OPEN DRIVE MOTOR ALIGNMENT

NOTE: All compressor interconnecting piping must be checked for excessive piping strain in pipe sizes 2" and larger. Mount two dial indicators on the compressor shaft reading the driver shaft in the X and Y planes. Starting with the largest piping connection and working toward the smallest (above 2"), remove the studs/bolts and make sure that 1) the shaft movement does not exceed .002" in either plane, and 2) the studs/bolts are not bound in their holes. When corrections have been made, tighten the studs/bolts in the smallest connection moving toward the largest using the same shaft movement test. When large lines are attached to the compressor body after alignment an alignment confirmation must be made to insure piping strain has not altered the alignment. If necessary, flame align piping as described in M.M.I.B. 4.6.1.10., and recheck for piping strain per above.

1.1.1. Locate the driver shaft per the shaft separation specified on the general arrangement drawing. Locate the motor shaft at the indicated magnetic center (sleeve bearings) or the center of the motor axial float (anti-friction bearings).

NOTE: For sleeve bearing motors, the end float is usually about ½". A scribe mark or shoulder on the shaft should align with an indicator or the seal cover surface at magnetic center. Refer to the motor IOM. If magnetic center has not been identified, contact Engineering for resolution.

1.1.2. With the driver free standing, check all mounting feet with feeler gauges to determine soft foot. In general, 80% of the foot in contact with the mounting surface (exception: when the component manufacturer provides the shims or when the component foot is excessively large). Correct any observed soft foot with shims. (See Appendix I for soft foot procedures).

1.1.3. Use a straight edge to rough align compressor and driver side to side (parallel alignment). With the straight edge on the compressor side a gap should be observed between the straight edge and the top of the driver coupling if no shims have been installed.

1.1.4. Measure the distance between the straight edge and the compressor coupling rim using feeler gauges. Subtract .010" from the measured amount and shim all four feet of the driver accordingly. Shims should be smooth and free of burrs or damage. Use the fewest number of shims possible under each foot and, do not "bird nest" shims. Shims should be stacked with the thickest shims on the bottom to the thinnest on the top of the stack. No more than 4 to 5 shims should be under any one foot when alignment has been achieved. The thickness of shims (less one spacer plate permitted) shall not exceed 1/4" unless otherwise specified.

1.1.5. Confirm rough alignment using the straight edge. Check the coupling alignment top and bottom and side to side. If no substantial gaps (1/16" or less is desirable) are observed then the alignment indicators or laser alignment gear can be mounted.

1.1.6. Tighten to the torque values shown in **TABLE 4-1** in Appendix 4 (unless otherwise specified on the drawings) and test for softfoot (See Appendix I). Measure for soft foot using the Fixturlaser soft foot function (preferred) or dial indicators as follows unless otherwise specified on GA (GA may include special instructions or refer to driver IOM).

1.1.6.1. DIAL INDICATOR METHOD/SHAFT: Maximum allowable soft foot as measured using the dial indicator/shaft method is .001" (unless otherwise specified). Mount one dial indicator on the driver shaft reading the driven shaft at the 12:00 position. Mount another dial indicator on the driven shaft reading the driver shaft at the 3:00 position. With all mounting bolts wrench tight, zero both indicators. Loosen one bolt and record indicator readings. If any reading exceeds the above referenced limit, softfoot is indicated. Add shims of equal thickness under the loosened foot and the foot diagonally opposite and repeat the procedure until softfoot is not indicated.

1.1.6.2. FACE-RIM METHOD: This is the traditional method and is used for large coupling hubs where the shafts are close together. It is difficult to obtain face readings if the shaft has axial movement. When using this procedure, it is mandatory that the shafts are forced to stay in contact with a machined thrust collar or bearing. Refer to Section 5 for alignment procedure.

1.1.6.3. REVERSE INDICATOR METHOD: This method is becoming more popular. It is generally more accurate than the Face-and-Rim when the shaft gap is greater than the coupling hub diameter. The method is difficult to use because of the graphical representation needed to validate the readings. Refer to Section 4 for alignment procedure.

NOTE 1: Unless otherwise specified on the GA drawing, parallel offset alignment tolerance for screw compressor applications is as follows unless otherwise noted on drawings. See “Alignment units” in glossary.

MODEL	PARALLEL	ANGULAR
Foot Mtd Motors	+/-2.0 mil (.002”)	+/-0.5 mil per in of cplg face dia
RXF	+/-7.5 mil (.0075”)	+/-2.0 mil per in of cplg face dia
RWF	+/-5.5 mil (.0055”)	+/-2.0 mil per in of cplg face dia

NOTE: All compressor interconnecting piping must be checked for excessive piping strain in pipe sizes 2” and larger. Mount two dial indicators on the compressor shaft reading the driver shaft in the X and Y planes. Starting with the largest piping connection and working toward the smallest (above 2"), remove the studs/bolts and make sure that 1) the shaft movement does not exceed .002" in either plane, and 2) the studs/bolts are not bound in their holes. When corrections have been made, tighten the studs/bolts in the smallest connection moving toward the largest using the same shaft movement test. When large lines are attached to the compressor body after alignment an alignment confirmation must be made to insure piping strain has not altered the alignment. If necessary, flame align piping as described in M.M.I.B. 4.6.1.10., and recheck for piping strain per above.

Face and Rim Alignment is the simplest form of indicator alignment. Face and Rim Alignment can usually be used when the distance between the coupling hubs is less than the diameter of the hubs. Before using the Face and Rim Method of alignment eliminate any observable soft foot and rough align using a straight edge until the observed misalignment is approximately 1/32” or less. Starrett 196A (or equivalent) indicators display a .100 “ scale on the face so misalignment in excess of .100” can cause indicator rollover if the indicator movement is not observed closely. Generally, It is desirable to obtain a close angular or “face alignment” first. Figure 1 illustrates the typical relationship between the hubs when in angular misalignment.

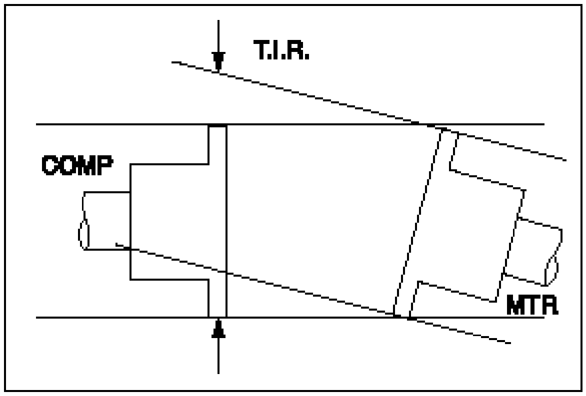


Figure 3

MEASURING ANGULAR MIS-ALIGNMENT

1. To check angular alignment, as shown in Fig. 4., attach dial indicator rigidly to the motor hub. Move indicator stem so it is in contact with the outside face of compressor hub, as shown in Fig. 4.

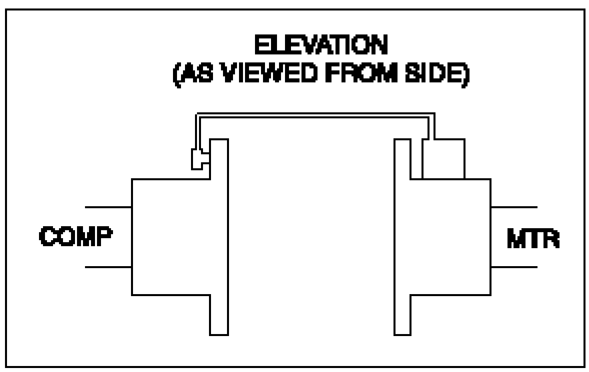


Figure 4

NOTE: When aligning couplings used on motors with sleeve bearings and magnetic centers, it is necessary to secure the two coupling hubs with a bolt to prevent them from drifting apart when rotating.

2. Rotate both coupling hubs several revolutions until they seek their normal axial positions. Check the dial indicator to be sure that the indicator stem is slightly loaded so as to allow movement in both directions. Also verify that the indicator remains in contact with coupling face during full rotation and does not rotate past .100".

3. Set the dial indicator at zero when viewed at the 12 o'clock position, as shown in Fig. 4.

4. Rotate both coupling hubs together 180 (6 o'clock position - as shown in Fig. 5. At this position the dial indicator will show total angular misalignment.

NOTE: The use of a mirror is useful in reading the indicator dial as coupling hubs are rotated.

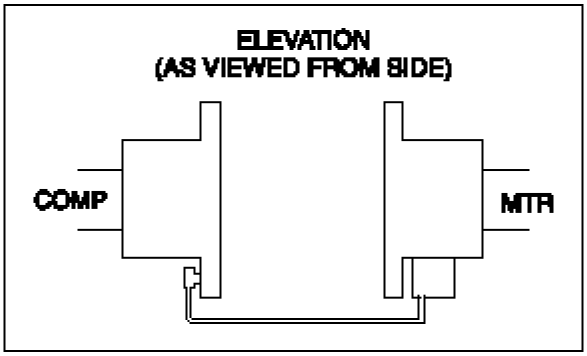


Figure 5

5. Loosen motor anchor bolts and move or shim motor to correct the angular misalignment.

After adjustments have been made for angular misalignment retighten anchor bolts to prevent inaccurate readings. Repeat Steps 3 through 5 to check corrections. Further adjustment and checks shall be made for angular misalignment until the total indicator reading is within the specified tolerance.

PARALLEL ALIGNMENT

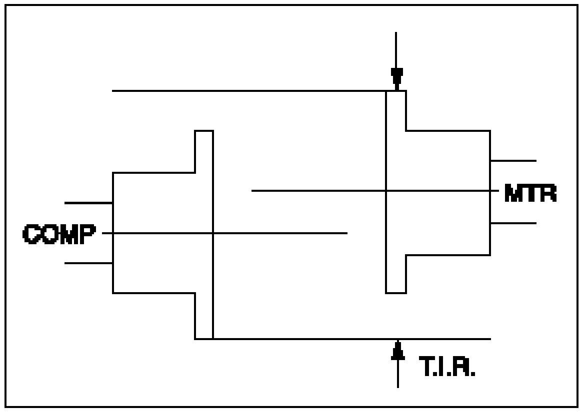


Figure 6

6. To check parallel alignment, as shown in Fig. 6, reposition dial indicator so the stem is in contact with the rim of the compressor hub, as shown in Fig. 7.

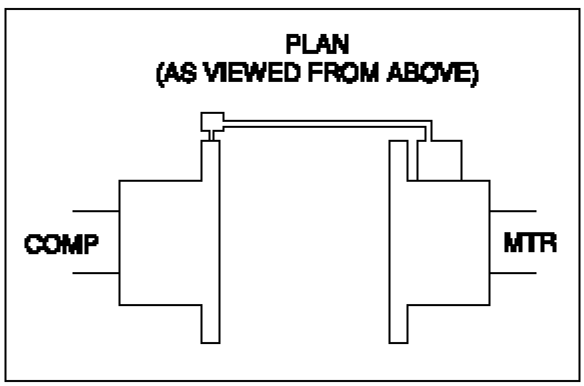


Figure 7

Check the dial indicator to be sure that the indicator stem is slightly loaded so as to allow movement in both directions.

7. Check parallel height misalignment by setting dial indicator at zero when viewed at the 12 o'clock position. Rotate both coupling hubs together 180° (6 o'clock position). At this position the dial indicator will show TWICE the amount of parallel height misalignment.

8. Loosen motor anchor bolts and add or remove shims under the four motor feet until parallel height misalignment is within specified tolerance when anchor bolts are retightened.

CAUTION: CARE MUST BE USED WHEN CORRECTING FOR PARALLEL MIS-ALIGNMENT TO ENSURE THAT THE AXIAL SPACING AND ANGULAR MISALIGNMENT IS NOT SIGNIFICANTLY DISTURBED. **The indicator bracket sag must be checked as all**

brackets have some flexibility. The best way to view this is to attach the dial indicator and bracket on a pipe at the coupling span distance. Zero the indicator in the 12:00 position, and rotate the pipe so the indicator is in the 6:00 position. The reading on the indicator in the 6:00 position is the bracket sag. This value must be included in the dial indicator readings when affixed to the coupling for an accurate alignment.

9. After the parallel height misalignment is within tolerance, repeat Steps 1 through 5 until angular misalignment is within specified tolerance.

10. Check parallel lateral misalignment by positioning dial indicator so the stem is in contact with the rim of the compressor hub at 3 O'clock, as shown in Fig. 8.

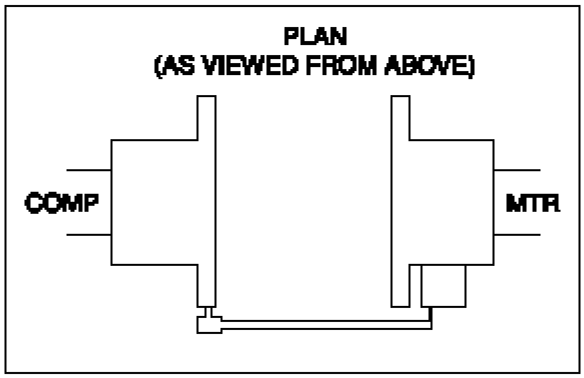


Figure 8

Set indicator at zero and rotate both coupling hubs together 180° (9 o'clock position), as shown in Fig. 7.

Adjust parallel lateral misalignment using the motor adjusting screws until reading is within specified tolerance.

11. Recheck angular misalignment and realign if necessary.

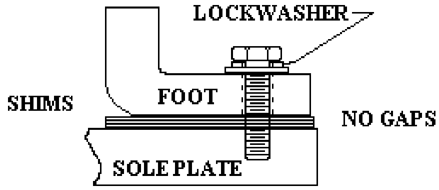
12. Tighten motor anchor bolts and rotate both coupling hubs together, checking the angular and parallel misalignment through the full 360° travel at 90° increments. If dial readings are in excess of specified tolerance realign as required.

13. When the coupling hubs have been aligned to within specified tolerance, a recording of the cold alignment must he made for unit records and usage during hot alignment.

Softfoot

Definition: The term softfoot describes a condition where the machine's feet do not lie in the same plane as the matching surfaces of the base.

Soft foot is a commonly used term to describe a condition where one or more feet of a component to not rest perfectly flat against their supporting base. Theoretically, if all four feet of a component were perfectly flat in relation to each other, and, if the mounting surfaces were perfectly flat in regard to each other, then there should be no gaps when the surfaces are brought together. In the real world a perfect mating of surfaces is not likely and some

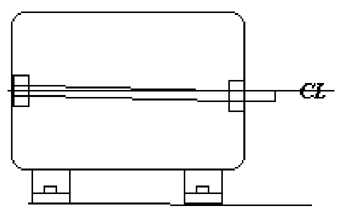


END VIEW
MATING FLAT SURFACES

irregularities exist. The severity of the irregularities depends on the design and tolerances the components are manufactured to.

Three Effects of Soft Foot – Vibration – Bearing wear – Seal Leakage

Soft foot can result in higher vibration levels in machinery by offsetting alignments and deforming machinery casings. Tightening a machine's hold-down bolts to force out a soft foot can result in stressing the machines casing and binding the bearings resulting in vibration and / or premature bearing failure. In compressors seal leakage may be aggravated by a soft foot condition. Soft foot can also cause difficulties in obtaining the predicted alignment as indicator readings may change each time the motor bolts are tightened.



DEFORMATION OF MOTOR CASING

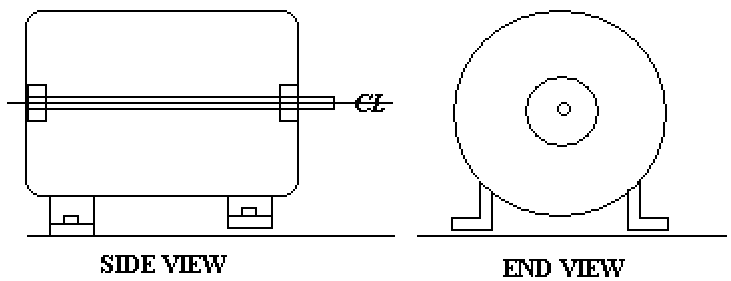
CAUSED BY SOFT FOOT

Types of Soft Foot

We can identify four different types of soft foot, parallel soft foot, bent foot, squishy or rubber foot, and induced soft foot.

Parallel (Air Gap) Soft Foot

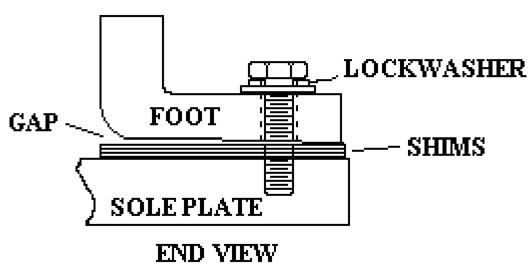
Parallel or air gap soft foot is the easiest of the four conditions to correct. Many motors and compressors are assembled in three components, two end housings and a body. The feet of one end housing may have been milled in the correct plane but not in the same plane as the other housing. As a result, when the motor is placed on a true flat surface two feet on one housing touch the surface before the other two feet. The gap under the two feet not in contact is likely parallel. To correct this problem the same amount of shims are required under each foot of the feet not touching.



This condition is probably the least common but easiest to correct. The amount of gap under each foot is the same everywhere. Simply measuring the gap and adding the same amount of shim stock would remove the soft foot from this machine.

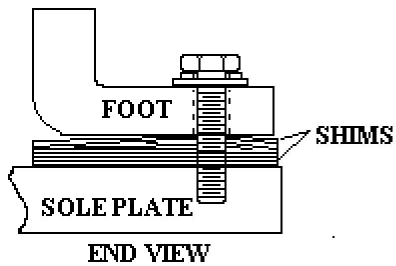
Bent or Angular Soft Foot

Bent or angular soft foot results when the bottom of the machine's foot is either bent or is not parallel to the base (i.e. the base or sole plate is warped). Ordinary shimming methods may not correct this problem. Step or tapered shims may be required.



Springy Soft Foot

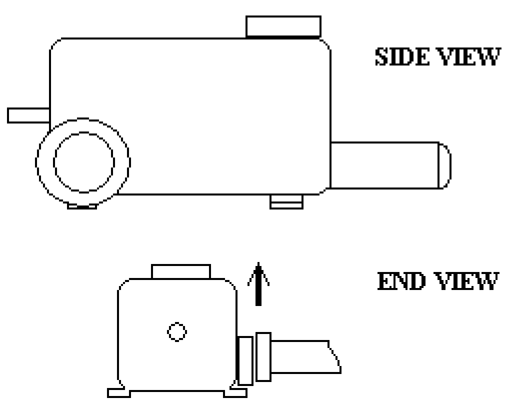
Occasionally, a machine will have a certain amount of soft foot that cannot be detected by a feeler gauge. This results from either too many shims under a machine's foot or bent, burred or dirty shims causing a soft foot condition. The only way to measure the deflection at the foot is using a base mounted dial indicator. The amount of soft foot deflection results from the feet springing up from the base. Any deflection of either the machine's shaft or foot cannot be corrected using a feeler gauge, as there is no visible gap between the foot, base or shims.



Stress Induced Soft Foot

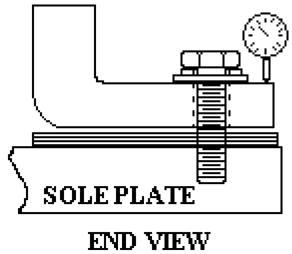
Stress induced soft foot is probably the most difficult to detect. External forces resulting from pipe strain, improper leveling, or coupling strain can cause distortion and result in a soft foot.

Most of the time, this is seen as a soft foot condition on one side of the machine. The external forces will usually cause a rocking side-to-side or front-to-back movement of the machine. Caution must be taken when analyzing this type of soft foot. During the alignment process an effort should be made to ensure all possible soft foot influences are eliminated.

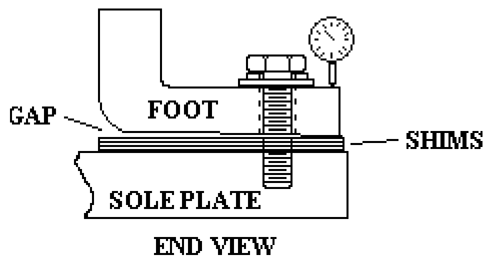


PIPE STRAIN PULL CASING UPWARD
CAUSING A STRESS INDUCED SOFTFOOT

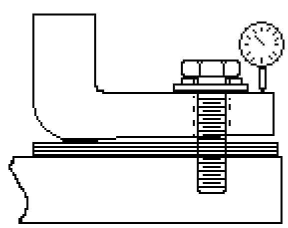
USING A DIAL INDICATOR TO CHECK SOFT FOOT



A) On parallel soft foot, illustrated above, wherever the dial stem is placed it should read the same. The foot should be checked in more than one spot.

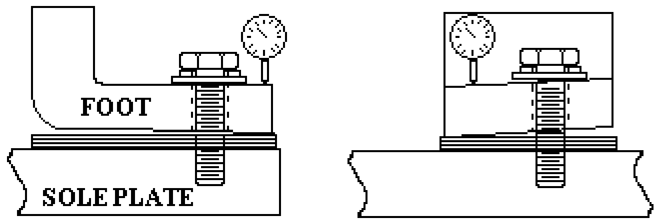


B) In situation above, the foot is touching the base at the furthest out position. When the bolt is tightened, there will be almost no change on the dial reading. Yet, there is a soft foot.



C) In the example above, the foot is touching the base closest to the machine's main frame and the largest gap is furthest out. The foot may pull down but will pass the stress into the casing with unpredictable results.

D) The bottom of a machine's foot may not be the simple plane surface that we might expect.

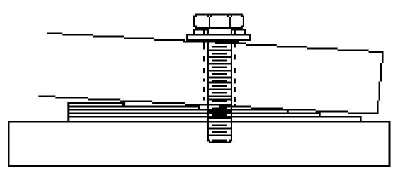


END VIEW SIDE VIEW

In some cases a foot may be out of plane in more than one direction as in the case above. In a case like this, it has been found that the gaps under each corner of the same foot had to be treated separately. In such a situation, ordinary shimming methods would almost always result in a soft foot.

METHODS OF CORRECTING SOFT FOOT

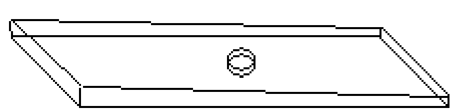
1. The use of step shims is the crudest way of compensating for a non-parallel soft foot. The problem with step shims is they require resetting each time the component is moved. For this reason step shims are not a desirable means of correcting the problem.



STEP SHIMS DO NOT PROVIDE
80% CONTACT

2. Tapered shims or “feather” shims are similar to step shims except the shims themselves taper in one direction from thick to thin. Feather shims may provide more contact area but still pose problems for maintenance and serviceability. Where a soft foot is in more than one direction feather shims would be difficult to arrange.

3. A machined shim can be machined to match the taper of a non-parallel gap. If a machined plate is used the plate should be stamped and match marked to the foot to ensure replacement in the same location and plane.



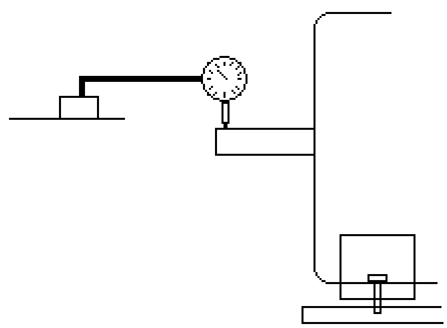
MACHINED TAPERED PLATE

4. Re-machine either the base or the component’s mounting feet.

METHODS TO DETERMINE SOFTFOOT

Two methods are generally used to determine soft foot, foot measurement or shaft measurement.

In the shaft method a dial indicator is mounted to the base or some other rigid support and the indicator is placed on the end of the shaft. All four motor bolts are tightened and the indicator is zeroed out. Each foot bolt is loosened one at a time and the deflection of the shaft is measured by the indicator. Generally .002 deflection is the maximum deflection allowed. While the shaft deflection approach has merit, measuring soft foot at each foot provides a more accurate reading. If foot readings are taken in preparation for alignment and any observable soft foot corrected at that time, a shaft soft foot check should simply service as a confirmation. For details on performing a shaft softfoot check on centrifugal drivelines refer to drawing 560D0132, “Fabrication Notes for Refrigeration Systems using Centrifugal Compressors for PRS”, Section 4.6 and 4.7.



CHECKING FOR SOFTFOOT
USING THE SHAFT METHOD

SHIMMING TO CORRECT FOR SOFT FOOT

On four footed components with feet on separate housings a soft foot condition can occur on a machined flat base front-to-back, side-to-side, or corner to corner. Where soft foot conditions cannot be corrected using full size shims and / or less than 80% foot contact can be obtained, contact engineering for approved methods of disposition. Shim area may be less that 80% of the foot area when the shims are provided by the component manufacturer or the foot area is excessively large.

accuracy -- How close a measurement is to an absolute quantity being measured.

actual runout The actual true distance between centerlines or planes as compared to total indicator runout which is twice the actual.

air gap A type of soft foot characteristic by parallel air space between underside of the foot and the baseplate contact area.

alignment Positioning two or more machines so that the rotational centerlines of their shafts are collinear at the coupling point under operating conditions.

alignment specifications Desired intentional offset and angularity at coupling sight to compensate for thermal growth and/or dynamic loads. Most properly specified as an offset and an angle in two perpendicular planes, horizontal and vertical.

alignment units Alignment units are normally reported in thousandths of an inch or decimal fractions of a meter. The Fixturelaser alignment equipment reports radial misalignment in mils of offset. 1 mil = .001”. Angular alignment is reported in .1 mils per inch of hub diameter. This is equivalent to .0001” per inch of coupling diameter. A 12” diameter coupling for example would have a tolerance of .0012 “ or 1.2 mils. (.0001 X 12).

angularity The angle between two machines shaft centerlines.

axial float/end float Movement of one shaft along its centerline due to he freedom of movement permitted by journal or sleeve bearings.

backlash The torsional play between adjacent moveable parts such as two shafts that are flexibly coupled.

baseplate The surface, often made of steel plate or cast iron to which the feet of a machine are attached.

bent foot A type of soft foot characterized by a wedge shaped air space between the underside of the machine foot and the baseplate contact area.

coefficient of thermal expansion The constant value or factor of expansion of a metal for a given increase in temperature and length of the metal.

collinear Two or more lines positioned in space with no offset or angularity between them. (This is the objective of performing an alignment.) In effect, all collinear lines are the same line.

coplanar Lying or acting in the same plane.

hold-down bolts The bolts anchoring or holding the machine to the base or foundation. Also called base bolts or anchor bolts.

induced soft foot A type of soft foot that is caused by external forces (pipe strain, coupling strain, etc.) acting on a machine independent of the foot to baseplate connection.

jackscrew or jackbolt A bolt or screw attached to the base or foundation used to move or position the machine.

offset Distance between rotational centerlines at my given normal plane, usually measured at the coupling midpoint.

parallel offset the vertical or lateral distance between the shaft centerlines of two components being aligned. Offset is distinguished from T.I.R, which is twice the shaft offset.

perpendicular At right angles (90') to a given line or plane.

reverse indicator Method for taking shaft alignment readings with indicators mounted radially at opposite ends of a manned section.

rim and face A method of measurement when, the indicators are mounted radially and axially during measurement.

sag Deflection due to gravity acting on a cantilevered or a simply supported object.

shim A thin piece of metal material inserted between the base and machine feet to produce precise vertical adjustments of the machine centerline.

soft foot A term used to describe my condition where tightening or loosening the bolts of a single foot distorts the machine frame. Soft foot must be corrected prior to final alignment

soleplate The lower plate to which a machine frame or base is bolted.

specifications Desired intentional offset and angularity at the coupling to compensate for thermal growth/or dynamic loads Most properly specified as an offset and an angle in two perpendicular planes, horizontal and vertical.

squishy foot A type of soft foot characterized by material (could be shims, paint, rust, grease oil, dirt etc.) acting like a spring between the under side of the machine foot and the base plate contact area.

step shim Use of several shims to fill the wedge shaped gap of a bent foot. Each shim is inserted to a different depth so that a stair-step shaped support is built to better support the entire foot. All of the steps together are called a step shim.

thermal growth Movement of shaft centerlines associated with (or due to) a change in machinery temperature between the static and operating condition.

tolerance The maximum permissible deviation from a specified alignment position, defining the hints of offset and angularity.

total indicator runout (tir) The sum of the deviations from zero on the indicator taken from two positions. For example a reading of –.015 at the 3 o'clock position and a reading of .027 at the 9 o'clock position would be a total indicator runout of .042. The actual runout would be one half that amount or .021.