press the shim icon as you normally would and note the feet position. This is the vertical position of the movable machine at the feet **BEFORE** the hold down bolts are loosened. Then press the live adjustment icon.

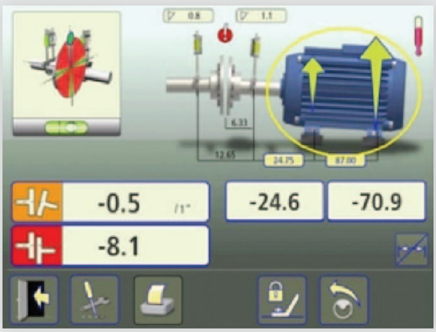


Since the 3rd alignment measurement was taken in the vertical plane, the live screen now shows the vertical view. After the hold down bolts are loosened note, if any, the change in the foot values as you will need to compensate the "live" vertical adjustment by this amount. (Remember the true vertical position of the movable machine is with the hold down bolts tight).

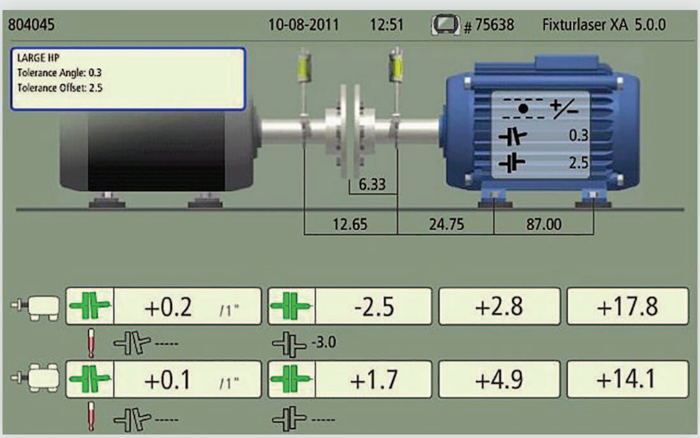
Perform the vertical adjustment, per the adjustable chock manufacturer's recommended procedure, until the vertical alignment meets tolerance. Leave the hold down bolts loose or slightly snug.



Rotate the shafts to a horizontal plane following the same direction of rotation the alignment measurements were taken in. The XA's screen will automatically change to the horizontal view. Correct the horizontal misalignment, then tighten the hold bolts in a cross torque pattern in three passes. Then re-measure.



If further minor adjustments are required to meet the vertical and/or horizontal tolerances, do so accordingly; however, remember the sensors need to be in the plane you are correcting as both the vertical and horizontal corrections are done live with adjustable chocks. Once the alignment meets tolerance, document it by saving.



ALIGN A COOLING TOWER IN UNDER AN HOUR

By Stan Riddle
February 7th, 2012

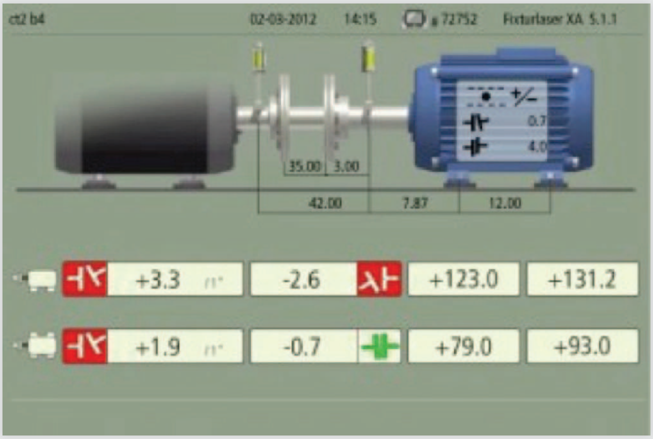
Aligning cooling towers with spacer shafts can sometimes present a challenge. We recently provided alignment training and assistance to the HVAC Group at the Federal Reserve Bank in Richmond, VA.

This was a Marley cooling tower, with a 60 HP motor, connected to the gearbox by a 48″ spacer shaft.

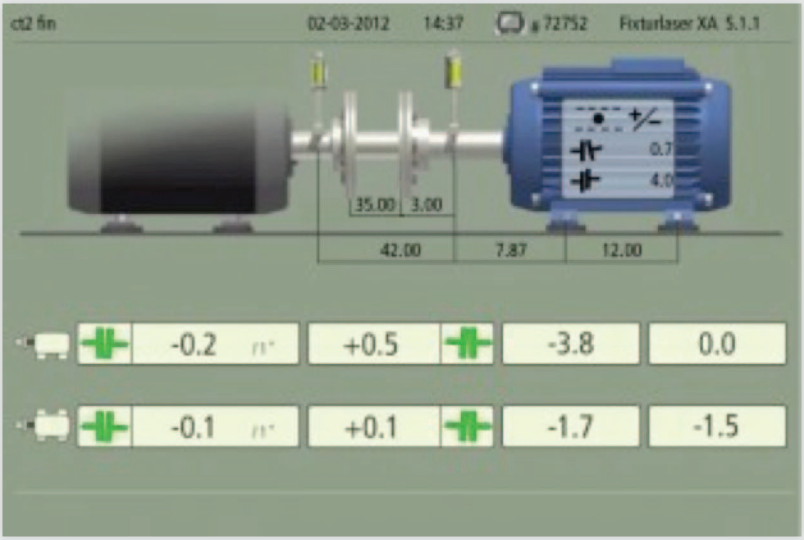
That's me, the trainer, inside the fan. The mechanics are using their Fixturlaser XA, and telling me how to shim up their gearbox. How often do you get that from a trainer?

The motor had recently been changed to an inverter-duty motor, in preparation for installing variable speed drives on this tower.

The initial measurements showed that the motor was sitting about 1/8″ too high. There were no shims under the motor, so it could not be easily lowered.



Using Live Mode, and employing the Verti-Zontal process, we shimmed the gearbox up vertically to correct a base-bound problem, twisted it horizontally a bit to correct a bolt-bound problem on the motor, and completed vertical shimming of the motor to align it to the gearbox.



Total time to align – 22 minutes!

Align a cooling tower – in under an hour? That's Verti-Zontal power!

SAVING TIME AND MONEY

Planning ahead is a major part of proper alignment practice. By using the proven techniques outlined in this chapter, your alignment job will be quicker, smoother, and yield better results.

THE IMPORTANCE OF ROUGHING-IN MACHINES BEFORE PERFORMING A SHAFT ALIGNMENT

By Brad Case
January 24th, 2013

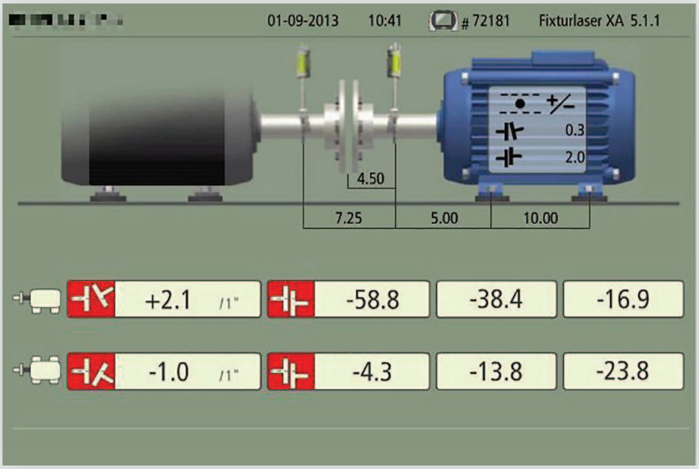
During our Best Alignment Practices Training classes our staff of VibrAlign Trainers stresses the importance of rough aligning the machines as part of the pre-alignment steps. The main reason to do so is to minimize the coupling influences on the movable and stationary machines' rotational shaft center-lines so the final alignment can be completed with as few moves as possible using the VibrAlign Verti-Zontal Compound Move®.

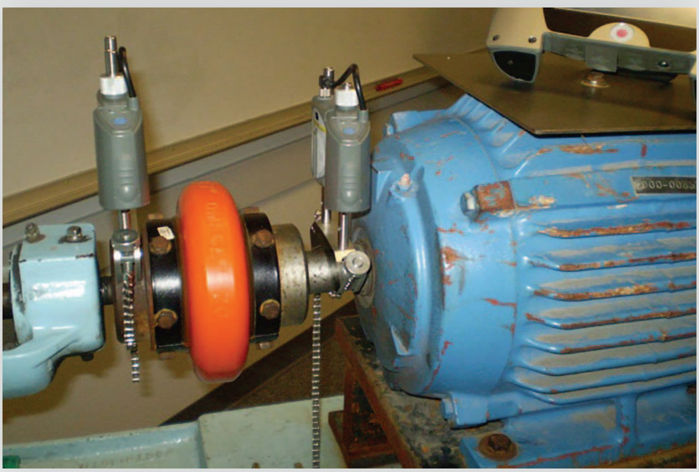
When two machines are grossly misaligned, even flexible couplings can influence the alignment readings whether you are using dial indicators or a laser shaft alignment system. The question that does come up in class is "how much can the coupling influence the alignment readings or results?" The answer(s) are as varied as there are coupling types and machine designs.

As Stan stated in his January 10, 2013th blog post "Flexible Couplings and Flexible Shafts" this problem "in no way lays blame on the coupling or machine design." It is simply a fact of life an aligner needs to be aware of and deal with accordingly.

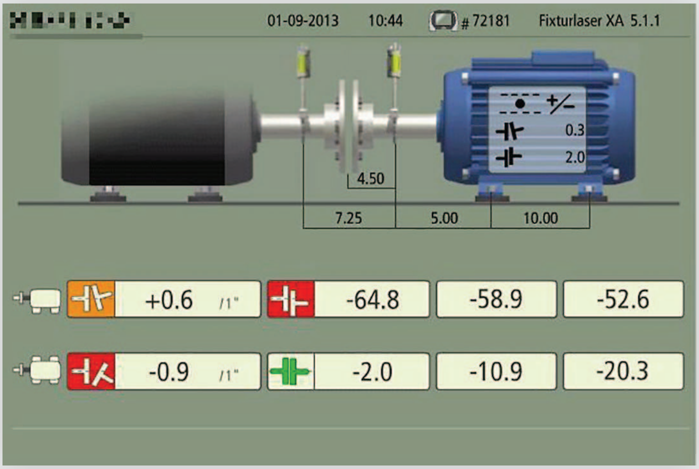
So how much can a coupling influence the alignment? Good question! I recently had the opportunity to experiment with a 30 HP pump and motor set with a "tire" style flexible coupling. All shims were removed from under the motor feet and 3 sets of measurements were taken. 1st with the coupling assembled, 2nd with one half of the outer cover removed and 3rd completely uncoupled. The differences between the 3 measurements are very enlightening!

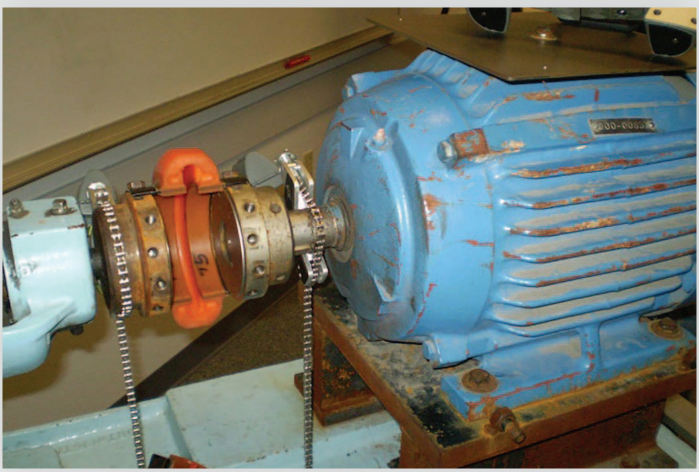
Results with coupling outer covers in place.



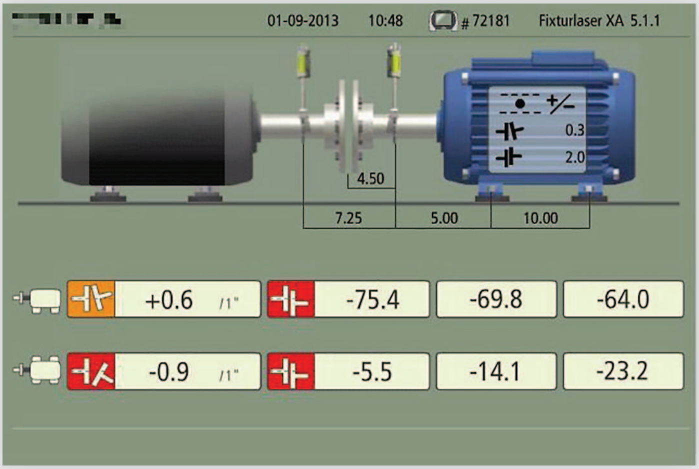


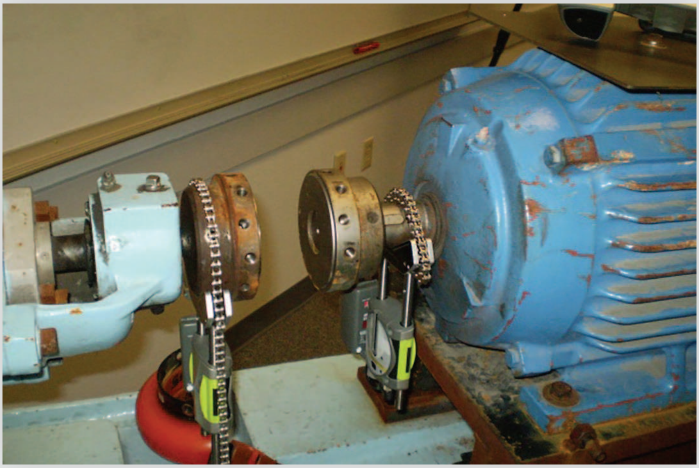
Results with one half of the outer cover removed.





Results uncoupled.





When comparing the “coupled” measurement to the “uncoupled” measurement it is obvious the coupled set isn’t close to the true vertical position of the motor to the pump as indicated by the uncoupled set. In this case the flexible coupling and gross misalignment, together, are influencing the Vertical Angle by 1.5mils/1”, the Vertical Offset by 17 mils, the front foot by 31 mils, and the rear foot by 47 mils!

If your 1st set of vertical and horizontal corrections doesn’t give you the expected results, by a large disparity, take a small step back and rough in the movable machine to the stationary machine, uncoupled if necessary. The few minutes you take to do so can save you a lot of time and frustration during the final precision alignment

PRECISION SHAFT ALIGNMENT AND ENERGY CONSUMPTION

By Steve Matthews
February 25th, 2014

It has been a long-standing belief amongst maintenance and reliability professionals that electric motor energy consumption must be less when rotating machines are precision aligned vs. when misaligned. There have been several studies on this subject that have shown varied results, from 1% to as much as 10% less energy consumption for a precision aligned machine.

In the opinion of this author, energy savings specifically due to alignment are quite difficult to quantify, particularly in the testing or laboratory environment. Although it does make intuitive sense, if a machine has less stress and strain to overcome due to misalignment, power consumption should also be less. However, in the field, there are many variables in play that may affect power consumption such as motor efficiency, load, VFD's, coupling type, proper installation, proper lubrication, state of component wear, proper design for service, etc.

Recently, I had an opportunity to actually measure the energy consumption of two identical pump sets before and after precision shaft alignment. The new Chilled Water Pumps were each driven by 75 HP electric motors. The power consumption data was taken before and after alignment at identical speeds (CWP 1 VFD = 46.6 Hz; CWP 2 VFD = 47.3 Hz) and load (all three pumps on the Chilled Water Loop were in operation).

CWP 1 power consumption decreased by 8% (5.7kWh) and CWP 2 power consumption decreased by 2.5% (1.7kWh). In order to estimate cost savings for the reduced energy consumption, we have to make a couple of assumptions. For the sake of discussion we will assume these machines consume power at this rate for 80% of the year at an average electricity rate of 7 cents per kWh. Using these assumptions, CWP 1 cost savings is $2,796/year and CWP 2 cost savings is $834/year. The formula for cost savings used in this example is: Reduction in consumption (kWh) X 8760 hrs./year X 80% X $0.07 (kWh rate).

Full disclosure: these machines were found to be substantially misaligned. The units were shipped on a skid that was only rough aligned at the factory. Final alignment was left to precision tolerances of less than 0.5 mils/inch angularity and 2.0 mils offset. Despite having made such substantial improvement in the alignment condition, the comparison is still valid. We often see these types of machines, especially HVAC pumps, with severe misalignment. Many times this is a result of reliance on factory alignment on a pump skid, or use of a straight edge only for field alignment.

While this data does not represent a large sample size, it would appear to support the theory that precision alignment can contribute to reduced energy consumption. For the particular client site, where this data was taken, there are at least 36 similarly sized units (and many smaller units). If we apply the lower amount of the two cost savings (2.5%) to this population of machines, the potential energy cost savings for simply precision aligning 36 pumps could easily exceed $30,000. Suddenly we are talking about real money!

30-MINUTE ALIGNMENTS

By Stan Riddle
June 20th, 2011

One of our trainers recently taught an XA Pro class at a large chemical company in Western Kentucky. Normally, our training classes consist of one day of classroom training, and ½ day of field alignments done by the students.

During the field alignment part of the class, the students aligned four overhung pumps, rated between 50 to 100 HP, in two hours. This included lockout/tag out, removing guards, alignment and replacing guards.

Student comments included:

- This XA makes alignment so easy, it doesn't even seem like work!
- We can align faster than the electricians can wire up the motor!
- Even old guys like me can use this!
- If I follow the training, and get rid of the soft foot, (the alignment) goes exactly like you said it would!

Express Alignment—there's a reason for the name!

PRE-ALIGNMENT STEPS SAVE $$$

By Stan Riddle
April 15th, 2010

There are many types of tools with which we can perform an accurate shaft alignment. For most of us, laser alignment is considered the most accurate and effective. But shaft alignment can be done with reverse dial indicator sets, or dial indicators and chain-type brackets, or a straightedge, feeler gauge, and an outside caliper. I've even done it with a carpenter's level, a stack of shims, and a flashlight. Some of these methods are much faster and more accurate than others, but all of them can be used to achieve a reasonable degree of shaft alignment.

I want us to look at some easy things that can usually be done in 15 minutes or so, and can make shaft alignment faster, and more effective, regardless of the method employed.

THE KEY TO GOOD ALIGNMENT IS GOOD PREPARATION

DON'T MAKE ASSUMPTIONS

Just as you should never assume that proper lockout/tag out has been implemented, never assume that the equipment is properly aligned, even if you did it the last time. Structural and thermal changes can occur in the machine components, their piping or ductwork, and the machine bases, which can cause changes in alignment over time. And there is a possibility that it was not aligned correctly the previous time.

If the machine is new, don't assume it was properly aligned by the installers. And never assume that a machine came from the factory aligned. Even if it was truly aligned when it left the plant, it can change during the ride to your facility, and while being installed.

KNOW WHAT YOUR OBJECTIVE IS

All too often, shaft alignment is based on the coupling manufacturer's recommendations. These recommendations are not for alignment of the shafts—they are the maximum misalignment allowed by the coupling manufacturer. They do not take into account the excessive forces placed upon the component's shafts, bearings, and seals, which often lead to premature component failure.

Ask the maintenance supervisor or the plant engineer what the component alignment tolerances are. If applicable, use the component manufacturer's recommendations for alignment. If none are available, consult with the engineering department, or your alignment tool representative.

In addition, there are thermal and dynamic forces which can act upon the components being aligned. Thermal growth values and dynamic forces should be determined, and compensated for, before precision alignment can be achieved.

VISUAL INSPECTION

Once the machine has been properly locked and tagged, and all sources of energy have been controlled, remove the coupling guard, and make the following visual inspections.

- Are the hold down bolts tight on both the stationary and the movable component?
- Are the couplings mounted correctly?
- Are the set screws tight?
- Does the axial spacing between the coupling flanges appear to be correct?
- Can the shafts be rotated?
- Is there excessive backlash noticed in the coupling? Is it due to wear? Should the coupling insert be replaced before alignment is performed?

- Does pipe strain exist in the system, especially near the components to be aligned? Perform a quick visual inspection of the piping system to determine if pipe hangers or other supports are installed correctly.
- Is the machine base structurally sound? Do you notice large cracks in the grout or broken welds in the base?
- Is the machine base mounted solidly to the floor or support structure?
- Have jacking bolts been installed on the machine? Make sure they are not touching the component feet before performing aligning.

HAVE YOUR TOOLS IN PLACE

Have the correct hand tools, shims, and measuring devices in place before you begin the alignment process. This will make the shaft alignment faster. It often makes it more accurate as well, since you can usually complete the process with minimal interruption.

PRE-ALIGNMENT CHECK FOR SOFT FOOT

Once the machine has been properly locked out, before loosening any foot bolts, do a quick soft foot check of the feet of both the stationary and the movable components. Using a 0.005" shim or feeler gauge, try to insert the shim under the component feet. Measure for soft foot at three corners of each foot, if three corners are accessible.

If the shim will go halfway to the bolt, under any corner, make a quick note of which foot, or feet, are "soft." A more thorough soft foot check will be done next.

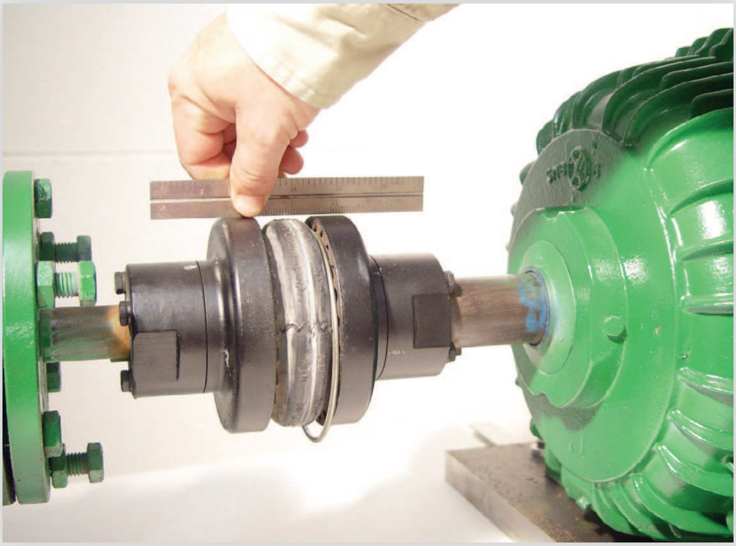
ROUGH CORRECTION OF SOFT FOOT

Loosen all foot bolts on the movable machine. Using a pry bay, apply slight lifting force under the foot, and measure for soft foot with a shim, or feeler gauge. Add shim as needed to correct for soft foot. Then continue on to the other feet on the movable machine, until a 0.002-0.003" shim or feeler gauge cannot be inserted under the foot.

Be mindful of an angular soft foot. If a movable machine foot has an angular soft foot, you may have to cut a partial shim or shims to correct for angular soft foot.

ROUGH ALIGNMENT

This process is often overlooked by mechanics, but it can save time in achieving precision alignment, and help to reduce gross errors in the alignment process.



Using a straightedge, check the tops of the coupling flanges for parallelism. If a gap exists while checking for parallelism, measure the gap with a shim, or feeler gauge. Insert the measured amount of shim under each of the movable machines to bring the components into rough vertical alignment. Repeat the procedure on the sides of the coupling flanges to correct for rough horizontal alignment. Be sure to tighten the feet of the movable machine back down before beginning alignment.

After completing the rough alignment process, you are now ready to begin alignment.

PERSISTENCE PAYS!

By Chris Troutt, BRI
April 11th, 2012

Not too long ago I was called to one of our sister shops to perform a laser shaft alignment on a 3600 RPM skid-mounted end-suction ANSI pump. Easy, right? Honestly, I made a few mistakes right off the bat:

1. Thinking this would be easy (and starting right before quitting time).
2. Taking for granted that all surfaces had been properly cleaned and inspected.
3. Not doing all the steps that I have been taught and the same steps I teach our techs.
4. Not asking why it was in for repair.

I performed a quick pre-alignment, mounted the equipment and took a reading. The motor needed to come down over 200 mils and move horizontally 406 mils. I wasn't expecting that. So we took another set of readings with the same results. A quick look at the coupling did not show it being off this much.

So I stepped back and thought….."What am I missing?"

I wanted to ensure we did not have a laser issue, so we mounted the laser alignment equipment to a piece of stock in a lathe and took some readings. All repeated, three times in succession, so no laser issue! I inspected the shaft and coupling run outs, and did a thorough visual inspection of the entire unit. I pulled the pump off the base, cleaned rust from the base feet, scrapped off a coating on the base, and did the same to the motor. Next I removed both the couplings, looked for burs/dings on the fits, faces and bores, ensured a slip fit on all coupling hubs, key-ways, and bores. Then I replaced all bolts with new hardened bolts and flat washers – no lock washers! I did soft foot checks on both motor and pump uncoupled from each other, and did find some in the pump. I tightened everything down using a three-pass method, did a final soft foot check, and started a fresh alignment.

This alignment check indicated the motor was 101 high in the front and 103 high in the back, and the horizontal was out 45 in the front and 98 in the back. I made all corrections in about 15 minutes, with one spin of the shaft. Final readings were well within a 3600 spec!

Lessons of the day…

1. Always check for yourself. Your idea of "ready for alignment" may not be everyone else's.
2. Don't overlook all the alignment steps; sometimes it takes a little more than a couple soft foot checks and a torqueing sequence to get an alignment to go well.
3. After seeing the old coupling, I knew why it was in for repair! It had worn off the original teeth and had cut new ones 3/8" below where they should have been. This thing had serious trouble in its alignment!
4. Here is the biggie! Don't let it get you frustrated; back up, take a breath, and cover the basics we all know. Most of the problems we see can be eliminated through simple fixes.

I am not sure what part of my "basics" check list eliminated my trouble spot, but through all of that I got the bad actor out of it!

From VibrAlign – Special thanks to Chris Troutt, Reliability Analyst at BRI (a Cogent Company based in St. Louis, MO) for a great blog post! We want to encourage any of our readers to post comments, questions, case histories and ideas to the blog. We'd love to hear what you have to say!

RETURN ON ALIGNMENT– ENERGY SAVINGS

By Michael Keohane
April 20th, 2012

Although the benefits of precision shaft alignment are well known to companies that do have a good shaft alignment program, it remains a fact that many machines are still not precision aligned. This can be attributed to difficulty in figuring out the return on investment. It is difficult because good alignment practices lead to cost avoidance. This is much harder to measure than cost of acquisition. While most organizations know their overall cost of maintenance, they do not know such critical things as meantime between failure and the total cost of operating an asset. It is not always easy to figure out.

Energy savings for shaft alignment are seemingly easy to measure but the source of some controversy because the savings are difficult to pin down to shaft alignment. Some studies show energy savings of 3% – 10%:

Precision Alignment Provides Big Reductions in Electricity Consumption

- Reliability Magazine May/June 1995, Gord Cybolsky & Pat Pathn, Accuride Canada

Reducing Power Loss Through Shaft Alignment

- P/PM Technology October 1993, Ming Xu, et al.

Other studies indicate that perhaps the energy savings are not that great:

No Significant Measurable AMP Correlation When Brought from Coupling Tolerance to Precision Alignment Tolerance

- Rotating Machinery Energy Loss Due to Misalignment, Energy Conversion Engineering Conference 1996,Gaberson and Cappillino
- Motor Shaft Misalignment vs. Efficiency Analysis, P/PM Technology October 1997, J. Wesley Hines, et al.

Even these studies showed energy savings do exist but are closer to 1%-1.5%. So here's the question: is a 1% energy savings significant?

Here is an example:

- 1% drop on a 480 volt motor running 8400 hours/yr drawing 50 amps (~40hp) with a cost of $0.07/kWhr
- kW Reduction = (480V)(0.5A)(0.92PF)(1.732)/1000
- 0.38 kW reduction
- Total Savings = 8400 hours/yr x 0.38kW drop x $0.07/kWhr = $225 for this one machine
- Total Plant savings for 50 machines, averaging 50A, if 50% are misaligned
- $5625/yr

The assumption is a 1% energy savings is a 0.5A drop on a total of twenty-five 50A motors. In addition, we assumed this savings was realized on 50% of the machines since historically misalignment is the root cause or premature failure of around 50% of the assets.

The conclusion is that energy savings can be realized through precision alignment in even the most conservative estimates. Would these savings alone be enough?

OL2R – THE TRUE MEASURE OF A MACHINE'S MOVEMENT

By Tom Shelton
December 11th, 2014

OL2R is the acronym for OffLine 2 Running. OL2R is an optional program and special precision bracket set that is available for the Fixturlaser NXA Pro & Ultimate (also XA Pro & Ultimate). This option allows the shaft aligner to accurately measure vertical AND horizontal changes of machines from a static (OffLine) position to a Running position.

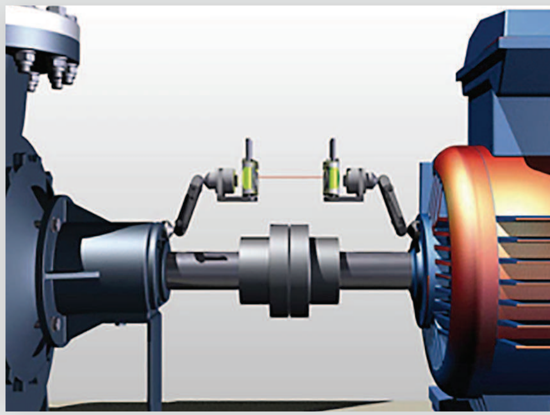
This allows for very precise targeting of rotating machinery during a shaft alignment while the machines are OffLine. When a precision shaft alignment is performed, the goal is to have the rotational centerlines of the machines collinear when in a running state. Due to dynamic forces such as thermal growth or shrinkage, piping influences, and/or process pressures, the position of the machine's rotational centerlines can change from the aligned static position to the operational position.

If known changes to a machine are going to occur from a cold static position to a running position the machines are aligned based on the given targets such as thermal offsets. When targets are used, they must be calculated or supplied to the mechanic from any number of sources, usually a plant engineer or reliability specialist, but where do they get this information?

Usually from manufacturer-supplied data or calculations of some type which are typically only for changes in the vertical plane. When using the OL2R program and brackets you get REAL data regarding position changes for the specific machine(s) in question. Not only will you see any vertical changes in position, but you will also discover horizontal changes that you may not be aware are occurring. This will definitely impact the reliability of this piece of equipment, and isn't improving equipment reliability what we are trying to achieve?

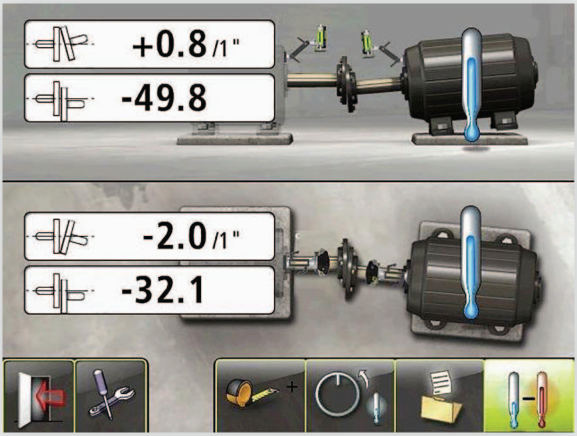
The way the OL2R system works is very simple;

1st – Mount the OL2R brackets to the stationary and movable elements of your machine. Make sure that you are able to replace coupling guards without disturbing the brackets.

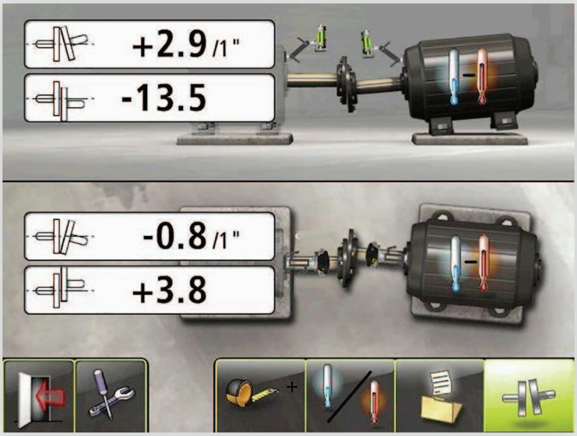


2nd – Take the "Live" hot reading with the machines at full running state, up to temperature and under common load and save it. The "Hot" Position will be displayed. Note: this is not an indication of the actual hot alignment, but simply a known "Hot" Position. (You can also start by taking the "Cold" readings first.).

3rd – After allowing the machines to cool to ambient temperature take the cold readings and save it. The "Cold" position will be displayed. Note: This is not an indication of the actual cold alignment, but simply a known "Cold" Position.



4th – Once these measurements have been saved, the NXA will compare the Cold minus Hot readings and display the REAL Targets needed to compensate for dynamic changes from Offline 2 Running. The Targets are then saved for future shaft alignments. At this point you can align the machine as indicated by the procedure. Simply touch the coupling icon and align the machine. You will now have a true precision shaft alignment.



This is a much-abbreviated explanation of the OL2R process. With training and practice this process can yield very positive results for your company or customers.

To find out more about Thermal Growth and OL2R checkout the "On Demand" Webinar hosted by VibrAlign's Stan Riddle and Mike Keohane, entitled "Hot Alignment & Thermal Growth." The Webinar steps through 4 ways to deal with thermal growth target values when performing a shaft alignment!

1. Inputting thermal growth targets as provided by the engineering department,
2. Using a Hot Check to measure the thermal growth and set targets,
3. Using the free ThermAlign app to calculate the thermal growth targets, and finally,
4. Measuring the thermal growth, as well as dynamic changes in machinery, using OL2R software and fixtures.

To see the recorded "On Demand" version of the webinar please visit our sponsoring partner, Plant Services. Click the "On Demand" tab and scroll to the bottom of the list of webinars and you will see "Hot Alignment & Thermal Growth." Click Login. You will need to set up a login to view the webinar, which lasts about an hour including questions and answers.

ADDITIONAL THOUGHTS AND IDEAS

The following chapter is a compilation of stories that touch on other aspects of precision shaft alignment. Some may already be familiar to you; others you may encounter in the future.

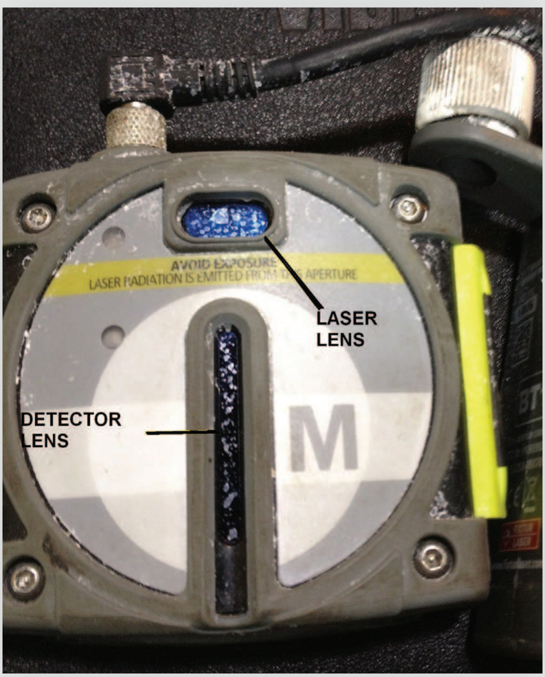
HELP YOUR LASER SHAFT ALIGNMENT SYSTEM SEE!

By Stan Riddle
November 13th, 2014

For precision shaft alignment, nothing beats a good laser alignment tool. But the best of tools can have errors, or not even work at all, if the Sensors (detectors) can't "see" the laser beams!

We received a customer support call, and the aligner stated that his laser alignment tool wasn't repeating. This is a rare occurrence, so one of our sales managers talked the user through some basic troubleshooting procedures. Our manager asked this gentleman to take a photo of the laser sensors, and send it to him.

This photo is what he saw! There was so much buildup of grease, grime and dirt on the sensor lenses, the detector couldn't "see" the laser beam. Another way to put it is the laser beam couldn't shine through the build up of gunk.



This photo shows the Sensor with clean lenses. Quite the difference!

The lenses of both sensors should be treated like camera lenses. The cleaner they are, the better they can see.

To clean the lenses of your sensors:

- Use air to gently blow dirt and particles off the lenses.
- Use a cotton swab, and alcohol, or a good quality glass cleaner.
- Gently wipe the lenses until clean.
- Do not use a shop towel, or dry safety glass wipes, as they could scratch the lens.

This should be done on a regular basis. Even if your facility is fairly clean, dust, oils, solvents, and particulate matter can build up on the glass, making measurements difficult.

So remember, if your laser is giving you inaccurate or non-repeatable measurements, check the lenses to see if they are clean. If you have any doubts-clean them first.

MECHANICAL SEAL BASICS

By Mac MacCormack
September 17th, 2014

After completing a recent training class, I had opportunity to ask our customer what were some of the highest cost failures they experienced. The answer? Mechanical seal failures. Mechanical seals come in a wide variety of configurations and manufacturers. The cost of these seals can range from $1000 to $3000 per inch of shaft diameter. These are very close tolerance and will not withstand misalignment for long if at all. A high percentage of mechanical seal failures are due to vibration induced by misalignment.

While researching several mechanical seal manufacturers to gain some insight as to what their tolerances were (they are specific to configuration and are provided with the mechanical seal), I ran across the following very good article on mechanical seal basics.

BACK TO BASICS: MECHANICAL SEALS EXPLAINED

Posted by: SuperSailor, 30 June 2013

INTRODUCTION

Because mechanical shaft seal failures are the number one cause of pump downtime, we decided to dedicate this column to mechanical seal basics.

Years ago, most pump shafts were sealed using rings of soft packing, compressed by a packing gland, but this type of shaft seal required a fair amount of leakage just to lubricate the packing and keep it cool. Then came the development of the "mechanical seal," which accomplishes the job of restraining product leakage around the pump shaft with two very flat surfaces (one stationary and one rotating). Even though these mechanical seal faces also require some (very small) leakage across the faces, to form a hydrodynamic film, this leakage normally evaporates and is not noticeable. Most pump shafts today are sealed by means of mechanical seals. However, because of the delicate components used for this new sealing method, mechanical seal failures are the greatest cause of pump down time. This begs for a better understanding of this seal type and its application.

THE BASICS

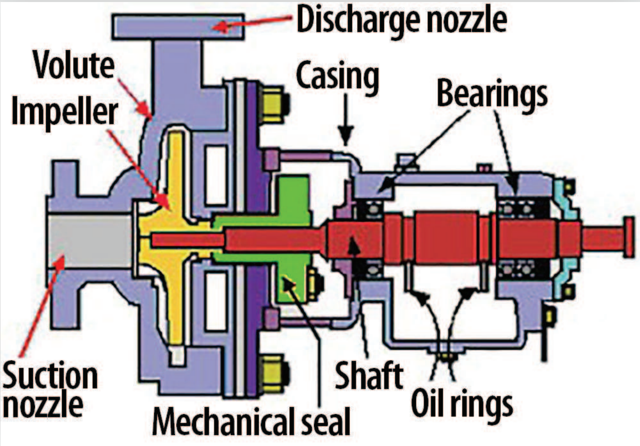


Figure 1

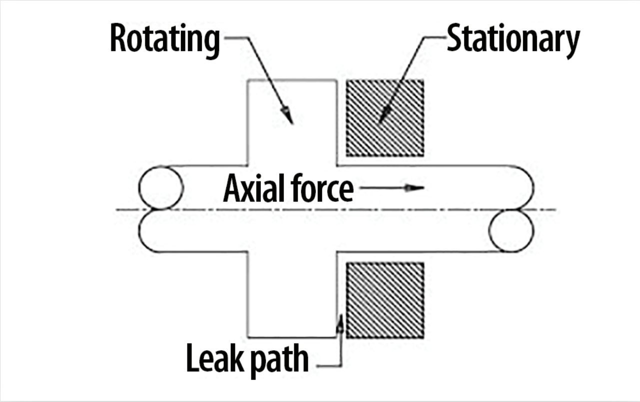


Figure 2

Mechanical seals are leakage control devices, which are found on rotating equipment such as pumps and mixers to prevent the leakage of liquids and gases from escaping into the environment. Figure 1 above shows a typical centrifugal pump, which highlights its constituent parts, including the mechanical seal.

A mechanical seal consists of 2 principle components. One component is stationary and the other rotates against it to achieve a seal (Figure 2). There are many types of mechanical seal, ranging from simple single spring designs to considerably more complex cartridge seal types. The design, arrangement and materials of construction are essentially determined by the pressure, temperature, speed of rotation and product being sealed (the product media).

THE DESIGN

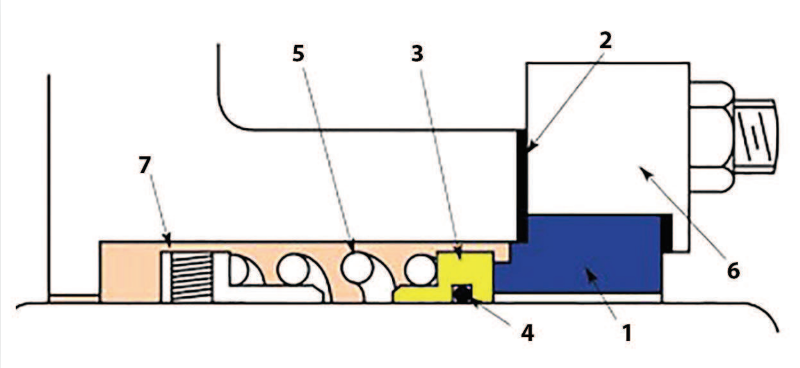


Figure 3

By way of example, a simple mechanical seal design has 7 components (Fig 3):

1. Stationary component; commonly referred to as the seat.
2. Stationary component sealing member.
3. Rotating component.
4. Rotating component sealing member.
5. Spring.
6. Gland plate.
7. Clamp ring.

THE SEALING POINTS

A mechanical seal has 4 main sealing points:

I. The seal between the rotating (3) and stationary faces (1). This is known as the primary seal.
II. The seal between the stationary member (1) and stuffing box face, i.e. Gasket (2).
III. The seal between the rotating member and shaft or shaft sleeve (4). This is known as the secondary seal and may be an o-ring as shown, a v-ring, a wedge or any similar sealing ring.
IV. The seal between the gland plate and stuffing box, this is usually a gasket, or o-ring.

3 of the 4 main sealing points need little explanation, but consideration is required for the sealing point between the rotating and stationary components (faces). This primary seal is the basis of a mechanical seal design, and is what makes it work. The rotating component (3) and stationary component (1) are pressed against each other, usually by means of spring force. The mating faces of both components are precision machined (lapped) to be extremely flat within 2 light bands, which is an optical method of measuring flatness.

This flatness minimizes leakage to a degree where it is essentially negligible. In fact, there is leakage between these faces but it is minute and appears as a vapor.

Spring compression (usually) provides initial face pressure. This pressure is maintained when the seal is at rest via the spring(s) thus preventing leakage between the faces.

FLUID FILM

If the mechanical seal faces rotated against each other without some form of lubrication they would wear out (and the seal would fail) due to face friction and the resultant heat generated. So, lubrication is required which for simplicity, is supplied by the product media. This is known as fluid film and maintaining its stability is of prime importance if the seal is to provide satisfactory and reliable service.

The primary disadvantage of this seal type is that it is prone to secondary seal hang-up and fretting of the shaft or sleeve, especially when the seal is exposed to solids. A pusher seal type should not be selected if the secondary seal is likely to hang-up. Can small deposits of solids form ahead of the secondary sealing member?

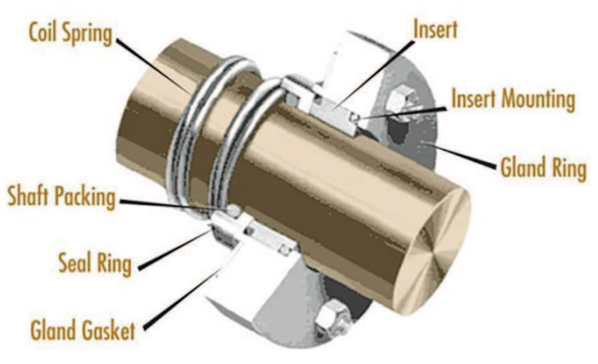
MECHANICAL SEAL TYPES

There are multiple designs available for the mechanical seal configuration. Understanding how they work will help the readers select the appropriate type for their application.

They are:

- Conventional
- Pusher
- Non-pusher
- Unbalanced
- Balanced
- Cartridge

Figure 1: Single Typical Mechanical Shaft Seal



PUSHER SEALS incorporate secondary seals that move axially along a shaft or sleeve to maintain contact at the seal faces, to accommodate wear and to assist in the absorption of shaft misalignment.

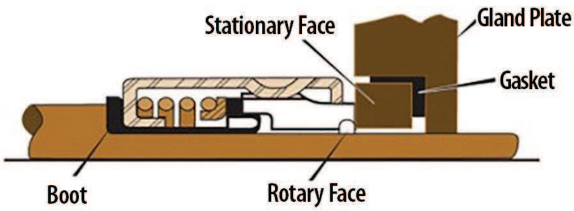
Advantages are that they are inexpensive and commercially available in a wide range of sizes and configurations.

NON-PUSHER OR BELLOWS SEAL does not have a secondary seal that must move along the shaft or sleeve to maintain seal face contact. In a non-pusher seal the secondary seal is in a static state at all times, even when the pump is in operation. A secondary sealing member is not required to make up the travel as the rotary and stationary seal faces wear. Primary seal face wear is typically accommodated by welded metal or elastomeric bellows which move to assist in the compression of the rotary to stationary seal faces.

Figure 2: Pusher Type Mechanical Seal

Figure 3: Non-Pusher Mechanical Seal

Figure 4: Mechanical Seal Elastomeric Boot



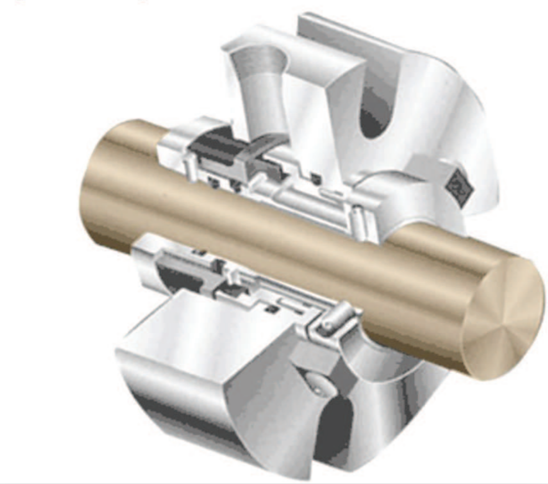
The advantages of this seal type are the ability to handle high and low temperature applications (metal bellows), and that it does not require a rotating secondary seal, which means it is not prone to secondary seal hang-up or shaft/sleeve fretting. Elastomeric bellows seals are commonly used for water applications.

The disadvantages are that thin bellows cross sections must be upgraded for use in corrosive environments, plus the higher cost of metal bellows seals.

CARTRIDGE SEALS have the mechanical seal pre-mounted on a sleeve (including the gland).

They fit directly over the shaft or shaft sleeve, and are available in single, double, and tandem configurations. Best of class pump users give strong consideration to the use of cartridge seals.

Figure 5: Cartridge Seal



The advantages are that this seal configuration eliminates the requirement for seal setting measurements at installation. Cartridge seals lower maintenance costs and reduce seal setting errors.

The primary disadvantage is the higher cost, plus in some cases they will not fit into existing stuffing box/seal housings.

MECHANICAL SEALS ARRANGEMENTS

Single seals do not always meet the shaft sealing requirements of today's pumps, due to the small amount of required leakage when handling toxic or hazardous liquids; suspended abrasives or corrosives in the pumpage getting between the seal faces and causing premature wear; and/or the potential for dry operation of the seal faces. To address these situations, the seal industry has developed configurations which incorporate two sets of sealing faces, with a clean barrier fluid injected between these two sets of seal faces.

The decision to choose between a double or single seal comes down to the initial cost to purchase the seal vs. the cost of operation, maintenance and downtime caused by the seal, plus the environmental and user plant emission standards for leakage from the seal.

Figure 6: Double Back-to-Back Seal

The more common multiple seal configuration is called a Double (dual pressurized) seal, where the two seal face sets are oriented in opposite directions. The features of this seal arrangement are:

- Potentially five times the life of a single seal in severe environments.
- The metal inner seal parts are never exposed to the liquid product being pumped, which means no need for expensive metallurgy; especially good for viscous, abrasive, or thermosetting liquids.
- The double seal life is virtually unaffected by process upset conditions during pump operation.

Figure 7: Tandem Seal

The other multiple seal configuration is called a Tandem (dual unpressurized) arrangement, where the two individual seals are positioned in the same direction. This seal arrangement is commonly used in Submersible wastewater pumps, between the pump and motor, with oil as the barrier liquid. The typical features of this seal arrangement are:

- The pressure between seals is lower than the seal chamber pressure (typically atmospheric.)
- The external fluid only lubricates the most outside set of faces.
- Pumped fluid lubricates most inside faces.
- The outside seal serves as a safety seal or containment device.
- Leakage to the atmosphere is external fluid, possibly mixed with small amounts of pumped fluid.

MECHANICAL SEAL SELECTION

The proper selection of a mechanical seal can be made only if the full operating conditions are known. Identification of the exact liquid to be handled is the first step in seal selection.

- Metal parts must be corrosion resistant, usually plated steel, bronze, stainless steel, or Hastelloy.
- Mating faces must also resist corrosion and wear. Carbon, ceramic, silicon carbide or tungsten carbide may be considered.
- Stationary sealing members of Buna, EPR, Viton and Teflon are common. *Pressure:* The proper type of seal, balanced or unbalanced, is based on the pressure on the seal and on the seal size. *Temperature:* Can determine the use of the sealing members as materials must be selected to handle liquid temperature. *Characteristics of the Liquid:* Abrasive liquids create excessive wear and shorten seal life.
- Double seals, or clear liquid flushing from an external source, allow the use of mechanical seals on these difficult liquids.
- For best results with double (or tandem) seals handling abrasive, the inboard seal faces should be a hard material, such as silicon carbide vs. silicon carbide, while the outboard seal faces should have maximum lubricity, such as silicon carbide vs. carbon graphite.

CONCLUSIONS

The seal type and arrangement selected must meet the desired reliability, life cycle costs, and emission standards for the pump application. Double seals and double gas barrier seals are becoming the seals of choice. Finally, it should be noted that there are special single seal housing designs that greatly minimize the abrasives reaching the seal faces, even without an external water flush, but this is a subject for another column.

DON'T BET AGAINST YOUR LASER SHAFT ALIGNMENT TOOL!

By James Pekarek
January 15th, 2014

During the classroom portion of a Fixturlaser GO Pro training class, at a sheet metal processing plant, one mechanic insisted the GO Pro alignment results were not repeatable in the field. The mechanic had the opportunity to use their GO Pro once before the training class and was convinced it would not repeat.

For the "OJT" portion of the class we set out to align the machine in question. The mechanic offered a "good natured" bet against the GO Pro which of course I declined. The machine is a 25 HP electric motor and pump set, operating at 1800 RPM. As the pump is pumping etching acid to clean sheet metal prior to painting, the pump was behind a wall, for safety, with only the coupling end of the shaft in view. Unfortunately photos were not allowed to be taken.

The first set of results indicated the vertical and horizontal alignment slightly out of tolerance. The class made a Verti-Zontal Compound Move® by adding shims to correct the vertical misalignment then adjusting the motor horizontally to bring it into tolerance. After tightening the hold down bolts and re-measuring, the results showed the alignment to be worse then when we started. Another set of measurements and different results, however still out of tolerance.

Non-repeating alignment results typically indicate something is loose-the sensor brackets, coupling backlash, hold down bolts, etc. We checked all we could see and everything was tight.

Several more sets of alignment measurements revealed the same non-repeatable results. Something had to be moving on the pump end. As the acid had been drained from the pump, we were allowed to open up the wall to view the pump. What we found hit us in the head like a 2 x 4! Literally, that was the problem: a 2 x 4!

One of the pump's 4 feet had broken off and a piece of 2 x 4 was wedged under it. Closer inspection revealed that acid had eaten away the wood and the foot was not supported by anything. As the pump was no longer securely mounted we had been attempting to align the electric motor to a moving target. All the mechanics had a good laugh at what we found.

Obviously, this pump had to be repaired or replaced before a precision shaft alignment could be performed, so we moved to another pump, and aligned it without incident.

Lesson(s) learned on the first pump?

1. Never assume anything when it comes to alignment; examine all machines being aligned.
2. You can't align a moving target. Check that ALL hold down bolts are tight.
3. If your alignment results are not repeating, more than likely something is loose; it's not the tool.

WHERE CAN I GET ALIGNMENT SPECIFICATIONS?

By Tom Shelton
December 3rd, 2013

This is a question that comes up surprisingly often in our training classes. The question is usually regarding Thermal Growth offsets (dynamic movement) and shaft alignment tolerances. There are several ways to obtain the data in question. The easiest and most readily available would be the equipment manufacturer. Most companies will supply specific offset and alignment instructions for their equipment. Below is the recommended Thermal Growth settings for the Goulds 3196 Series centrifugal pumps taken from the "Model 3196 i-Frame Installation, Operation, and Maintenance Manual."

Cold settings for parallel vertical alignment

Introduction

This section shows the recommended preliminary (cold) settings for electric motor-driven pumps based on different temperatures of pumped fluid. Consult driver manufacturers for recommended cold settings for other types of drivers such as steam turbines and engines.

Recommended settings for models 3196, CV 3196, and LF 3196

Pumpage temperature	Recommended setting
50°F (10°C)	0.002 in. (0.05 mm), low
150°F (65°C)	0.001 in. (0.03 mm), high
250°F (120°C)	0.005 in. (0.12 mm), high
350°F (175°C)	0.009 in. (0.23 mm), high
450°F (218°C)	0.013 in. (0.33 mm), high
550°F (228°C)	0.017 in. (0.43 mm), high
650°F (343°C)	0.021 in. (0.53 mm), high
700°F (371°C)	0.023 in. (0.58 mm), high

There are also other ways that VibrAlign offers to you to obtain Thermal Growth information. We have several free apps available through iTunes or Googleplay, two of which are Therm Align and AlignHot, for determining accurate thermal offsets. In addition, Fixturlaser has built into the XA Pro, XA Ultimate & NXA Pro Alignment Systems the ability to accurately measure the change in machinery positions from cold to hot (offline to running) and assess the proper offsets or target values.

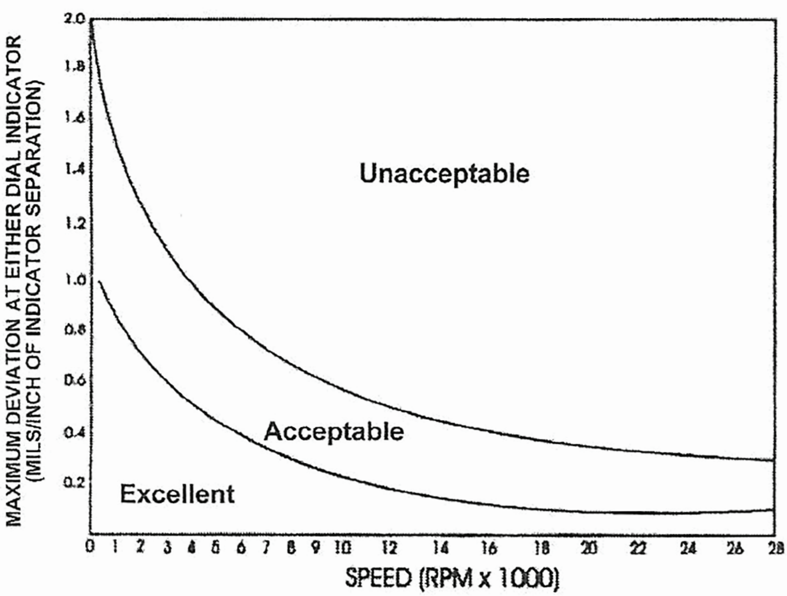


Fig. 3 Guideline for Alignment Tolerances

In addition to dynamic target values, the manufacturer may also include recommended alignment tolerances. The instructions that are commonly given are in dial indicator alignment terminology, either Rim and Face or Reverse Dial. Included below is the guideline for alignment tolerances taken from the same Goulds 3196 installation manual given as Reverse Dial Indicator Values.

As our clients and students have discovered, once trained in the use of the Fixturlaser laser shaft alignment tools, the alignment process is much faster and less complicated than with dial indicators.

That being said, the basic and essential "truths" of doing a proper precision shaft alignment using a laser system or dial indicators remains the same:

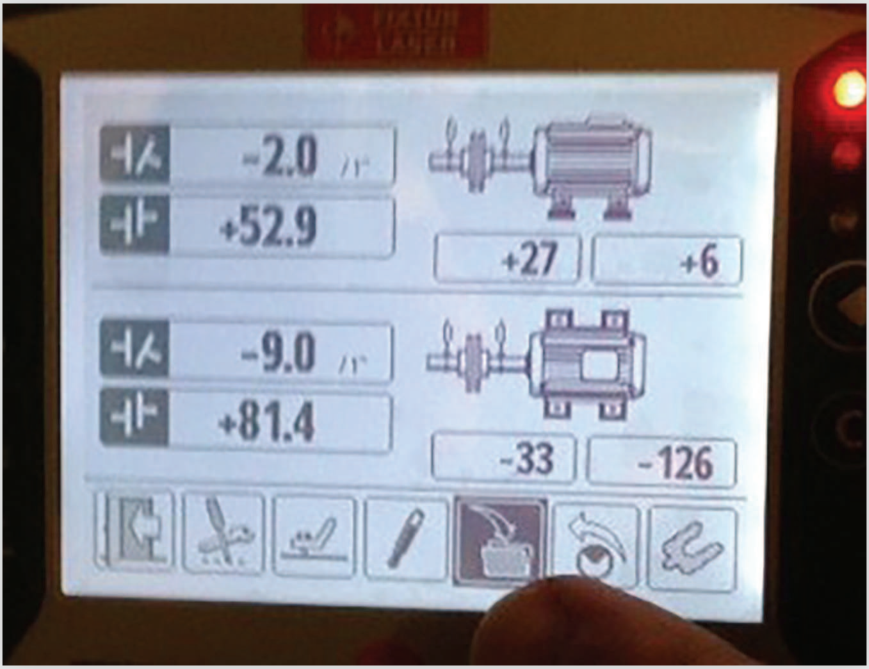
- Clean. Remove dirt, debris, burrs, etc. from the base and the feet of the machine.
- Measure your shims.
- Pre-alignment steps.
- Measure, correct the misalignment, verify and document the alignment. In short, look to the machine maker's literature to obtain the specific information that you seek. Those little sheets of paper in your coupling box or taped to the pump may have all the information that you need. If not, consult web sites and manuals to determine the appropriate specifications to complete your alignment correctly. And remember, if you need help, call us; we are here to help!

IT'S BRAND NEW, SO IT MUST BE ALIGNED, RIGHT?

By Stan Riddle
August 26th, 2013

During a recent training class at a new facility in Indiana, the class wanted to check alignment of a recently installed circulating pump. Their response was, "It's brand new, so it must be aligned, right?". To which I responded, "I'll bet it isn't."

Here are the alignment results as we found it.



For an 1800 RPM machine the maximum allowable angular misalignment is +/- 0.7 mils per inch and a maximum allowable offset of +/- 4.0 mils in both the vertical and horizontal planes.

The vertical angle is almost 3 times tolerance with the horizontal angle almost 13 times tolerance! The vertical offset is 13 times tolerance and the horizontal offset is 20 times tolerance!

Never trust that a newly delivered machine is aligned. I do not care if it has a tag saying it is. I do not care if the company you purchased it from says it is.

Even on the outside chance it was aligned correctly when it was installed, lots of things can happen between the factory floor and your plant floor.

- Machines can be moved to connect piping, ductwork, etc.
- Bases and piping can cause the alignment to be moved.
- Several hundred miles of hauling the machine down an interstate can change the alignment.
- And their degree of alignment may not match yours. I recommend aligning machines as soon as they are unloaded from the truck, whenever possible. Not only can you verify the alignment is now "good," you can correct any bolt bound or base bound problems before any additional components, such as piping and conduit are installed. After all the accessory components are installed, check it again.

IT HAS TO BE ALIGNABLE!

By Brad Case
June 24th, 2013

One of the issues precision shaft alignment technicians face is whether a machine is alignable. There will be times that a machine cannot be aligned in its current condition.

A recent Fixturlaser GO Basic training class ran into this issue when performing alignment checks on 4 small centrifugal pumps. All pumps had 10 HP electric motors, 2 operate at 3600 RPM and 2 at 1800 RPM.

The two alignment teams found all pumps to be slightly out of tolerance. 3 of the 4 pumps were aligned to tolerance within 1 hour total time, the 4th pump not so.

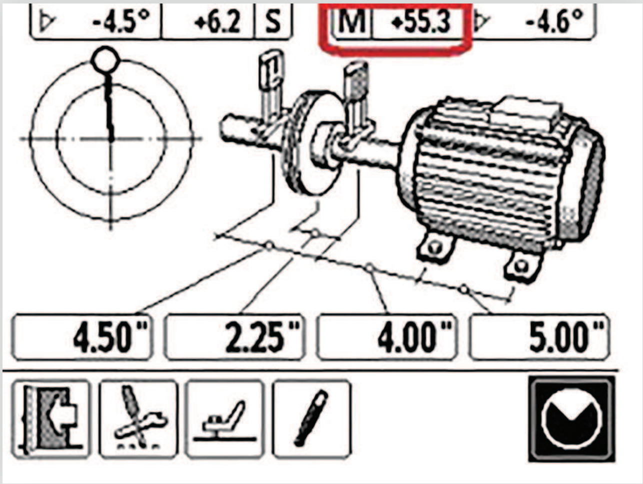
The 4th pump's coupling values in the vertical plane where not repeating; the angular value was changing by almost 1 mil/1", and the offset by approximately 8 mils (1.0 mil = .001"). Something had to be moving.

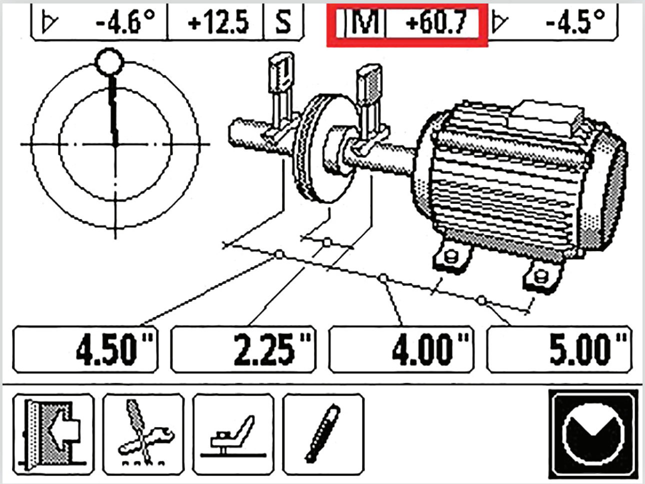
When it comes to precision shaft alignment 2 of the biggest culprits that affect repeatability are looseness and backlash (coupling looseness). If it moves, the alignment system will see it. (Sometimes in the heat of battle folks forgot to tighten the sensor fixtures tightly! It happens more than you think).

In this case the looseness was not with the sensor fixtures or coupling backlash but within the electric motor. The class found the motor to have excessive play in the bearings. So how did they find it? By a simple lift check of the shafts using the displayed detector values of the GO Basic.

While in the measuring screen the sensors were rotated to the vertical plane; while looking at the S Sensor value they lifted or pulled up slightly on the pump shaft. The S detector value changed by less than 1.0 mil, just a few 10ths actually.

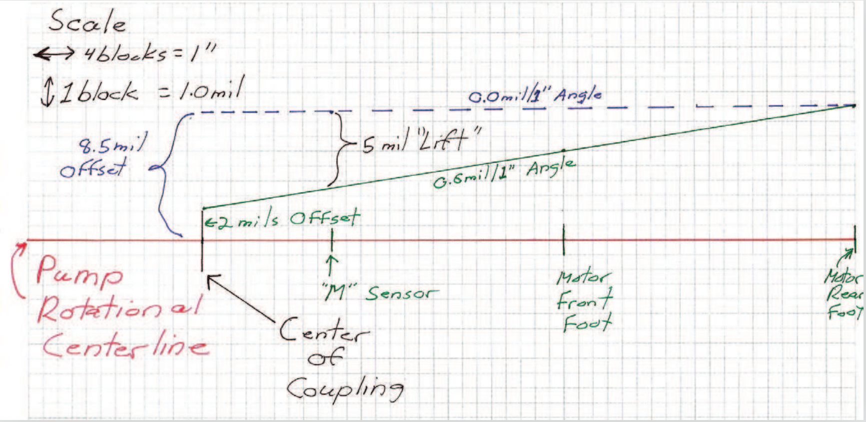
When performing the same lift check on the motor shaft, while now viewing the M sensor detector value, the displayed value changed by 5.0 mils.





This excessive play caused the motor's rotational centerline to vary each time a set of alignment measurements was taken. This movement is easily illustrated in the graph below.

The red line represents the reference rotational centerline of the pump extended across the page. The green line is the electric motor rotational centerline from the first set of measurements. The blue dashed line shows how much the 5.0 mils of looseness in the motor shaft bearing affects the position of the rotational centerline. The vertical angular misalignment drops to almost 0 mil/1" while the vertical offset increases to 8.5 mils at the coupling center.



This machine will not be alignable to the tolerance specified for 1800 RPM, (max. allowable angle of +/- 0.7mil /1" and max. allowable offset of +/- 4.0 mil) until the motor is replaced. In its current condition the angular misalignment is within tolerance; however, the offset misalignment is almost 2 times tolerance.

THE DEVIL IS IN THE DETAILS!

By Tom Shelton
May 29th, 2013

During the field alignment portion of a Fixturlaser GO Basic shaft alignment training class, we were attempting to align a 100 H.P., 3600 RPM motor to a double suction pump. Sounds easy enough!

Here's the skinny… The pump and motor were the top set in a vertical, two unit skid made of Ibeams and very flexible and we were aligning to a tight 3600 RPM tolerance of +/- 0.5 mil/1" Angular and +/- 2.0 mil Offset Misalignment at the coupling.

We worked at it for some time and took care to follow the training. The class made sure they had a good rough alignment, no soft foot and an established bolt tightening sequence to follow. We noticed however, there was a particular foot causing the motor to move when tightening the hold down bolt. We checked for soft foot again… Nope it was good, we changed the slightly cupped washer…we have it now, or so we thought. It still moved when the hold down bolt was tightened. Hmm, something has to be moving!

We decided to take turns inspecting the situation and compare our observations. Only one guy caught the problem… The wedge washer below the frame was turned 90 degrees! He corrected the washer and fifteen minutes later we had a great alignment and were packing up the GO Basic.

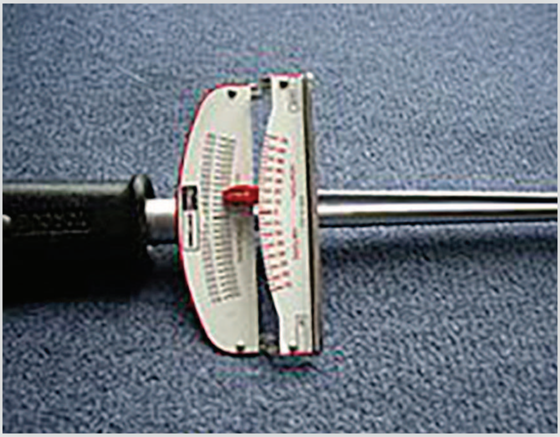
When trouble starts and the alignment doesn't go as planned, you have to go back to the basics. Look critically at every possible player in the situation. You have to broaden your view from only seeing numbers on the display unit screen and step back and look at each individual element of your machine and their purpose and effect it will have on a good alignment. If it moves the laser will see it!

DOES USING A TORQUE WRENCH MAKE SHAFT ALIGNMENTS MORE ACCURATE?

By Stan Riddle
November 4th, 2012

Some companies have a policy of torquing motor hold down bolts to set prescribed value. While this may be a regulation in some industries, or required on specific types of machines, it really has little to do with the quality, accuracy or repeatability of shaft alignment–if the alignment is done properly.

Most millwrights may disagree. This is because they have seen changes in the alignment values during the tightening process, and attribute it to bolt torque. But the real reason the values change is because of uncorrected soft foot.



If a cast iron motor foot sits on a stainless steel shim, which sits on a steel base – high torque tightening with a wrench WILL NOT cause the foot to get any closer to the base. To do so one of two things must happen:

1. Voids due to a bent foot or warped base, or contaminants such as dirt, paint, rust, or some other foreign material MUST BE between the foot, shims, and base.

2. The stainless steel shim must flow, and become thinner.

#1 happens frequently. Most mechanics know the crackling sound it makes as the foreign materials are broken apart due to the force imparted by tightening. It also puts minute dents in the shims, feet, and base.

#2 is pretty much impossible, because either the bolt will shear from such a force, or the threads would pull out, long before the stainless steel shim gets any thinner.

So, the changes in shaft alignment that happen while the bolts are being tightened are from soft foot, or foreign material under the feet, not from differing torque values.

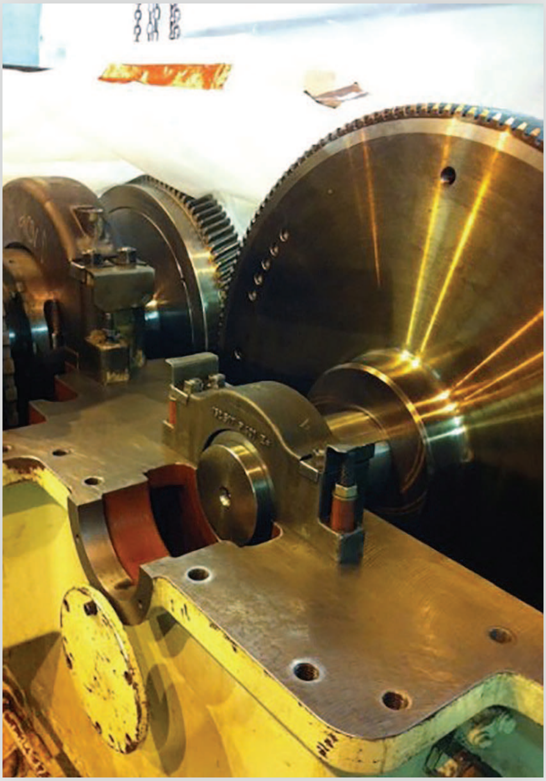
Make sure the base, shims, and motor feet are clean. Deburred is even better. Correct for soft foot. Use clean shims.

If you use a torque wrench, that's fine. But just remember the wrench won't get the motor feet any closer to the base than the thickness of the shims, no matter how hard you pull on a wrench!

DEFINING LEVEL VS. FLAT

By Stan Riddle
October 15th, 2012

In mechanical trades, most of us have been taught that most installed machines must be installed level and the bases must be flat. But contrary to what many of us think, level and flat are two completely different terms. Level simply means that the machine is parallel to earth, or horizontal. Flat means that the base, and the feet which mount upon it, are in the same plane.



For most machines, the degree of level is relative. I have installed pumps which were required to be level, but were leveled with a torpedo level. Not exactly the most accurate of leveling devices. The main reason a pump needs to be level is usually just to make sure that oil gets to both bearings, and so that gravity doesn't tend to move the shaft downhill.

If a machine is a few tenths of a degree out of level, it usually is not harmful. But if a machine is installed on a base that is not flat, some problems may occur:

- Shaft alignment will be difficult, due to soft foot. But this can be corrected by shimming.
- Machine cases can be warped when tightening the foot bolts down. This can cause changes in bearing clearances, gear mesh clearances, even deforming the stators in electric motors. But this can also be corrected by shimming the feet so that this distortion does not occur while tightening.
- The machine feet can be flat (in the same plane) while the foot bolts are loose, but change when they are tight.

So, keep this simple rule in mind: Most machines can be run slightly out of level, but they cannot be run "out of flatness."

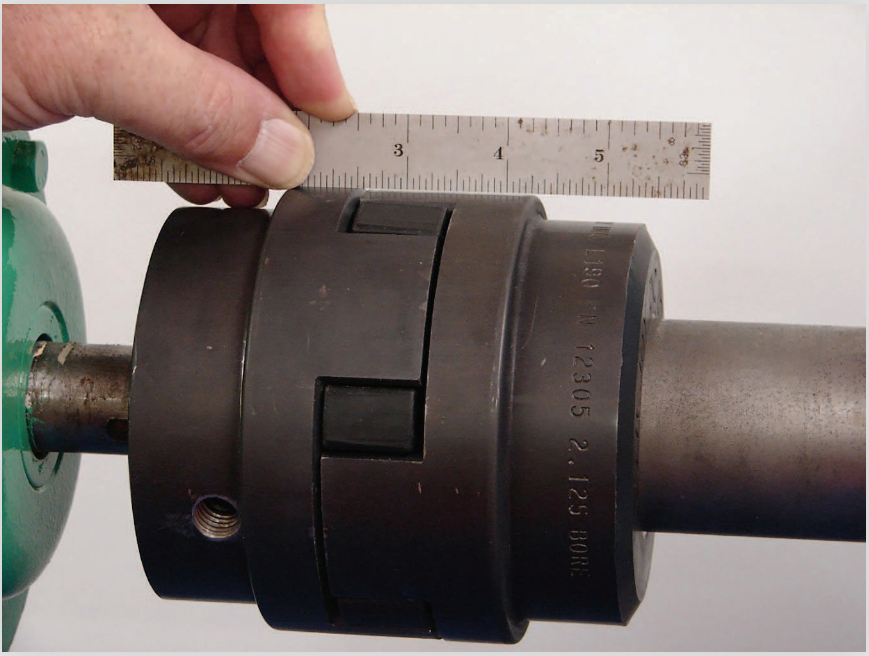
I can bolt a baseplate to the floor, and it can be both level and flat. I can bolt it to a wall, and it will no longer be level, but it will still be flat.

30+ YEARS OF ALIGNMENT – A LOOK BACK

By Stan Riddle
September 28th, 2012

Back around 1982, when I made my first forays from machinist into mechanical maintenance, I remember hearing about coupling alignment while working at a now-defunct rope factory in North Carolina. I considered myself a decent machinist, although I had little experience beyond technical school. I remember a welder showing me how to align shafts.

"Straight edging," he called it. No rim or face straight edging, just rim. Not even horizontal, as I recall – just vertical. No dial indicators. No lasers (I don't think they had even been invented at that time).



Just straight edging.

Many of you may have learned it the same way. You may still be doing it the same way. And if you're honest with yourself, "straight edging" is insufficient.

So, if a straight edge isn't sufficient for precision machinery, what about dial indicators?

As a machinist, I knew how to use them. I performed my first rim and face alignment with dial indicators while working as a millwright for a wood products company in the mid-80's, using shop-made brackets. Bracket sag? Never heard of it. TIR? Same thing.

Dials are definitely better than straight edges and calipers, but they still require experience and a good grasp of the math required to calculate shims and moves. And when you add the complexity of bracket sag and thermal growth – it becomes a long process, wrought with opportunities for error.

In my career, I have worked for companies that had "alignment gurus" – the guys you called to align the machines, because even though most of the mechanics knew something about it, only a few were good at it. And when the "guru" left or retired, you were back to straight edges.

And then, there were lasers!

The mill I worked for bought a laser alignment tool. And it was awesome, although the beam was invisible, the instructions were probably in German, and we had no training. But my work partner and I sat on opposing buckets – one on each side of the machine – and by much trial and error, learned to use it. But the soft feet, coupling backlash, bolt-bound, and thermal growth things slowed us down quite a bit, because we didn't know what they were. We thought we were doing pretty well if we could align two machines per day.

Fast forward to today. Shaft alignment is an industry unto itself. I now work for a company that sells precision shaft alignment tools. Technological advances have made the alignment process fast, simple, and extremely accurate.

But the same alignment problems still exist, which we like to call the Five "T's":

- TIME – If you want to perform a good alignment, you must take adequate time to do it right. I've heard all the same arguments you have. "We've got it get it back on line!" "Just put it back together– we'll align it on the next outage." "The coupling is supposed to wear out – that's its job!" And so on. Sometimes you have to "work slow to work fast." You can complete the alignment properly, and quickly, and you may not have to do it again for many years.

- TRAINING – Many maintenance specialists today are woefully ignorant of what alignment is, and how to perform it. A generation ago, new millwrights learned alignment either from apprenticeship training, or by working with older, more experienced mechanics. Now many companies assume you'll learn it by doing it, with little or no instruction as to what "it" is.

- TOOLS – The better the tool, the faster and more accurate the alignment will be.

- TOLERANCES – Aligning to zero is impossible to accomplish, and is a huge waste of time and effort. Find out what you company's alignment tolerance is. If they don't have one, you are welcome to use ours. But know when to stop.

- TROUBLESHOOTING – Learn the causes of alignment problems – things like soft foot, coupling looseness, bolt- and base-bound conditions, a proper tightening pattern, pipe strain, dirt on shims and feet. Know them, know how to check for them, and assume that every machine you align may have one or all of these problems.

Spend some time learning shaft alignment. Buy the best alignment tools your company can afford, and use them. Learn about the pitfalls of the alignment process, and what you can do to prevent them. Practice. Aim for a tolerance, and stop once you achieve it.

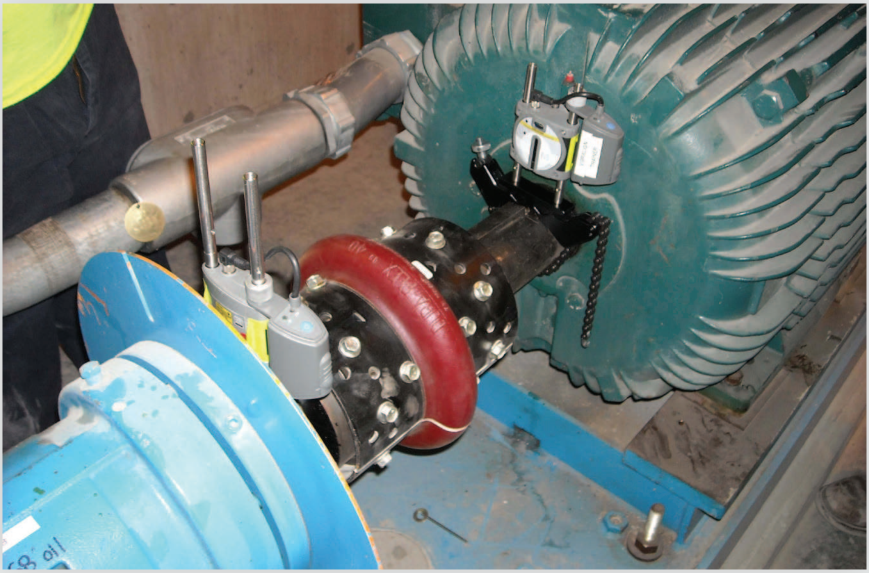
Make yourself an alignment "guru."

THE FOUNDATION OF GOOD SHAFT ALIGNMENT

By Stan Riddle
July 15th, 2012

There are several things that must come into play to achieve a quick and accurate shaft alignment. One of those things is starting with a good foundation. By foundation, I mean everything between the bottom of the machine and the floor.

So, let's start at the bottom and work our way up.



Inertia Block or Base – The inertia block, or base, serves two purposes:

1. Give a solid, flat mounting surface for the machine. The machine may be bolted directly to the base, but often the entire machine skid is mounted to the base.

2. Facilitate sufficient mass to support the machinery and its secondary components, such as piping and ductwork. The mass also serves to minimize unwanted vibration.

Skid or Frame – The skid should be solidly bolted to the base. Shims are sometimes used to level the base. Shims should be located under the bolts to provide maximum stiffness to the frame. Bolts should be sufficiently tightened and should be rechecked periodically since concrete bases can shrink, creating gaps under the frame.

Isolator Springs – In many instances, isolator springs are used between the frame and base, especially when the machine is located "off grade" or on an upper floor or roof. The isolator springs serve to isolate any machine vibration from reaching the base, and becoming a nuisance vibration or noise issue. Isolator springs are normally sized according to the mass of the machine they are supporting, and should be adjusted to have the proper spring compression to minimize this nuisance vibration.

Motor Risers and Adaptors - These are often used to raise the motor to a height sufficient to allow the motor to be aligned to the driven machine. Make sure the adaptor is attached solidly to the frame.

When performing a shaft alignment, especially on newly-installed machinery, all of these components should be checked prior to performing the alignment.

- Confirm that all bolting is tight.
- Check for cracked welds.
- Check for proper isolator spring compression. If you do not know the proper compressed height, step on the machine to see how "springy" the isolators are. If they move easily, check with your supervisor or engineering department to confirm that they are adjusted correctly.

Taking a few minutes to inspect the things that support the machine will help confirm that the machine can be quickly and accurately aligned.

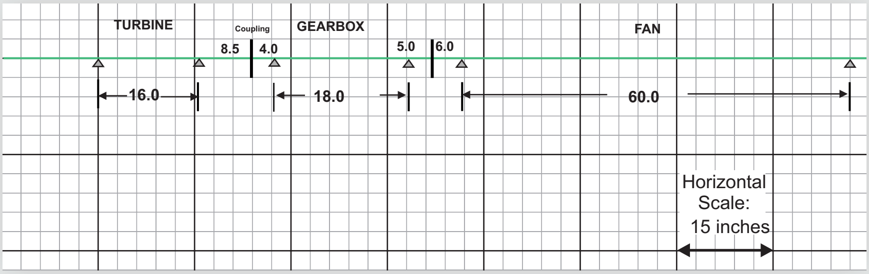
TRAIN-ING

By Stan Riddle
October 8th, 2011

A machine train alignment, one in which there are more than two machine components, and more than one coupling, may seem difficult to most aligners. But with some basic understanding, and the ability to "see the forest as well as the trees," a machine train alignment can be performed accurately and quickly.

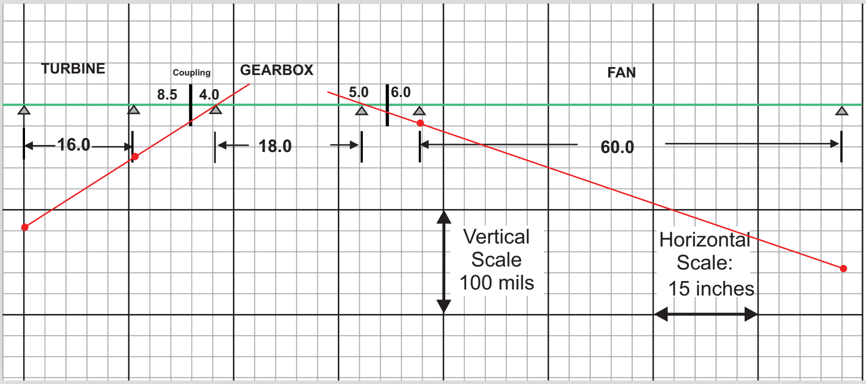
We recently helped a customer who had been working unsuccessfully for two weeks to align a three-machine train. With their newly acquired Fixturlaser XA Pro Machine Train program, and a little training, this job was completed in just over two hours.

First, careful measurements of all machine dimensions—distance between machine feet and distances to coupling centers—must be taken. If using the XA Pro Machine Train program, all of these dimensions can be put into one alignment file, and your XA can do all of the graphing for you. Or, it can be done on graph paper.



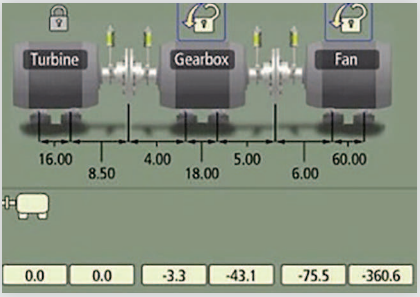
In this example, there was a steam turbine, coupled to a gear reducer, which was coupled to a center-hung fan. Measurements were taken between the turbine and gearbox, then between the gearbox and fan. In each measurement, the movable machine was on the left, and the stationary machine was on the right. For simplicity, we will concentrate on the vertical correction only.

A graphical representation requires some experience in determining which feet to move. In addition, some machines may not move at all. In this case, the turbine had rigid piping, which allowed for only a slight movement, and the fan could not be lowered, or a rub would be induced in the fan housing.

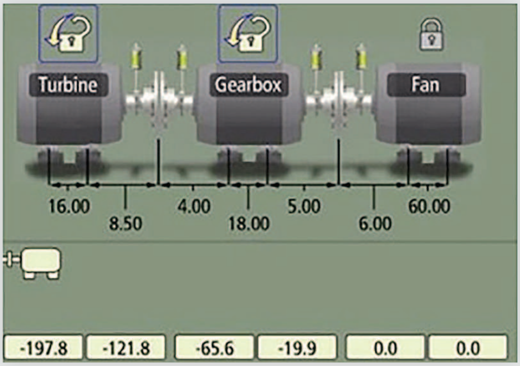


But with the XA Pro Machine Train program, they had options!

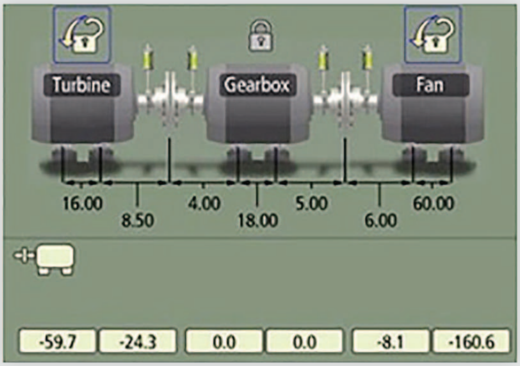
They could lock the position of the turbine feet, and see how much movement would be required on the gearbox and fan.



The fan could not be moved up almost 3/8″ or a rub would be induced in the fan housing. Or, they could lock the fan feet, and see how much movement would be required on the turbine and gearbox.



The piping to the steam turbine would not allow it to be moved up 0.197″ without major piping re-work. Or, they could lock the position of the gearbox feet, and see how much movement would be required on the gearbox and fan.

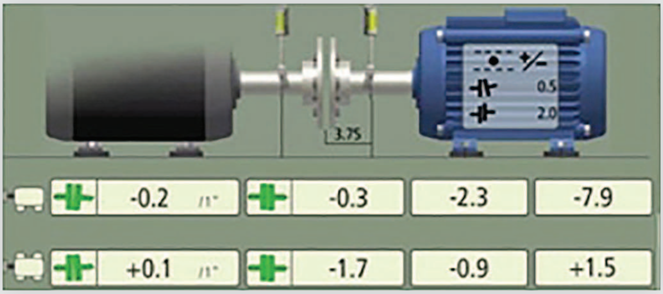


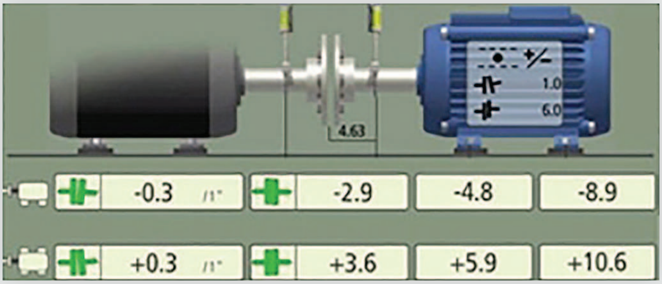
Locking the gearbox in as the stationary machine and making relatively small movements of both the turbine and the fan allowed this machine train to be aligned.

They could also make rough adjustments to each machine position, and then do the alignment as two separate machines—aligning the gearbox to the fan, and then aligning the turbine to the gearbox. In the end, a combination of both was used, and below are the final alignment values. The XA Pro Machine Train program gave the customer the flexibility to look at numerous options, and make the best choice.

The gearbox was lowered by 0.075", and all dimensions were re-measured. The alignment was completed between the turbine and gearbox. Then, the alignment was completed between the gearbox and fan.

The results are as follows:





Options – a good thing to have when performing a machine train alignment! They helped turn an unsuccessful two-week alignment into a successful two-hour alignment.

THAT'S A BAD SIGN

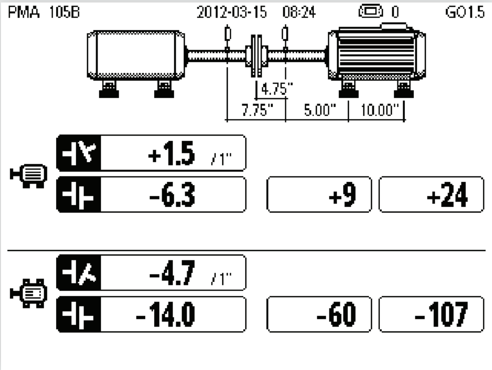
By Stan Riddle
April 6th, 2012

A manufacturing operation in western North Carolina recently purchased a Fixturlaser GO and shaft alignment training. This company is going through a multi-million dollar expansion. We decided, as part of the training, to check some alignments of recently "installed and precision-aligned" machinery.

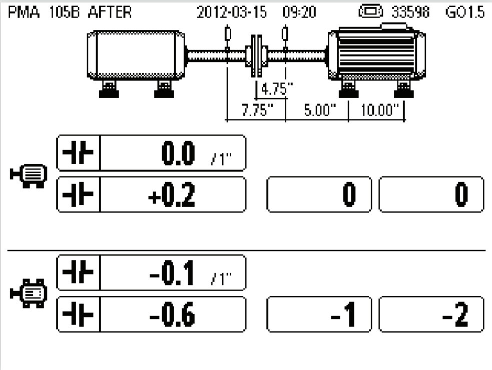
Here's Your Sign

Tags like these were placed on the machines that were supposedly precision aligned. There's just one little problem. Of the machines we checked, 50% were misaligned. Most of them were not out by a tremendous amount, but they were out of tolerance. What's so dangerous about aligned equipment, anyway?

Here's an example:



Before the 'real' alignment



After the 'real' alignment

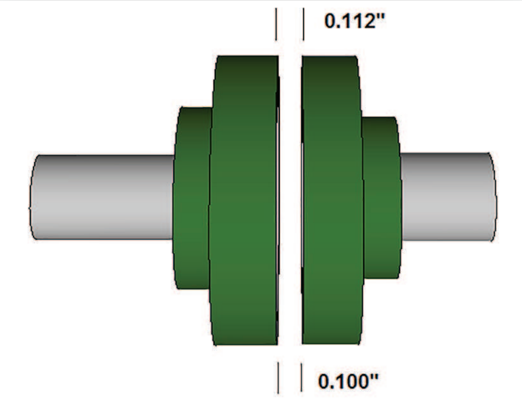
The machine was both base bound and bolt bound. Yet, the mechanics using their GO from VibrAlign corrected the misalignment in less than 1 hour!

The "Danger" part of the sign was correct!
Don't trust a handmade sign!

DEFINING ANGULARITY IN SHAFT ALIGNMENT

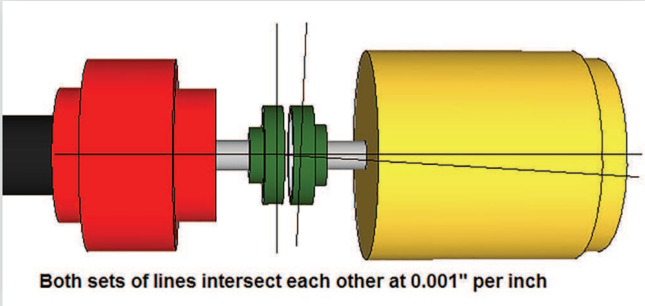
By Stan Riddle
November 27th, 2012

There are only two types of measurements for shaft misalignment – offset, which may be called parallel or rim, and angularity, which is sometimes called slope, or face. Offset (parallel or rim) is easy to understand. One shaft is simply higher, lower, or to the left or right of the other one.



But angularity can sometimes be confusing.

It means the shaft centerlines intersect at an angle. With dial indicators, we measure it as a gap difference between the top & bottom and/or the side to side of the coupling. If for instance, a 6" coupling has a gap of 12 mils across it (top to bottom), that is its slope.



It's important to note that, in this example, a slope of 0.012" across a 6-inch coupling face results in an angularity of 0.012"/6 inches, or 0.002"/inch (2 mil per inch). Since the coupling faces and the shaft centerlines are perpendicular, exactly 90 degrees, the slope change across the coupling faces is the same as the slope change along the lengths of the shaft centerlines. In other words, if the coupling faces have a slope of 2 mil per inch, the shafts also have a slope of 2 mil per inch.

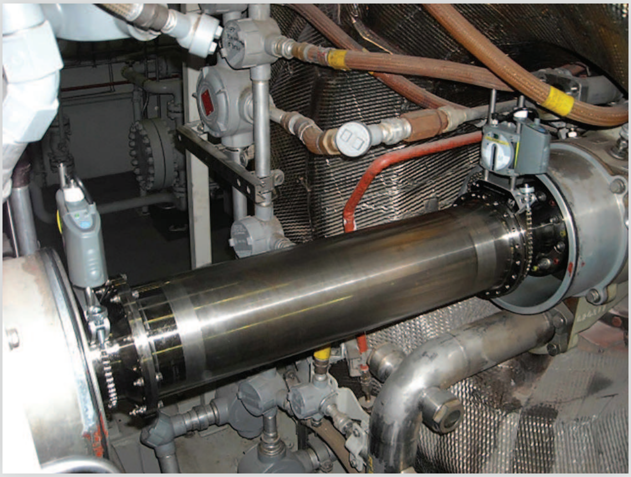
This simply means the slope from the coupling center to the movable machine feet slope at 2 mil per inch. If I measure from the coupling center to the inboard feet, say 18 inches, then the inboard feet need 36 mils of shim (2 mil per inch x 18"). If it's an additional 24 inches to the outboard feet (42 inches total), I need 84 mils of shim at the outboard feet.

This will correct the vertical angularity quite nicely. Horizontal angularity corrections work the same way. We still have the offset to correct, but that is easy to measure once the angularity is gone. Most quality laser alignment measuring tools will show both angularity and offset simultaneously.

CONSIDERATIONS FOR ALIGNING SHAFTS SUPPORTED BY SLEEVE BEARINGS

By Stan Riddle
August 7th, 2012

There are some special considerations to keep in mind when performing shaft alignment on machines which are supported by sleeve bearings, regardless of the type of alignment measuring tool being used.



Bearing Clearances. In all sleeve bearings, there is clearance between the bearing and the journal, or shaft. This amount of clearance should be known. The reason is, since the shaft "floats" on a film of oil between the bearing and journal there is a built-in degree of error which might be measured due to this clearance.

The best way to minimize errors due to clearance is to use a pressurized pre-lube system (if the machine has it). The oil should be circulating through the pre-lube system, and the oil should be at or near the normal operating temperature. If no pre-lube system is installed on the machine being aligned then the machine should be run to achieve normal operating temperature, and should be rotated a few times before shaft alignment measurements are made to ensure a good oil film underneath the shafts. Some mechanics use a viscous lubricant poured onto the bearing, such as STP Oil Treatment; but, this should be approved by the manufacturer and your engineering department before use.

Rotation of the Shafts in the Normal Direction of Rotation. Since there are clearances between the bearings and journals, it is important to rotate the machine in its normal direction of rotation while measuring for shaft misalignment. If the machines are rotated against normal rotation, the relative shaft positions may be different than normal. Even more important is to continue rotating in the same direction throughout the measurement process. Measuring with, and then against, rotation will increase the amount of error. On large machines, this can change the alignment values measured at the coupling by several mils.

Be Mindful of What's Going On Inside the Machines. On machines with large gearboxes, massive components, or reciprocating components, shafts can deflect slightly and momentarily, depending on things such as valves opening and closing, cams and gears loading and unloading, etc.

Almost all of these special circumstances can be controlled by following these simple guidelines:

- Ensure the machine is warm and has a good lubricant film.
- Rotating in the same direction, WITH ROTATION.
- Measuring in the same relative angular position each time.

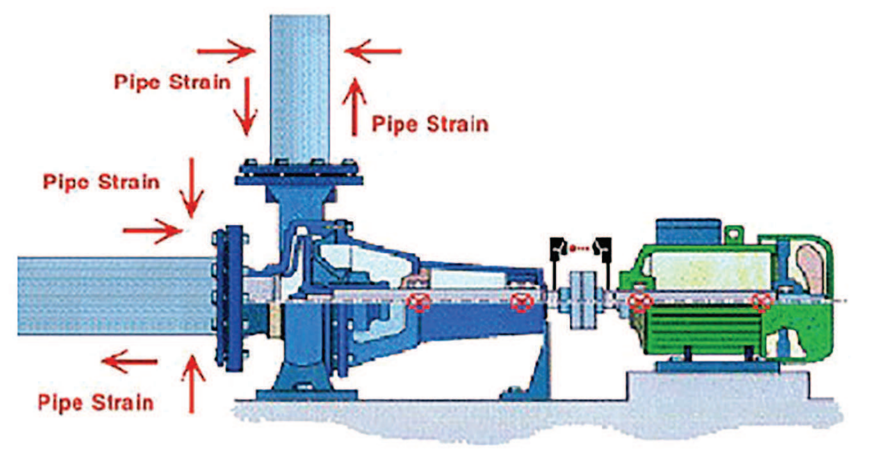
Are you taking the necessary steps? Need additional help?
Give VibrAlign a call.

USING A LASER SHAFT ALIGNMENT SYSTEM TO CHECK FOR PIPE STRAIN

By Michael Keohane
July 7th, 2014

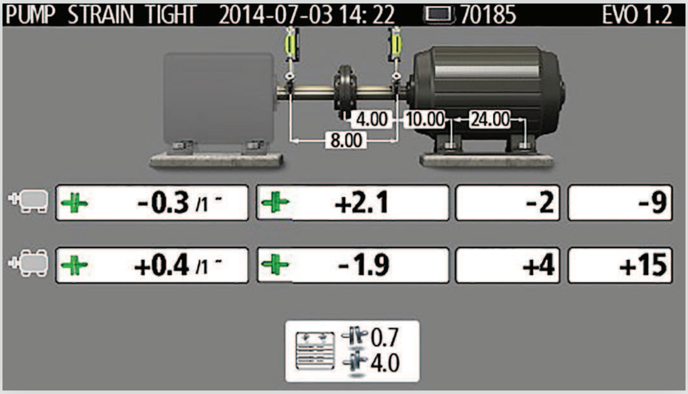
Pipe strain is a relatively common problem seen in pump installations. It is a cause of premature bearing and seal failure. Here is a link to an excellent article from Pumps and Systems magazine that discusses the detrimental effects of pipe strain.

www.pump-zone.com/topics/seals/how-do-plant-pipe-strain-problems-affect-my- pumping-systems



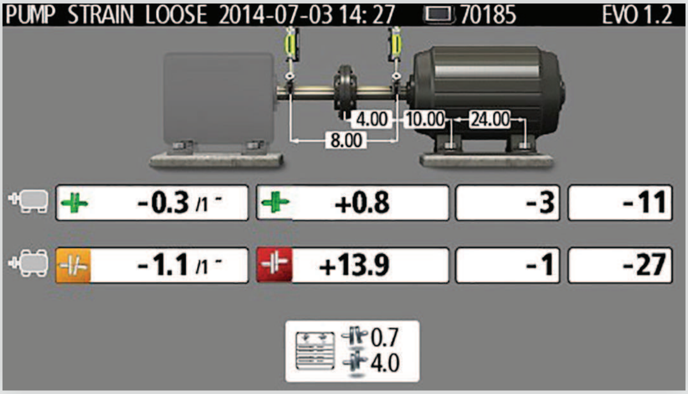
You can easily measure the effects of pipe strain using dial indicators or your laser system. Simply measure the misalignment with everything tight and then re-measure after loosening the pipe flange. Here is an example:

1 – Measure misalignment with everything tight:



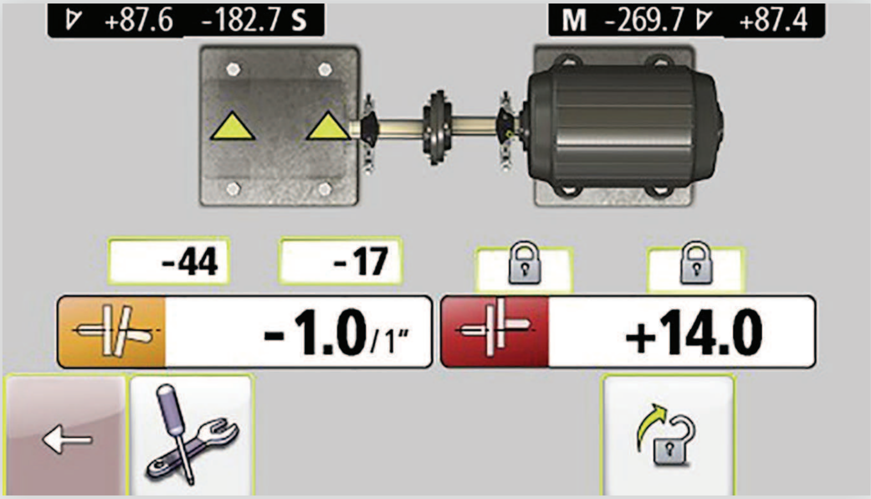
In this case the machine is well within alignment tolerances for an 1800 RPM machine.

2 – Loosen the pipe flange and re-measure the misalignment:



In this particular example the vertical misalignment did not change very much but the horizontal changed quite a bit, indicating that pipe strain is an issue in the horizontal direction.

3 – If you want and have the capability, you can use a foot-lock function to see the effects on the pump itself. Alternatively, you could have also set up with the pump as the movable element and look at it that way.



Unlike OL2R (off-line to running) measurements made to check for thermal growth, you would not typically try and compensate for pipe strain during the alignment, but it is very important to correct it up front for maximum machine life.

ABOUT THE AUTHORS

GET TO KNOW YOUR HOSTS

DAVID ZDROJEWSKI

David is the founder and CEO of VibrAlign. He is passionate about helping people improve machinery reliability, helping his colleagues grow personally and professionally, and promoting technical education in the USA through the Realigning America Scholarship program. He has authored numerous articles and training manuals on subjects associated with asset management. As an accomplished trainer, David keeps his hand in the training business despite his many other business duties.

STAN RIDDLE

Stan Riddle joined VibrAlign in 2008. He has 30 years experience in aligning industrial machinery. Stan received his AAS Degree in Machinist Technology from Surry Community College in Dobson, NC, and also holds a diploma in Industrial Systems Technology from Forsyth Technical Community College in Winston-Salem, NC, where he was also an instructor in the program.

Stan began his maintenance career working as a machinist and millwright for companies such as Weyerhaeuser, R.J. Reynolds, and Tyco Electronics. He also has over 25 years experience in Predictive Technologies, such as vibration analysis, thermography, oil analysis, and ultrasonic inspection. He is a certified Level III Vibration Analyst with the Vibration Institute, and is a Past Chairman and Board Member of the Piedmont Chapter.

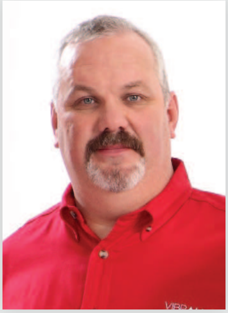
Stan and his wife live in Yadkinville, NC.

BRAD CASE

Brad Case has been associated with VibrAlign since 1990, first as a manufacturer's representative, then joining the company as a direct employee in 2005. He has 25 years experience in aligning industrial machinery. Brad attended Texas Tech University, in Lubbock, TX.

Brad began his career in the automotive industry providing technical training, sales, and service for Murray Goldseal, an aftermarket air conditioning component manufacturer. His background includes 25 plus years experience in sales, service and training, of Centralized Lubrication Systems (including large scale Oil Mist applications in petrochemical facilities), Couplings, Gearing, and Gear Reducers.

Brad and his wife currently live in Allen, TX.



JAMES PEKAREK

James Pekarek joined VibrAlign in 2013. He has 18 years of experience in machine installation, electrical systems, maintenance and service management.

James began his career in the automation industry installing and maintaining various types of machinery and performing technical training to customers in the semiconductor industry. He spent 3 years with Cummins Industrial Power Generation as Service Manager. James also spent 3 1/2 years as lead Electrical Instructor at a vocational college serving the Wind Industry. While there, he gained his NFPA 70E certification as well as NEC 1910. James is also a certified Electrical Safety Instructor.

During his technical instruction career, James was introduced to VibrAlign and many of the products. He was impressed by the company philosophy and values and decided to pursue a career as a technical instructor with us.

James and his family live in Vancouver, Washington. He enjoys the outdoors, family time and building cars.

TOM SHELTON

Tom comes to us as the result of a positive customer experience with VibrAlign. After 16 years with Wausau Paper in Rhinelander, Wisconsin, he was transferred to a greenfield project in Harrodsburg, Kentucky. One of this tasks was to research alignment tools. As Tom tells it, "I was amazed at the ease of use the VibrAlign tools offered. Then to understand the values of VibrAlign… I wanted to be part of this team."

Tom is a Journeyman Millwright/Pipefitter with 16 years in the paper industry and customer service training provided by Walt Disney World in Orlando, Florida.

MAC MACCORMACK

Mac was a Journeyman Millwright at a Kimberly-Clark paper mill in Washington State before moving into a Maintenance Team Leader position. Later, he moved to Kentucky where he went to work for Wausau Paper as Maintenance Team Leader on a new mill start-up. This is where Mac was first introduced to VibrAlign. "I was so impressed with the people, passion, and products of VibrAlign. I had always hoped to one day give back some of the knowledge I have been fortunate enough to gain from others in my field. VibrAlign has given me that opportunity."

STEVE GORDON

Steve Gordon has been involved in the machinery reliability business since 1985. After receiving a BA in Economics from the University of Colorado, he worked for Update International for more than a decade involved with training programs for vibration analysis, machinery alignment, mechanical skills and maintenance management. Steve has been with VibrAlign since 1999 and is the Western Regional Manager and Gas Compression Segment Manager.

MICHAEL KEOHANE

Mike Keohane has been involved in machinery reliability since 1985. He started as a field service engineer for IRD Mechanalysis. Prior to that he was a wireline logger for Schlumberger Well Services. He joined VibrAlign in 1992 and supports clients in Georgia, South Carolina, Alabama and the Florida Panhandle. In addition to precision alignment, he has field experience in vibration analysis, field and shop balancing, oil analysis and ultrasonics. Mike holds a BSME from Michigan State University. Mike and his wife and two children currently live in Peachtree City, GA.

PATRICK LAWRENCE

Patrick Lawrence is a Reliability Engineer at Merck in Elkton, VA. A former trainer at VibrAlign, Patrick is now a guest contributor with occasional ponderings on realigning his part of America.

STEVE MATTHEWS

Steve Matthews joined VibrAlign in 1999, shortly after his graduation from the University of Virginia. Over the years, Steve has served as a sales representative, trainer, field services manager, and is now a regional manager at VibrAlign. Steve is rewarded by helping clients solve machinery problems, and guiding them toward more efficient and effective alignment practices.

MATT RYBALT

Matt Rybalt joined VibrAlign in 2008 and served as an area sales consultant for 6 years gaining experience in the alignment of rotating machinery as well as geometric measurements. Matt is now the Midwest regional manager and recently graduated from Ohio University with an MBA. Matt enjoys spending time with his family, golf and is an avid Ohio sports fan.

BRIAN SHANOVICH

Brian Shanovich has been involved with reliability technologies for over 25 years. As a VibrAlign Product Manager and former Sales Manager, Brian travels the country to educate on the value of precision alignment.

BILLY STANLEY

Billy Stanley is the Reliability and Improvement Technician for the Koch Industries Georgia Pacific Madison GA mill. He has also had corporate responsibility as a Reliability and Improvement leader across the large mills for Koch Industries. Billy is certified in vibration analysis, ultrasonics and thermography.

CHRIS TROUTT, BRI

Chris Troutt is a Maintenance Reliability Engineer and Precision Maintenance professional in St. Louis, MO. Chris shares VibrAlign's passion for precision and continuous improvement and believes sharing past experiences through outlets like the Alignment Blog are an integral part of that continuous improvement.

RICHARD TALLEY

Richard Talley is the owner of Motor Service Technology in Winston, GA. Motor Service Technology offers machinery alignment, balancing and vibration analysis services throughout the Southeast. Richard has over 25 years' experience in the machinery reliability field. He can be reached at motorservicetech@bellsouth.net

JOHN VISOTSKY

John Visotsky, president of V-TEK Associates, founded this company in 1992 as an independent technical representative firm for leading technology manufacturers of signal analysis instruments and software. Prior to forming V-TEK Associates, he had more than 25 years experience in electronics manufacturing and engineering, with 15 years in management and supervisory positions focused primarily on signal acquisition instruments. John's final position prior to forming his company was VP Operations at Rockland Scientific Corporation, a manufacturer of Dynamic Signal Analyzers, Signal Generators and Filter Systems.

NOTES

VIBRALIGN

US$19.95

ISBN 000-0-00-000000-0
Placeholder
0 000000 000000