Recommendations
for Aligning
Open-Drive
Compressors

Application Data – Aligning Open Drive Compressors

Introduction

Most alignment procedures are very complicated and hard to follow. Some attempt to correct all four positions of alignment with one set of readings and one move. Most make heavy use of algebraic calculations and graphs and are easily subject to error.

This procedure is simple and straight-forward. These steps performed in sequence will eliminate guess work and backtracking and will consistently result in good shaft alignment.

We'll begin by outlining the four easy steps and the simple calculations that are basic to the procedure. Then, we'll cover the subjects that are common to all alignment procedures such as:

A. Taking alignment readings.
B. Pre-aligning equipment to compensate for thermal changes.
C. Calculating for coupling face runout.

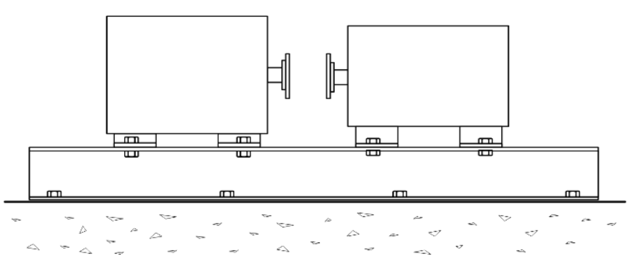

Figure 1 – Example Elevation View

Blueprint drafting standards established long ago that an elevation view is seen when standing beside an object looking straight ahead at the side or end of the object. Figure 1 shows a simplified diagram of two components in elevation view.

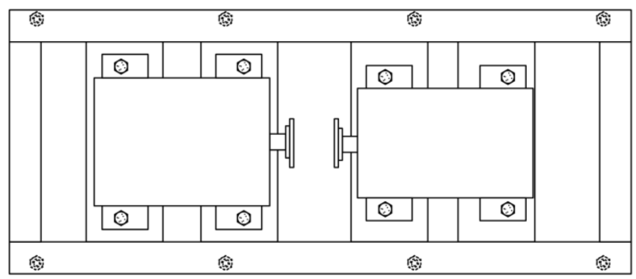

Figure 2 – Example Plan View

A "plan" view is seen when looking down on the object. Figure 2 shows a simplified diagram of the two components in plan view.

Since everyone in the service and building trades must be familiar with blueprints, the terms "Elevation" and "Plan" should be less confusing than some others which could be used.

Types of Misalignment

There are the four types of misalignment which can exist between two pieces of rotating equipment.

1. Angular misalignment in elevation
2. Parallel misalignment in elevation
3. Angular misalignment in plan
4. Parallel misalignment in plan

Figure 3 illustrates angular misalignment in elevation. This position must be corrected first. If any of the other three are corrected ahead of this one, they could be lost when this one is corrected. This correction is made with shims and will not change as the other positions are corrected.

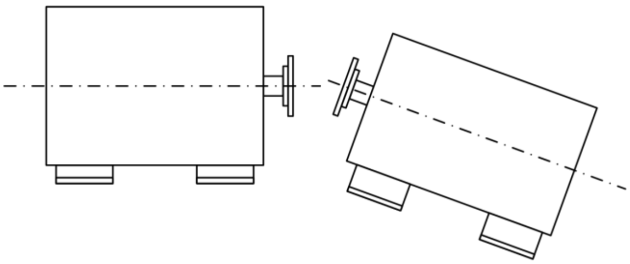

Figure 3 – First Correction
Angular Misalignment in Elevation

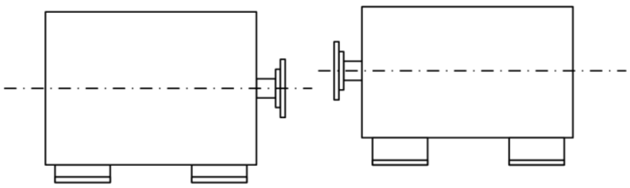

Figure 4 – Second Correction
Parallel Misalignment in Elevation

Figure 4 shows parallel misalignment in elevation. The correction here is straight up or down, involving equal amounts of shim stock under each footing·

If misalignment in the plan view is corrected ahead of the elevation view then one or both elevation corrections could be lost.

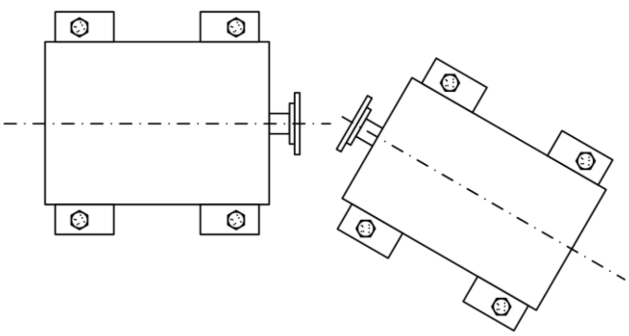

Figure 5 – Third Correction
Angular Misalignment in Plan

Figure 5 shows angular misalignment in plan. The correction here will be to slide the rear end of the movable equipment sideways on the sole plate to correct the angle. This correction must come ahead of fixing the parallel misalignment because the parallel alignment will definitely be affected in the process of correcting the angular misalignment.

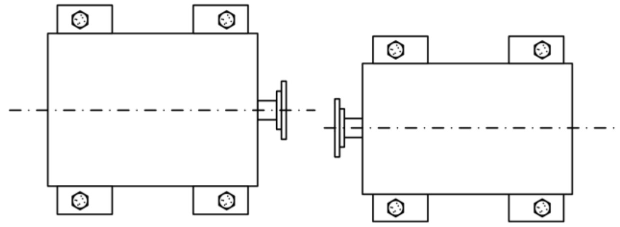

Figure 6 – Fourth Correction
Parallel Misalignment in Plan

Figure 6 shows parallel misalignment in plan. This can be corrected without losing the angular alignment by using a dial indicator at the footings and sliding the equipment straight over an equal amount at each end.

As described, there are four types of possible misalignment. Good alignment can be achieved by correcting each of these independently. However, this process only works when the corrections are made in the exact sequence described. Making corrections in any different order risks disturbing one of the previously completed adjustments.

Correcting the Alignment

It should be noted that the stationary unit is frequently a compressor or pump. The movable unit is most often the driver, such as a motor, engine, etc.

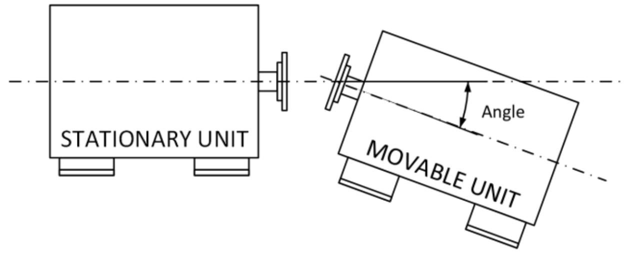

Figure 7 –Misalignment of the Shaft

Figure #7 again shows angular misalignment because the shaft of the movable unit runs off at an angle to the shaft of the stationary unit. Some equipment owners specify that this angle shall not exceed 0.0003" per inch of travel along the shaft. This means that at a point 10" along the shaft from the coupling, it shall not slope away from the other shaft more than .003".

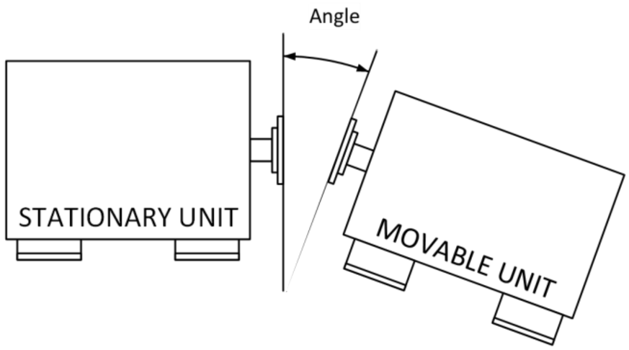

Figure 8 – Misalignment of the Coupling Face

If the faces of the hubs are perpendicular to their shafts, then the misalignment of the coupling hubs (shown in Figure 8) will be the same as the misalignment in the shafts (shown in Figure 7). This is not the reason this is called angular misalignment. We are aligning shafts, not couplings. Always keep this in mind even when taking alignment readings off the face or O.D. of the coupling hub.

As shown in Figure 9, the face of the coupling hub is always at a right angle (90°) to the bottom of the equipment footings. This will remain a constant no matter how high, low, short or long the shaft may extend out of the unit and no matter what moves we make to the equipment.

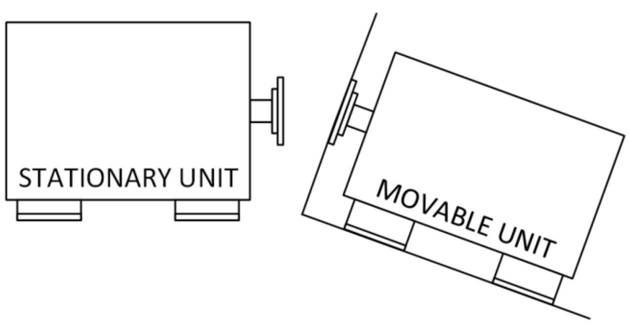

Figure 9 – Orientation of Coupling Hub

Correcting the Alignment

Now we will run through a hypothetical alignment using the four steps and show how to calculate the amount of each move.

Step #1

Correcting Angular Alignment in Elevation

Step 1 corrects angular misalignment in elevation. Assume readings have been taken across the face of the coupling hub, which is 4" diameter, and it is open at the top .005" more than at the bottom.

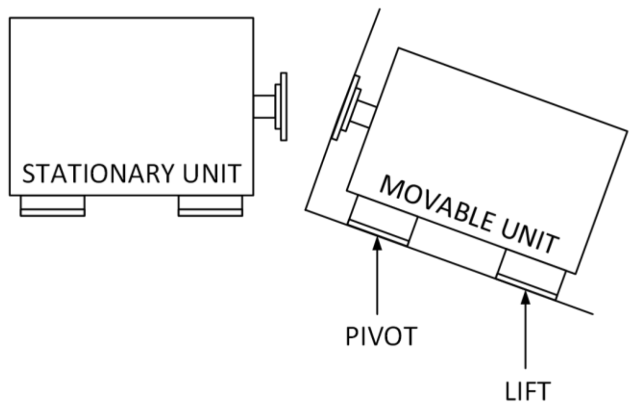

Figure 10 – Pivot & Lift Locations

Lifting the rear footings of the movable unit would tend to close the coupling at the top. To do this, the pivot point becomes the front footings as shown in Figure 10. It is obvious then that the distance between the rear footing and the pivot point (front footing) is a factor in how much the coupling faces will close at the top for any given amount of lift at the rear footings.

With a 4" diameter coupling, if the distance between the front and rear footings was also 4", as shown in Figure 11, then it would be a 1 to 1 ratio and lifting the rear footing .005" would close the coupling .005" at the top. If the distance was 8" between footings, the ratio would become 2 to 1 and the rear footings would have to be raised .010" to close the 4" diameter coupling .005" at the top.

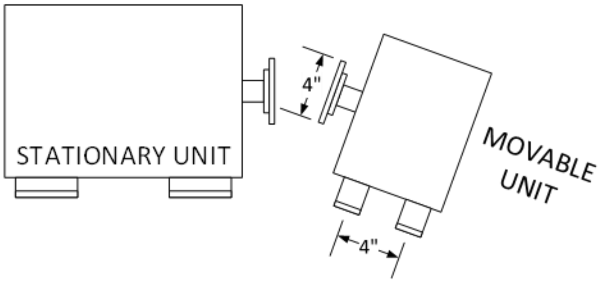

Figure 11 – Relation between Mounting Feet, Hub Diameter and Gap between Hubs

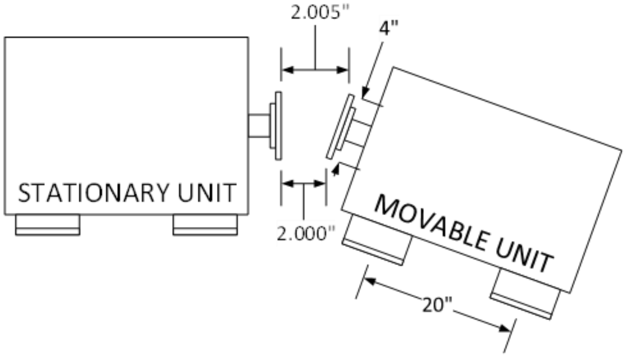

Figure 12 – Correcting Angular Misalignment in Elevation

The conditions shown in Figure 12 are more realistic. We have assumed the coupling is 4" diameter, the distance between front and rear footings is 20", and the opening at the top of the coupling is .005" larger than at the bottom. We make a simple calculation. "How many times will the coupling diameter go into the distance between the front and rear footings?" The answer obviously is 5 times. So five times .005" tells us that a shim .025" thick placed under each rear footing will bring the coupling into good angular alignment in elevation.

The distance between footings is measured from center to center of the hold-down bolts.

In our hypothetical measurements for Step #1, we assumed that the alignment check was made with a dial indicator with its button on the coupling hub face very close to the edge of the 4" diameter as shown in Figure 13.

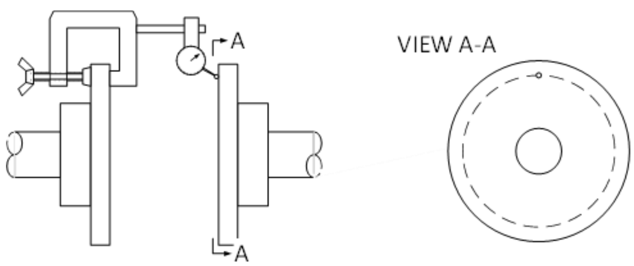

Figure 13 – Measuring Directly on the Hub Faces

Actually, the indicator button could be placed closer to the shaft center or further out from center if the coupling hub face is larger in diameter.

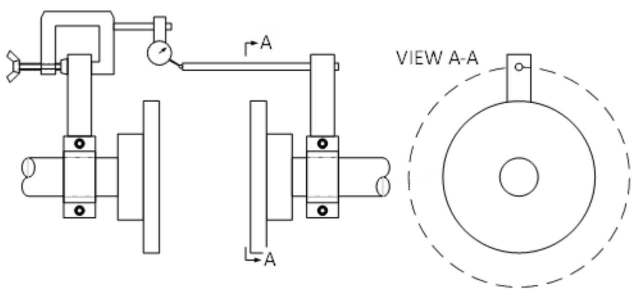

Figure 14 – Using Alignment Brackets to Increase the Measurement Diameter

The reading could even be taken off brackets attached to the shaft as shown in Figure #14. Now, the dial would rotate through a circle much larger than the coupling hubs. Using this larger diameter will improve the accuracy of the adjustments.

It is actually the diameter of the circle through which the button of the dial indicator rotates that must be divided into the distance between the front and rear footings of the movable unit.

After adjusting misalignment, always recheck to confirm that the correction was properly made.

Step #2

Correcting Parallel Misalignment in Elevation

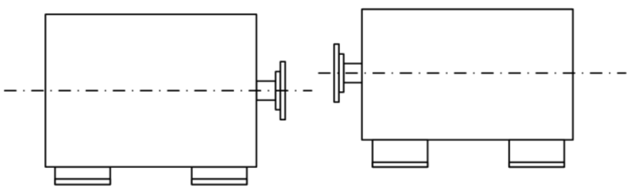

Figure 15 – Parallel Misalignment in Elevation

Step 2, correcting parallel alignment in elevation is very simple. With a dial indicator, check to see how high or low the shaft of the movable unit is in relation to the shaft of the stationary unit.

We will get into detailed use of the dial indicator later. For now, let's assume the shaft of the movable unit is .012" below the shaft of the stationary unit. Placing a .012" thick shim under each of its footings will bring the shafts into good parallel alignment in elevation.

Steps 1 & 2 are complete, the shafts are now aligned in the elevation. These corrections were both obtained with shims, Steps 3 and 4 will make additional corrections within this plane and thus will not affect the adjustments made in these first two steps.

Step #3

Correcting Angular Misalignment in Plan

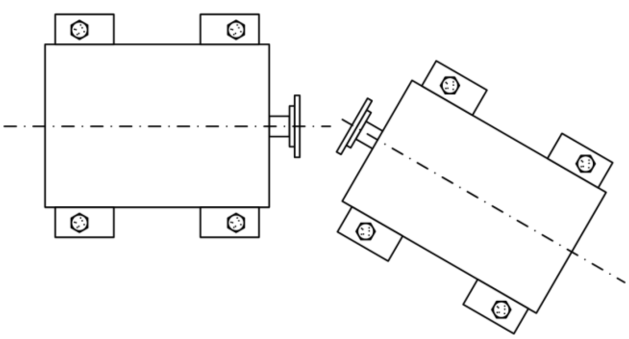

Figure 16 – Angular Misalignment in Plan

Step #3 corrects angular misalignment in plan. The calculation used in step #1 can be used here. Let's assume the distance between coupling faces is .008" greater on one side than on the other side. Divide the coupling diameter (4") into the distance between the front and rear hold down bolts, (20") and multiply by .008" (20 ÷ 4 = 5, 5 x .008" = .040"). So, the rear end of the movable unit will have to be moved exactly .040".

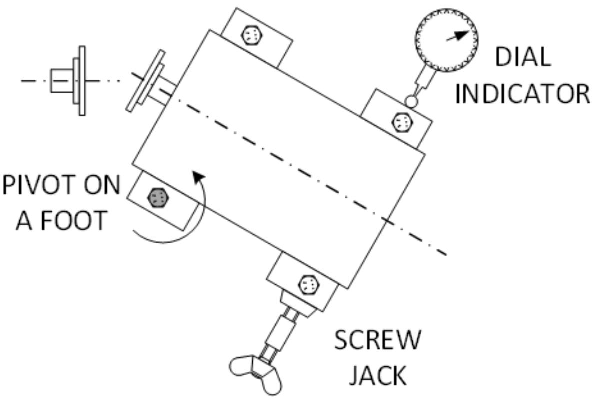

Figure 17 – Parallel Misalignment in Plan

To do this, place the dial indicator against the rear footing on the side which has the larger coupling opening as shown in Figure 17. It must be exactly in line with the hold down bolt. Set the indicator on zero.

Place a screw jack in position at the opposite rear footing to move the equipment toward the indicator.

Loosen both rear hold-down bolts and one front hold-down bolt.

Turn the screw jack and move the rear end against the indicator until it registers .040".

Tighten all hold-down bolts and recheck the indicator. If it has changed because of tightening the bolts, then loosen the same three bolts and readjust. It may be necessary to over-shoot or under-shoot the desired reading to have it come out right when the bolts are tightened.

Recheck angular misalignment. This pivoting move (Step #3) can be influenced by burrs on the bottom of very large footings. Burrs may cause the pivot point to be slightly off the exact distance between the hold-down bolts. The difference would be very slight. But if this happens, recalculate and make a second move. The same percentage error on the second move will bring the alignment well within tolerance.

Step #4
Correcting Parallel Misalignment in Plan

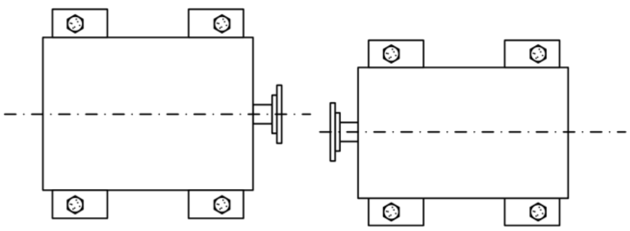

Figure 18 – Parallel Misalignment in Plan

Step 4 is to correct parallel misalignment in plan.

With a dial indicator attached to one shaft or coupling and the indicator button on the outside diameter of the other shaft coupling hub, find how much the shafts are offset one from the other. Let's assume it's .045".

Now the trick is to move the movable unit straight over .045" without disturbing the angular alignment made in Step 3.

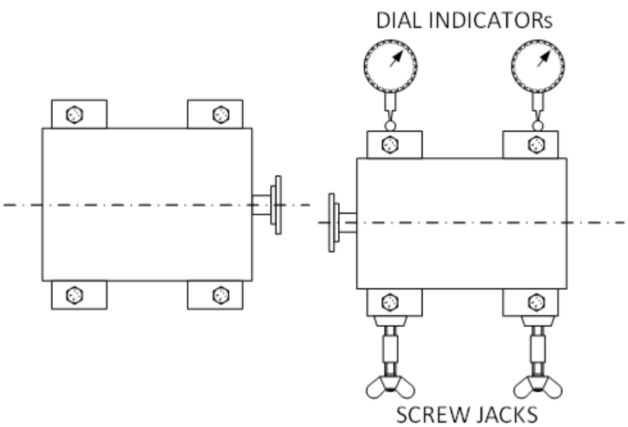

Figure 19 – Using Two Screw Jacks to Correct Parallel Misalignment in Plan

If you have two dial indicators and two screw jacks, you can set up and make the move as shown in Figure 19. If there is only one indicator on the job, then use it and the screw jack at the footings the same way you did in Step 3. Move one end of the unit against the indicator until it shows .045". Tighten the hold down bolts and move the indicator and screw jack to the other end of the unit. Loosen three of the hold down bolts and move this end .045". The pivot point must be on the same side of the equipment for each of these moves.

Recheck to be sure parallel alignment is within .002", and that angular alignment has not been disturbed.

When making angular adjustments in plan, the distance between the ends of the shaft will always be affected. This distance is important and should be held very close to the coupling manufacturer's recommendation which is usually stamped on high speed coupling hubs.

Check the distance between the shaft ends, then decide how to make the adjustment.

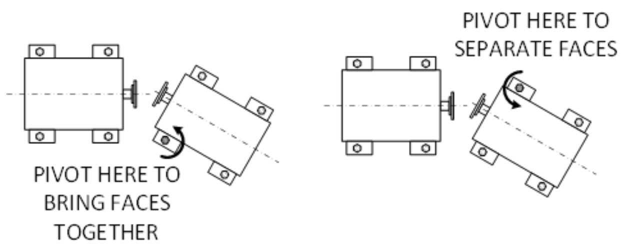

Figure 20 – Selecting the Pivot Location

As shown in Figure 20, pivoting on the front foot on the closed side of the coupling will shorten the distance between the shaft ends, whereas, pivoting on the front foot on the open side will lengthen this distance.

If the distance between shaft ends must remain as is then pivot half the required movement on one front footing and half on the other.

Temperature Effects

Up to this point, we have talked about aligning the shafts as close as possible to zero on the dial indicator.

There will be occasions, however, to intentionally misalign the shafts when the machine is cold so they will move into good alignment as operating temperatures take over.

Cast iron and steel will expand or shrink approximately 0.000006" per degree Fahrenheit change in temperature per inch of material length. Therefore, if the shaft's center is 20 inches above the bottom of the footings and the operating temperature is 50 degrees above the temperature at which the alignment was made, then change in the height of the shaft centerline can be estimated as follows:

$$\Delta Height = 0.000006\ {}^{in}/_{in\cdot{}^\circ F} \times 50^\circ F \times 20in$$

$$\Delta Height = 0.006\ in$$

The shaft will have moved upwards by approximately 0.006”.

Most equipment can be aligned as close to zero as possible and operated until it reaches normal operating temperature. Then shut down and check the alignment as quickly as possible. You can try to realign the machine before it cools down too far from operating temperature or wait and let it cool all the way to room temperature, then reset it to compensate for the changes you now know occur.

Estimates of machine changes caused by temperature changes are just estimates.

No machine is truly aligned until the alignment is checked at operating temperature, the necessary adjustments are made, and the alignment is checked again at operating temperature.

Doweling

After alignment has been checked at operating temperature (hot check), and final alignment completed, all machine components must be doweled to their sole plate or base.

Doweling each component allows for precise repositioning of the components if they have to be moved.

Dowel pins are provided with the 5H motor fastening accessory kits.

Kit #	Dowel Size
5F40401	#6
5F60401	
5F40401	#7
5F40801	
5H40401	

Fit the dowel pin so it extends through the rigid frame and sufficient length is left above the equipment foot to accommodate removal.

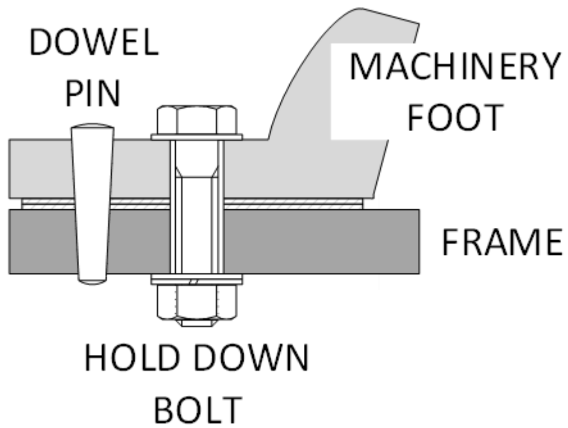

Figure 21 – Doweling

In the event of realignment, it is best to drill new holes rather than try to ream deeper into the old holes.

Place the dowel pins as nearly vertical as possible.

Before inserting the dowel pins into the reamed holes, coat them with an anti-seize, rust preventative compound.

Tap the dowel pins lightly into position with a small machinist's hammer. A ringing sound will indicate proper seating.

Carlyle compressors should be doweled only on the suction end of the compressor. Motors should be doweled in accordance with the manufacturer’s instructions.