

Soft Foot – The Boogeyman of Precision Alignment

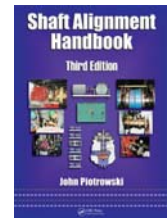
By Paul Berberian

Soft Foot – the boogeyman of precision alignment



Soft foot is one of the most prevalent conditions found in rotating machinery. This condition, if not corrected, makes an alignment job much more difficult and sometimes impossible. If the internal alignment is not correct, the external alignment won't matter.

In his book, **Shaft Alignment Handbook**, noted alignment expert *John Piotrowski*, defines soft foot as the condition "when rotating equipment is set into place on its base, frame or sole plate, one or more than one of the "feet" are not making good contact at the foot points of the frame." More generally, the condition is caused when there is poor (or no) contact between the feet and the machine base.



Think of it this way – three points (machine feet in our case) define a plane. When the fourth point, or foot is shorter than the other three there is a "soft foot" condition. This will, in some cases, be demonstrated by a measurable rocking of the machine. This is called gross soft foot. It is easily discernable and correctable with shims. But soft foot that is not as discernable can exist and will cause alignment problems and can even cause machine failure if not corrected.

So, what are the causes of soft foot? The frame can be warped or bent. The base plate can be warped or bent. The foundation can be uneven or have been damaged. Machine feet can be bent or broken. What is more likely is that you will find a combination of these issues.

Besides making alignment difficult, there are many reasons why soft foot should be corrected. Tightening down feet where a gap exists (using torque or tension to remove the gap) will cause feet to be bent and sometimes crack. This can also cause the machine case to warp. This condition will put undue stress on the shaft and upset critical clearances in both the driving and the driven machine – bearings, mechanical and shaft seals, pump wear rings, motor armature, stator gaps – the list goes on. Any critical component that comes in contact with the rotation of the shaft can be affected.



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Soft foot can cause high levels of vibration. Soft foot can be seen as looseness and exhibit a high 1 times vibration signature. In later stages, if left uncorrected, it may show as mechanical looseness as damage is done internally to the machine. Vibration can cause loosening of feet bolts and shims can work their way out from under the feet. At this point, the machine can shift drastically. Looseness may eventually present as a high 2x line frequency (7200 cpm) due to eccentric air gap.

So now we know that soft foot is bad. Let's talk about how to measure it and how to correct it. Even if you have a laser alignment system, it is a good idea to have a couple of dial indicators, a good feeler gauge and a micrometer in your alignment kit. Bring a wire brush for cleaning shims and base plates. A fine flat file is good for removing burrs on base plates and machine feet. You will need a good set of precision shims with actual thickness markings for precise stacking tolerances and some good tin snips – you may have to re-configure your shims. More about that later!

And speaking of shims, make sure they are clean of all rust and debris, especially if you are re-using existing shims. The shim should be wide enough to support the entire machine foot. Make sure any dirt and debris is cleaned from under the foot – we always want good metal to metal contact – base plate to shim to machine foot! Also, remember, we only want 3-4 shims under any foot. More shims than that can actually cause a type of Soft foot called "springy foot". Too many shims will start to act like a spring under the foot, even if the gaps are properly filled.



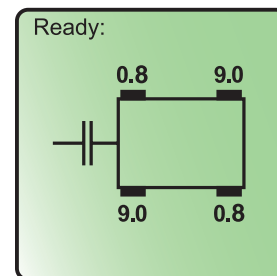
Before you start, check for gross soft foot. Loosen all of the bolts at the motor feet and check for any obvious rocking of the machine. This needs to be corrected with shims. This can be done with a feeler gauge. Make sure you clean the shim packs and only use 3-4 shims under each foot.

There are a number of ways to measure soft foot. You always start any soft foot measurement with all of the bolts securely tightened. As we go through the different methods, keep in mind that the industry standard for the maximum soft foot measurement is 2 thou (mils) or .25mm.

Dial indicators are a very good method of measuring soft foot. Dials should be anchored to the base plate or frame and the dial indicators positioned as close as possible to the bolt holes. Make sure the stems are touching the feet and zero set the dial.

Laser alignment tools include measurement programs for measuring soft foot. Read the instruction manual carefully to make sure you follow the proper procedure.

Now we are going to loosen and tighten each bolt, one at a time, in a systematic way to see how much each foot “springs” when it is loosened and all the other bolts are tight. With dial indicators, the best method is to place a dial indicator at each foot and measure the movement on each dial as you loosen and tighten each bolt. This way you can see the dynamic movement of the entire machine. You can also use one dial indicator and move it from foot to foot as you loosen and tighten. Remember, 2 thou (mils) or .25mm of deflection is within tolerance.

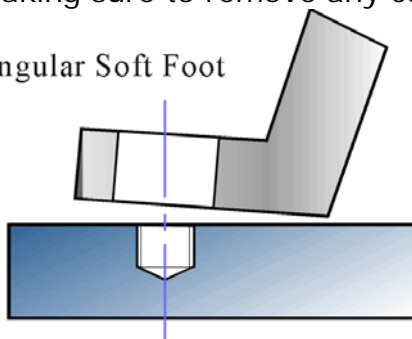


Any foot that rises (springs) more than that needs to be shimmed. The movement of the dial stem will record the spring of each foot. Write each movement down as you continue around the machine. This process is very similar to the one you will use with a laser alignment system. The laser system will record the values for you.

Now that we have done our measurement we have to fix the soft foot. Keep in mind that more than one foot can be soft and each foot needs to be corrected.

Having identified our soft feet, start by removing the existing shim pack from under the foot. Clean the base and the foot of the machine with a wire brush, making sure to remove any corrosion, debris or burrs. Next, use your feeler gauge to measure under each corner of the foot, paying attention for bent or cracked feet. Note the gap at each corner of the foot.

Angular Soft Foot



Now you want to fill those gaps. They may (probably will) be unequal and this is where you will need your tin snips. Full shims can be used for the base of the shim pack, but other shims will need to be cut to fill the different gaps under each corner of the feet. Shims can

be cut and constructed to form a “stair step” under the foot. Shims can also be cut into L-shapes, partial U’s or strips and be used to fill gaps accordingly.

Use the measurements gained by using the feeler gauge to build your shim pack. Use your micrometer to measure the thickness of the shim pack as most shims have a tolerance factor. Do not use more than 3-4 shims under any foot.



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Once the gaps are filled, re-tighten all of the hold down bolts. Use a diagonal pattern to tighten, from one corner to its diagonal opposite. Hand tighten at first, then work your way around the machine in the same pattern tightening each bolt a little more each time. Once the bolts are tight, re-measure – loosening and tightening each bolt one at a time. Make sure that no foot has a deflection of more than 2 thou (mils) or .25mm.

When you're done and you are confident you have eliminated the soft foot, re-tighten your bolts in the same pattern. Now you are ready to start your shaft alignment measurement.

There is a lot of work that can go into proper soft foot correction, but it is worth it. Even though you have aligned the shaft center lines, it does not mean that things are aligned internally once everything is torqued down to specification. Remember, our goal is to always make our rotating equipment last as long as possible. Do it right the first time and you won't have to do it again!

Need more training? Please contact Alignment Supplies, Inc at (800) 997-4467 to find out about our training programs or visit us at www.alignmentsupplies.com

For more information on soft foot and everything you ever wanted to know about shaft alignment, but were afraid to ask, check out John Piotrowski's book, the **Shaft Alignment Handbook** Third Edition.

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