THE ALIGNMENT FIELD GUIDE

SECTION: SAVING TIME & MONEY

VIBRALIGN

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

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

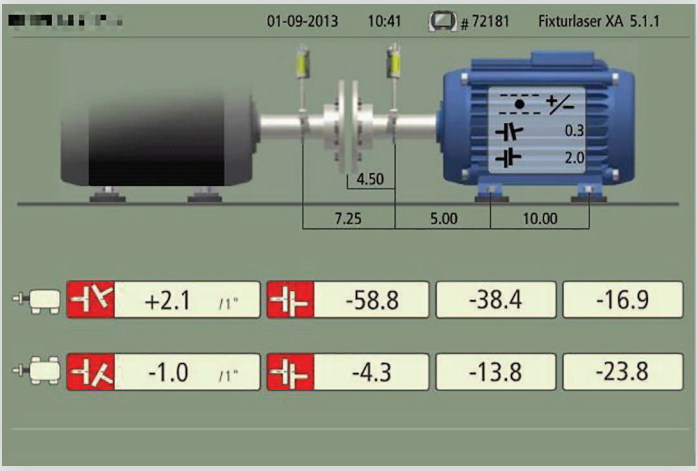
During our Best Alignment Practices Training classes our staff of VibrAlign Trainers stresses the importance of rough aligning the machines as part of the pre-alignment steps. The main reason to do so is to minimize the coupling influences on the movable and stationary machines' rotational shaft center-lines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

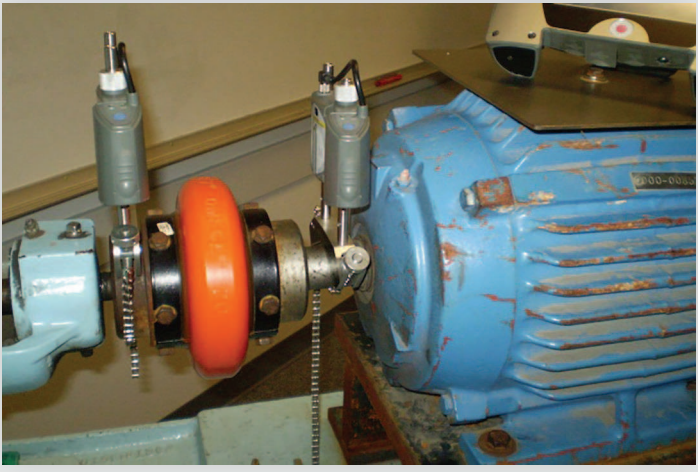
When two machines are grossly misaligned, even flexible couplings can influence the alignment readings whether you are using dial indicators or a laser shaft alignment system. The question that does come up in class is "how much can the coupling influence the alignment readings or results?" The answer(s)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

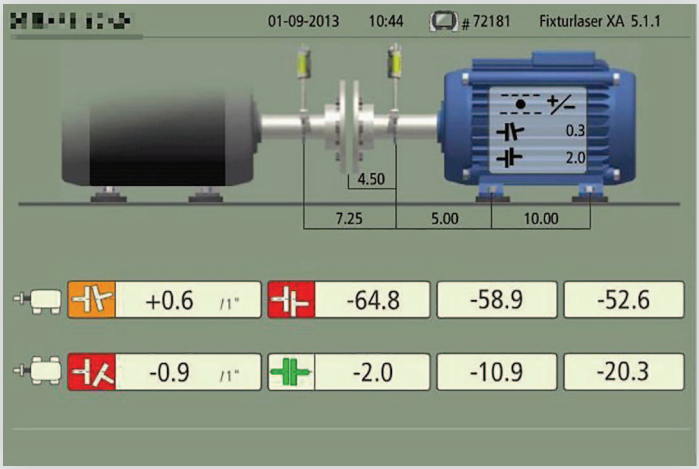
So how much can a coupling influence the alignment? Good question! I recently had the opportunity to experiment with a 30 HP pump and motor set with a "tire" style flexible coupling. All shims were removed from under the motor feet and 3 sets of measurements were taken. 1st with the coupling assembled,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

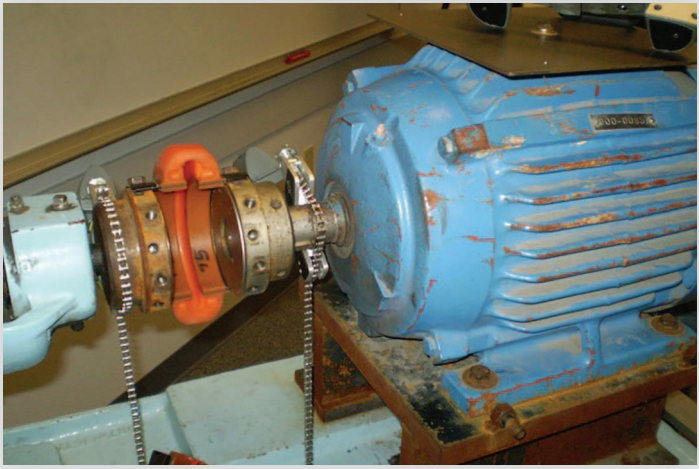
Results with coupling outer covers in place.



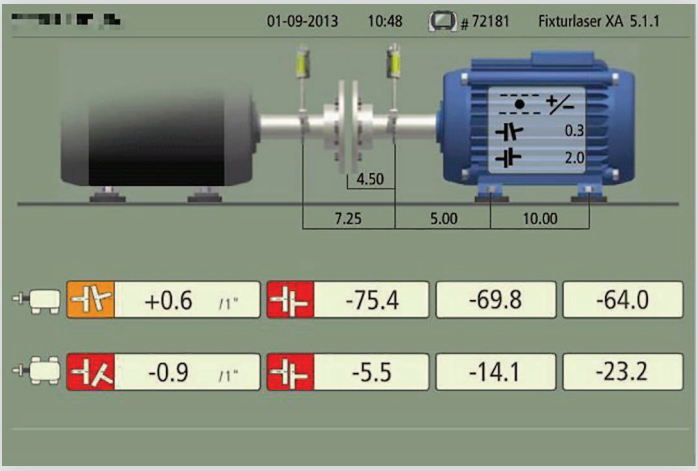


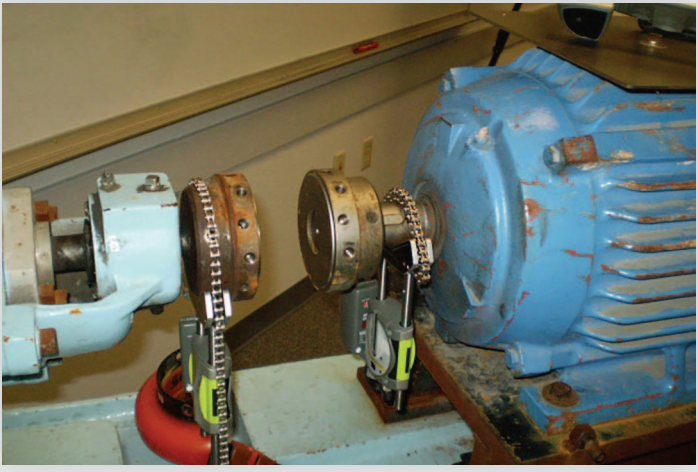
Results with one half of the outer cover removed.





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.

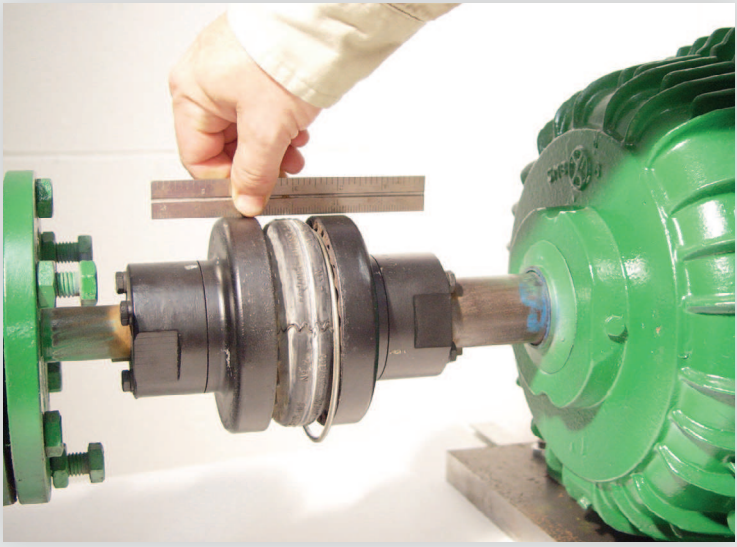
ROUGH CORRECTION OF SOFT FOOT

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.

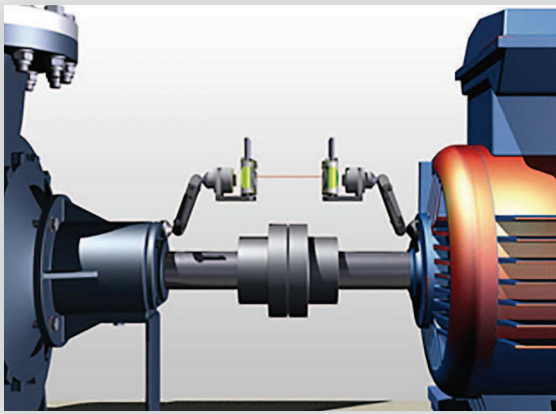
This allows for very precise targeting of rotating machinery during a shaft alignment while the machines are OffLine. When a precision shaft alignment is performed, the goal is to have the rotational centerlines of the machines collinear when in a running state. Due to dynamic forces such as thermal 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?

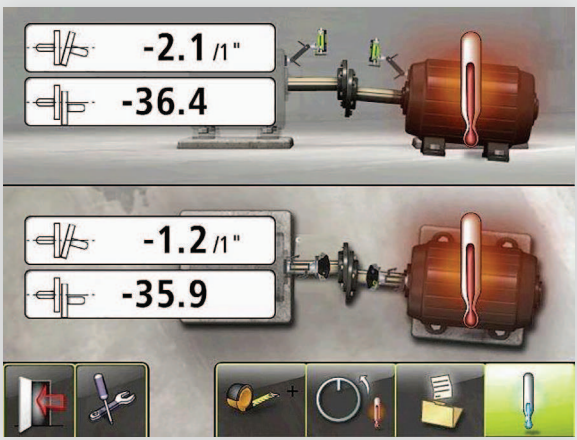
Usually from manufacturer-supplied data or calculations of some type which are typically only for changes in the vertical plane. When using the OL2R program and brackets you get REAL data regarding position changes for the specific machine(s) in question. Not only will you see any vertical changes in 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;

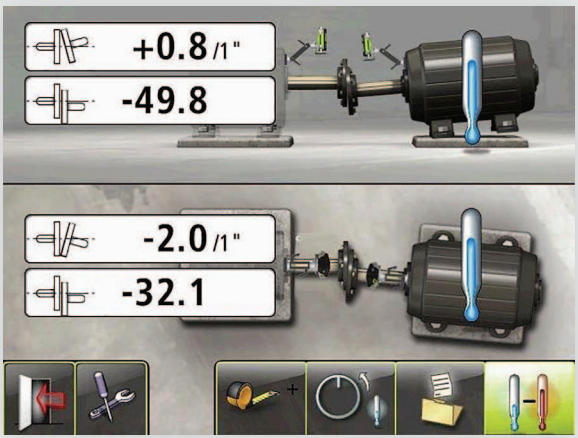
1st – Mount the OL2R brackets to the stationary and movable elements of your machine. Make sure that you are able to replace coupling guards without disturbing the brackets.



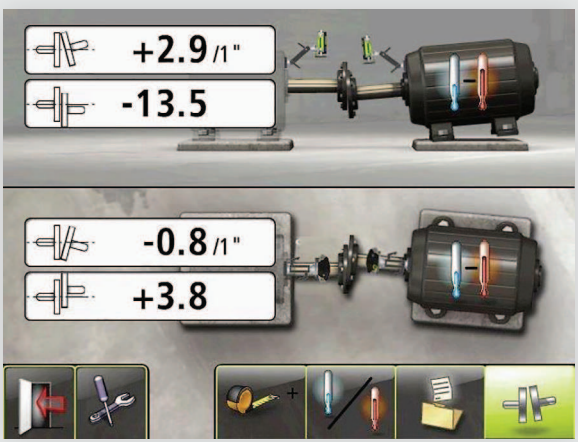
2nd – Take the "Live" hot reading with the machines at full running state, up to temperature and under common load and save it. The "Hot" Position will be displayed. Note: this is not an indication of the actual hot alignment, but simply a known "Hot" Position. (You can also start by taking the "Cold"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