SHAFT ALIGNMENT

(1) General Overview

Website: www.ttetraining.ltd.uk

Shaft Alignment

WHY ?

- to allow two shafts to run as one
- to reduce vibration
- to prolong the life of the equipment

Recording Shaft Misalignment

WHY ?

- to allow referral at a later date
- to allow data to be monitored
- to permit readings to be checked

What is the relation between alignment and machinery performance?

Alignment = Performance

Precise alignment between the pump and driver is mandatory for the correct pump system performance.

Incorrect alignment is one of the major causes of rotating equipment failure.

Results of Shaft Misalignment

- Excessive vibration(destructive).
- Abnormal bearing and coupling wear as both will exposed to additional loads.
- As a result equipment reliability life will diminish.

Alignment Methods

Specify Alignment Method:

- Initial Alignment.
- Face and Rim Alignment.
- Reverse Indicator Alignment.
- Laser optics Alignment.

Shaft Alignment

There are three methods used in industry to align shafts :

1

Taper gauges /
Straight edge feeler gauge

- **Basic method**
- **Limited accuracy (+/- 0.002”)**

2

Dial Test Indicators :

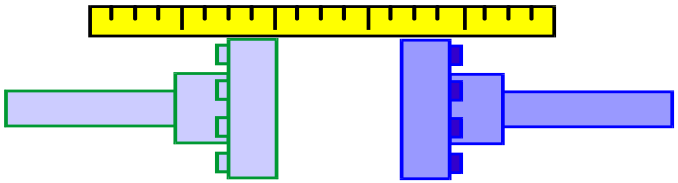
- **Increased accuracy (+/- 0.001”)**
- **Can be time consuming**
- **training required**

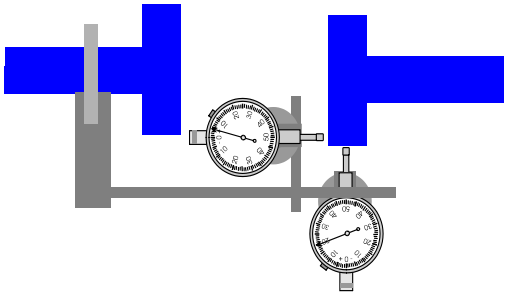
3

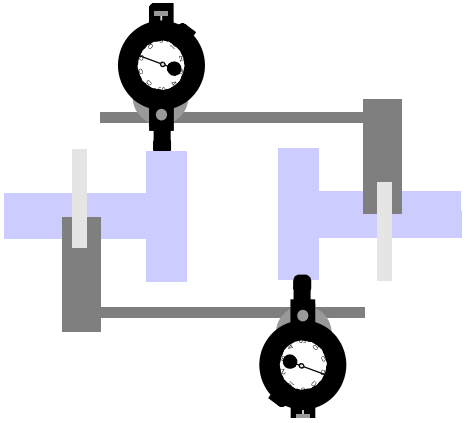
Lasers

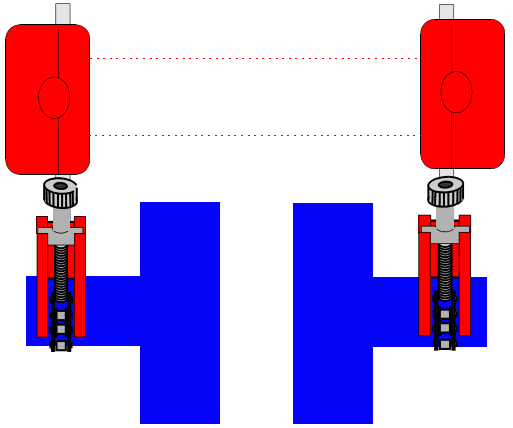
- **Most accurate (+/- 0.001 and below)**
- **Quick to use**
- **Initial cost high**
- **Training required**

Shaft Alignment









Shaft Alignment

To achieve accurate alignment, the procedure must be carried out in logical stages

The pump should be placed in position with relative pipework installed. This is your Datum

Ensure the pump is secure and under no stresses, i.e. Pipework

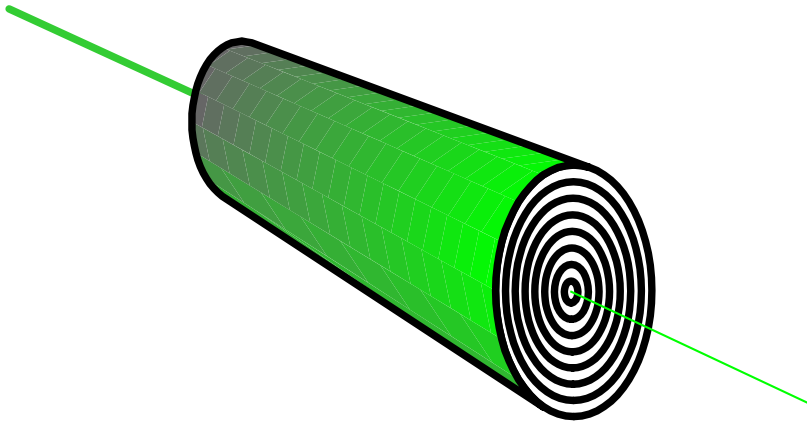
You should use DTIs to check for eccentricity of shaft and coupling

You should use DTI to check end float of shafts pump and motor

NB : Always record readings

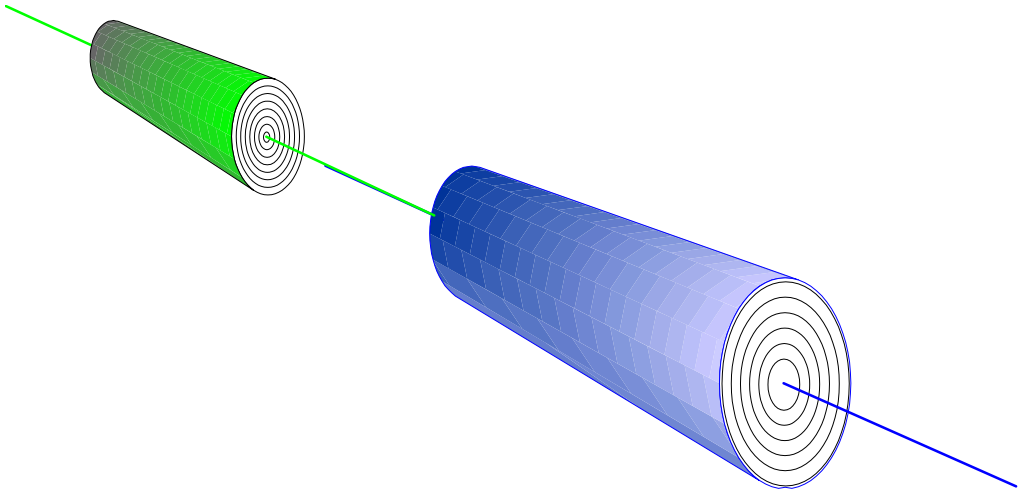
Shaft Alignment

Every shaft, bent or straight, rotates about an axis that forms a straight line.



Shaft Alignment

Shafts in this same straight line are considered co-linear, or in the same straight line.

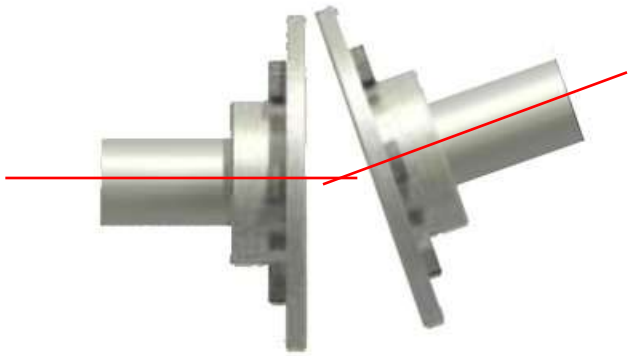


Misalignment

There are three types of misalignment :

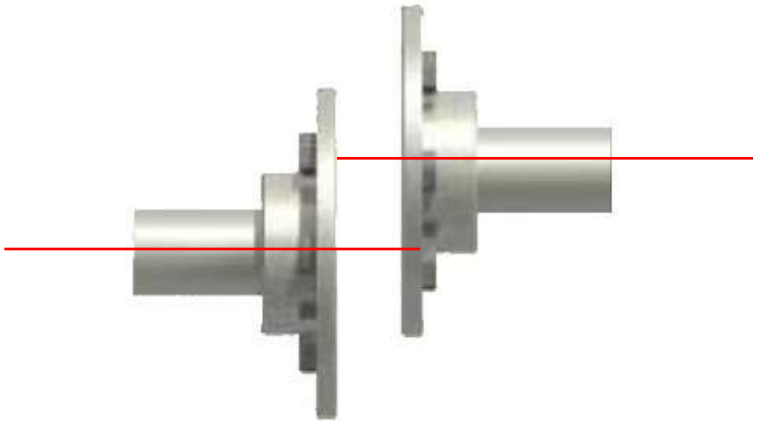
- Angular (in elevation, in plan)
- Parallel or Offset (in elevation, in plan)
- Axial

Types of Misalignment



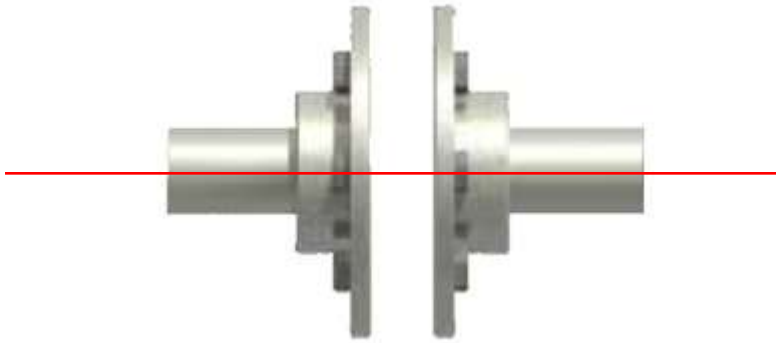
Angular – The shafts are not in the same plane, which causes a difference in measurement between measurements made 180 degrees opposite on the coupling faces. This can be both vertical and horizontal.

Types of Misalignment



Offset, – The shafts are parallel to each other, but are not in-line, or in the same plane. This can be both vertical and horizontal. Most misalignment issues are a combination of both angular and offset.

Types of Misalignment

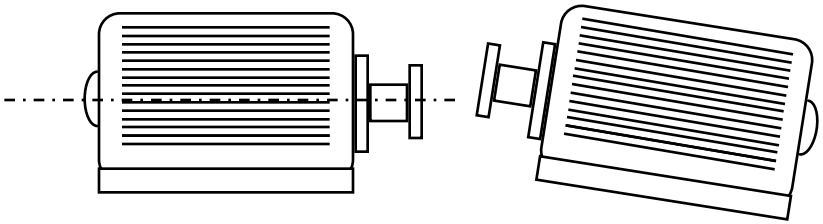


Axial – The shafts are parallel to each and in the same plane but the separation distance can vary.

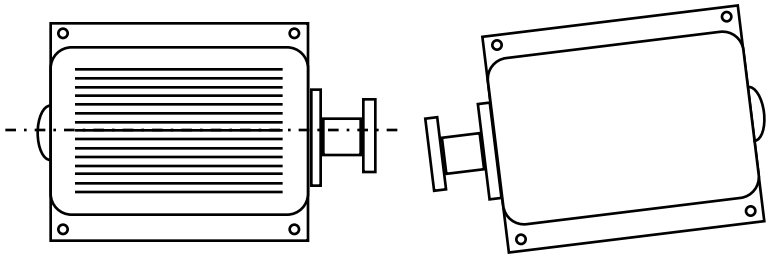
Alignment

Angular

Elevation

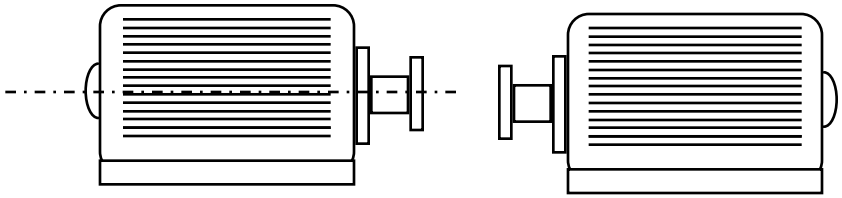


Plan

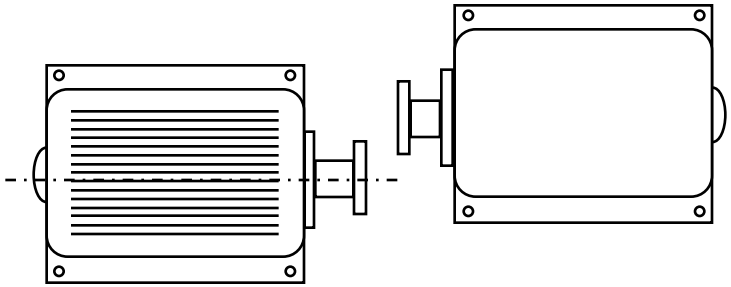


Parallel

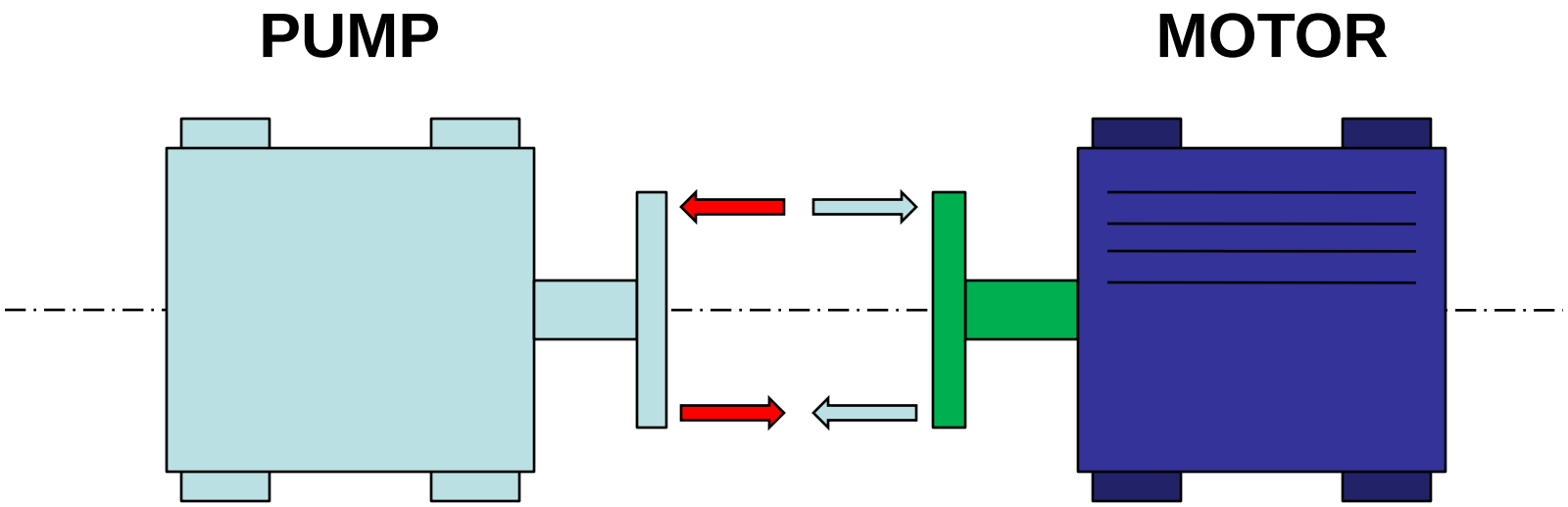
Elevation



Plan

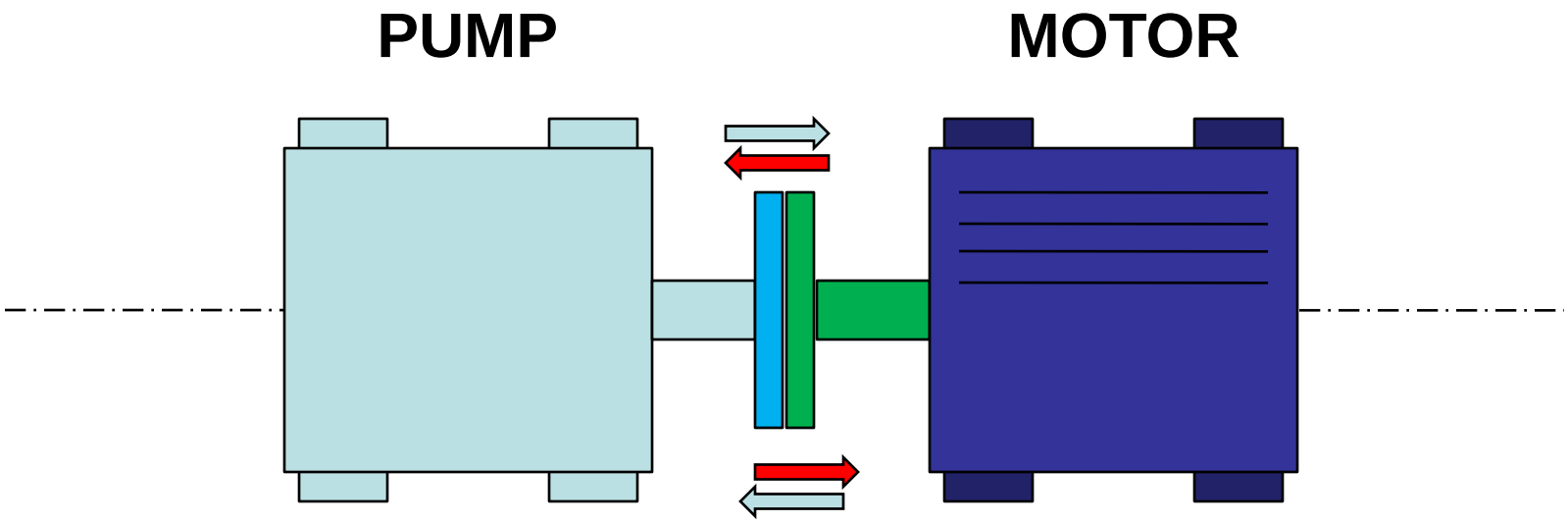


AXIAL



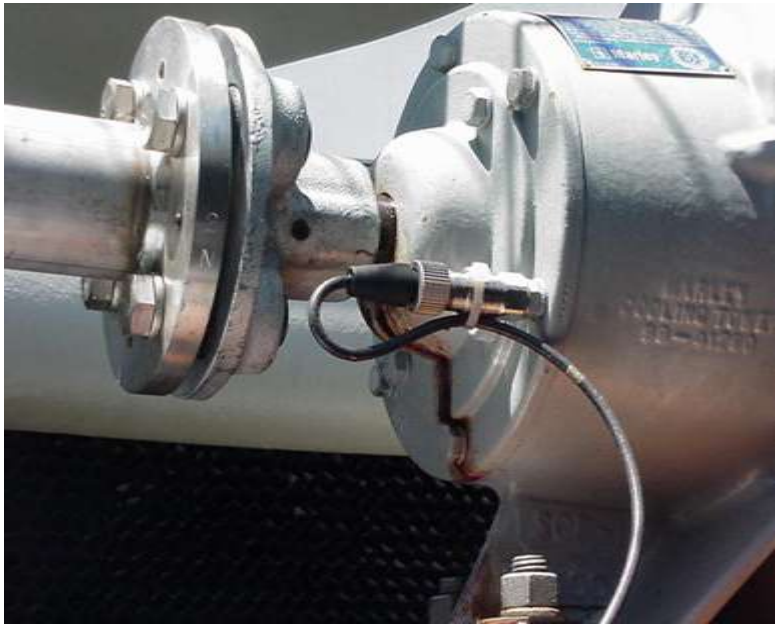
THE AXIAL FREEPLAY IS CHECKED FROM ABOVE OR DIRECTLY IN FRONT OF THE MOTOR / PUMP.

AXIAL



THE AXIAL FREEPLAY MUST NOT PERMIT THE SHAFT ENDS TO CONNECT!

What is coupling alignment?



Coupling alignment is shaft alignment. If the shafts are aligned, the couplings will normally go along for the ride.

Always check that the coupling hubs are running concentrically with the shafts

Alignment Preparation

Prior to starting your alignment process, perform a system survey to major items that are vital to good alignment.

The system survey

Base Plate:

The base plate mounting pads should be level within .002” in/ft.

New Installations:

It is considered good practice on large installations to install the fixed equipment unit on 6 to 10.mm packing strips to increase the adjustment potential at a later date should in be necessary for the driven units.

The system survey

Special Note :

Take great care when drilling and tapping the base plate at the holding down bolt locations. Very accurate hole location is required as the bolts need to sit in the centre of the motor feet holes when the motor is aligned in the horizontal plain. Failure to do this will almost certainly cause problem with bolts binding on the sides of the holes during alignment procedure or if a motor is replaced at a later date.

The system survey

Reference:
The pump and driver are moved into correct relationship per the outline drawing, and the shaft or hub separation is set according the outline drawing and coupling manufacturer.

Location:
Initial alignment is usually done by checking at the coupling hubs.

The system survey

Sequence of Alignment:
Move pump or motor? Determine which piece of equipment is to remain fixed and which is to be moved during alignment.

Setup Marking:
Some larger electric drive motor armatures are mounted on plain bearings and will align with the windings magnetic centre. This axial position needs to be reference so that coupling hub axial position is maintained when the alignment is adjusted.

Piping Connections

Piping inspection will assure that the piping is installed in apparent agreement with design criteria.

Look for proper placement and adjustment of guides, anchors, and support.

Disconnect suction/discharge piping from the pump.

Correct position of spring hangers.

Complete make-up of flanges with gaskets in place and bolts tightened.

Piping Connections

In short: it must be verified that the system is configured such that post-alignment piping modification will not nullify the alignment effort.

Shim Packs

Shim packs:

Shims should be placed under the driver to provide a solid, adjustable link between the equipment and mounting surface.

A shim stack under each mounting foot provides the ability to remove shims during alignment.

Avoid using lots of thin shims, as this can lead to errors.

SHIMS

These come in various thicknesses and various materials :

Brass } Do not
Plastic } corrode

Steel } Tends to corrode
S/Steel } Probably the Best

You **must** ensure they are undamaged

Ensure a minimum amount are used, i.e. if you require 0.075” of shim, use one large shim or plate 0.050” then 0.025”.

NB : Failure to do this will cause problems,
i.e. variations when tightening down !

Shim Packs

Physically check shims for :

Rust, improper-cut-shims, voids & wrinkles, hammer marks and dirt.

Replace many thin shims with fewer shims of greater thickness.

Equally important, surface of equipment supports and the base plate are clean and in good condition.

A Quick Comment on Shims…

Try to use a maximum of 4 or less shims under each foot. It's not always possible, but try to minimize the number of shims per foot.

When you insert shims under the foot, slide them all the way in, then back them out ¼", so the bolt threads don't bend them.

Be careful. A 0.003" shim can cut you like a knife. Trust me on this one!

Keep them neat.

Soft Foot

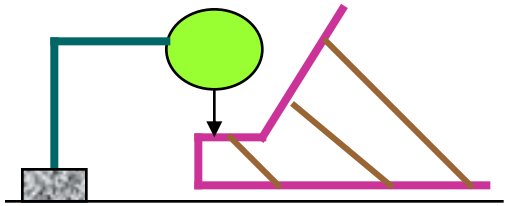
Soft Foot:

Check for “soft feet”, be sure each mounting foot actually rests on its support surface as follow:

Mount a dial indicator on the machine support with the indicator stem resting on the base-plate.

Watch the indicator as the hold-down bolts are loosened.

If the movement of the indicator is more than .001”-.002” , it is an indication of soft feet problem.



Soft Foot

Soft foot further checks:

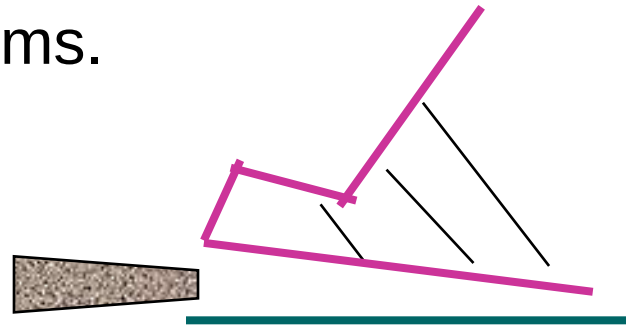
Remove shim pack underneath machine support.

Use feeler gauges to assure that machine supports are parallel with the soleplate/pedestal.

If supports are not parallel, re-work is required to correct the condition:

Re-grout, re-machine the support as required

Prepare tapered shims.

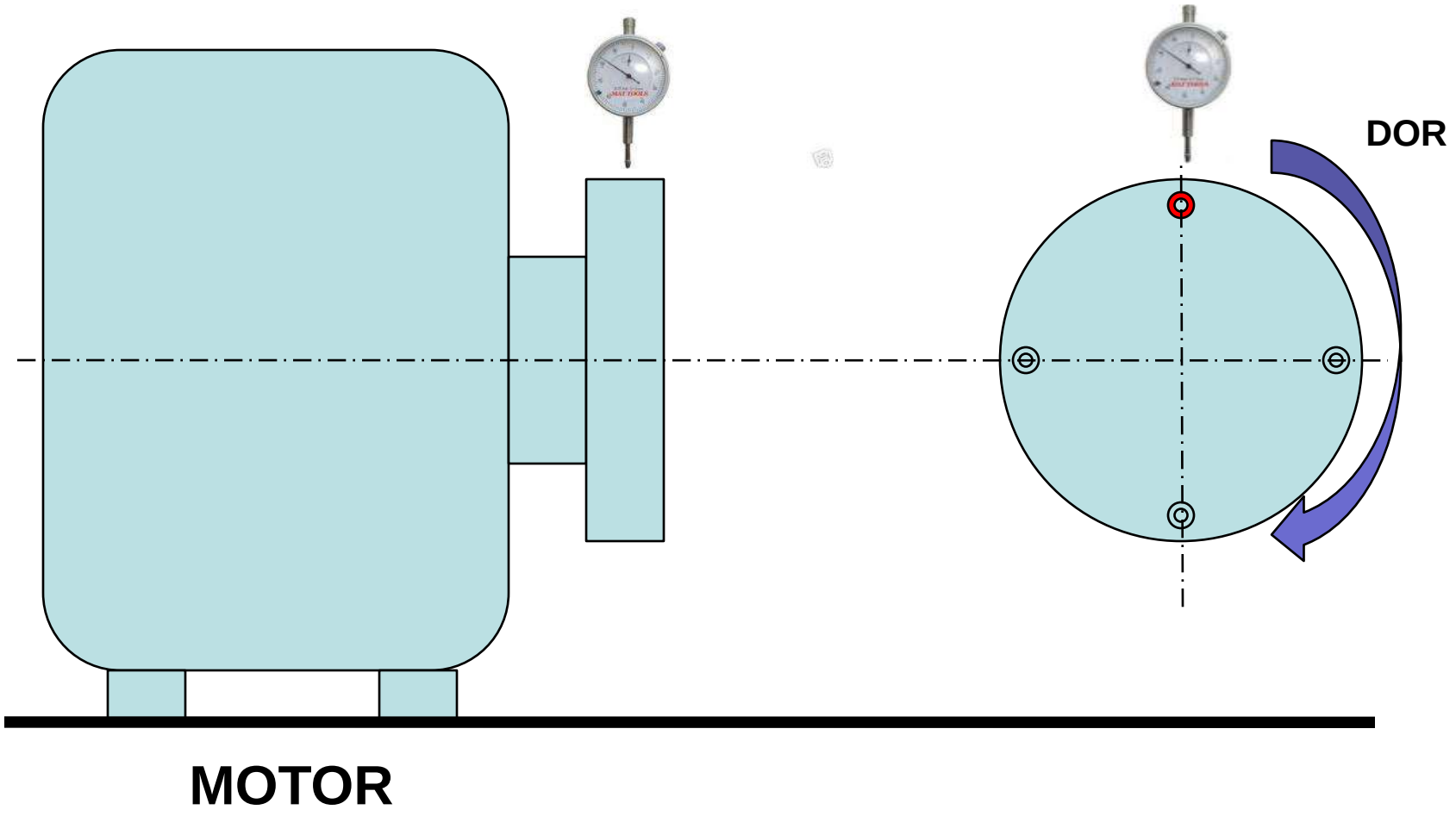


Indicator Bracket Bar Sag

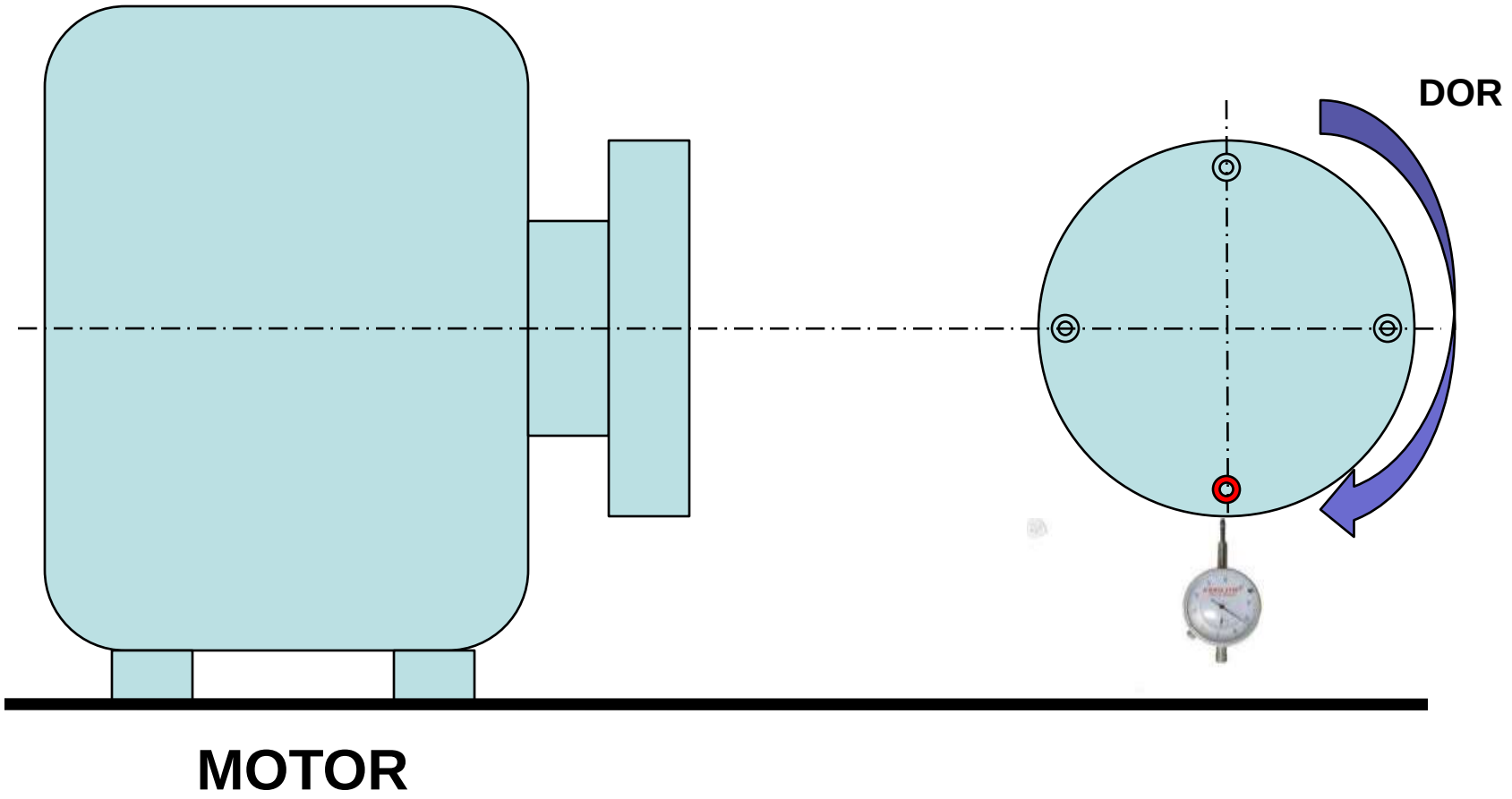
How to perform a sag check:

Clamp the brackets on a sturdy piece of pipe the same distance they will be when placed on the equipment. Zero both indicators on top, then rotate to the bottom. The difference between the top and bottom reading is the sag.

BAR SAG



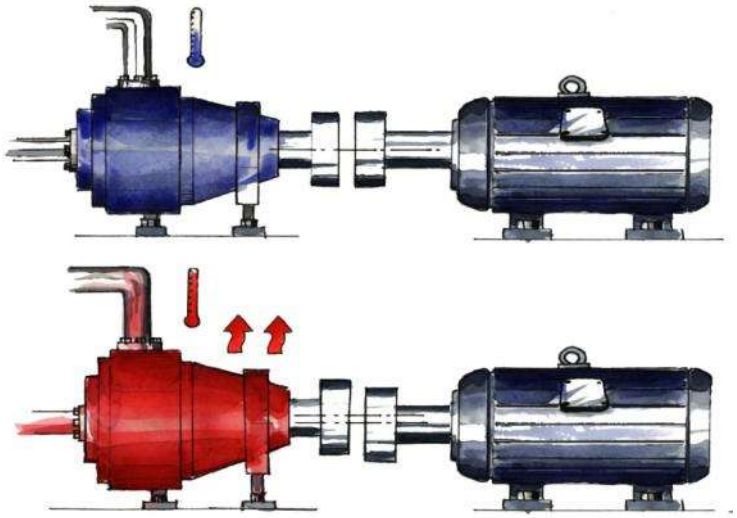
BAR SAG



Thermal Growth

Machines that operate at a considerably hotter or colder condition than the ambient room temperature should be thermally compensated.

They will “grow” or “shrink” as they heat up, or cool off



Thermal Growth

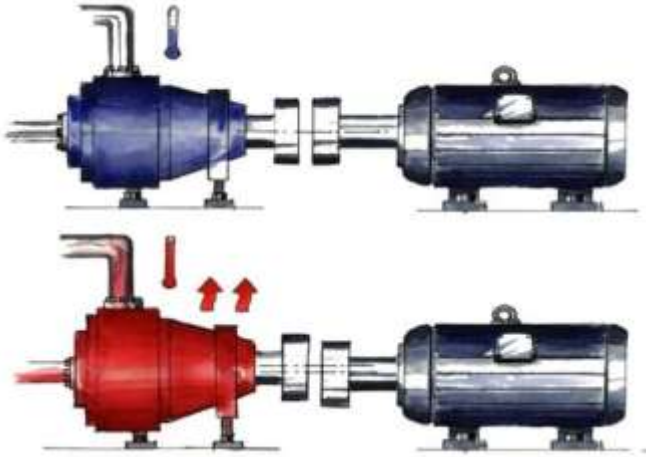
The machine manufacturer's specs are a good place to start but, the machine manufacturer probably does not know:

The exact temperature of the driver and driven machines

Ventilation quality or cooling effects

Piping strain influences

Piping thermal changes



Coefficient of Thermal Expansion

Coefficient of expansion: carbon steel
.0063 x length x temperature change = Thermal Growth (mils)

If you can't remember this chart, remember this:

length (inches)	temp change	growth (mils)
15.0	100	9.5
15.0	125	11.8
15.0	150	14.2
15.0	175	16.5
15.0	200	21.3

If one foot of steel get 100 degrees hotter, it grows about (0.008")

Thermal Growth

<u>However, this is not a magic formula!</u>

Machines do not usually heat or cool at the exact same temperature top to bottom.

You need to find a mean, or average temperature of the machine – from the centerline of the shaft, to the bottom of the foot.

Thermal Growth

<u>The Best Way to Know Thermal Growth Changes</u>

Measure them yourself.

Measure the machine in the cold condition, and pre-set it to the manufacturer's recommendations.

Re-measure in the hot condition, if possible.
Some lasers can do this calculation for you, or you can simply plot it on paper.

In addition, some laser alignment tool manufacturers sell equipment that allow you to measure the thermal changes.

Assumptions

NEVER ASSUME IT'S LOCKED OFF AND ISOLATED!

Don't assume it's aligned correctly, even if you did it the last time.

Can the shafts be rotated together? Can they be rotated individually? You may have to modify your alignment technique.

Is there a soft foot issue? Check and minimize before alignment.

Is there going to be thermal growth? How much? Which direction? Is it going to get hotter, or colder?

Assumptions

Is the coupling insert worn? Does it need replacement?

Is there adequate spacing between the shafts? Between couplings?

Has pipe strain been minimized?

Is the pump assembly sitting on isolators? Are they functioning properly?

Is the pump assembly sitting on an inertia block? Is it properly affixed to the floor?

Assumptions

Do you notice any cracks in the floor around the base?

Can you feel vibration in the floor?

Does the coupling insert have excessive backlash?

Are the coupling flanges tight to the shaft?

Are set screws and bolts tight?

Are keys in place?

Assumptions

Are the hubs concentric? You may be able to align an eccentric hub, but may cause vibration, and make you look bad, if you miss it.

Does the coupling guard clear the coupling?

How clean is the area?

Soft foot is not limited to just under the motor feet. It can happen between a riser and frame, and between a frame and a floor.

Are there jackbolts? Are they screwed tight to the motor?

General Observations

Some alignment systems are sensitive to backlash or “play” in the coupling. Not only lasers, but indicators can be misread due to backlash, especially if there is any eccentricity in the coupling.

Beware of bumping your indicators or laser detectors.

Beware of any binding or tightness in the machines as they are rotated.

General Observations

Always correct vertical misalignment first once the gross horizontal misalignment has been removed.

Once the vertical (top to bottom, up and down) is corrected, you can theoretically move the machine side to side as far as it will go, without changing the vertical alignment.

Then, correct misalignment in the horizontal plane (side to side).

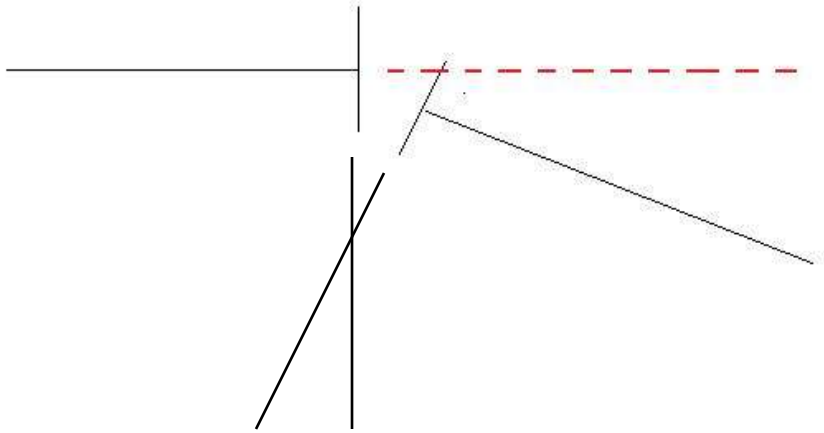
When your ready to align!

You must make the right moves in sequence !

Regardless of the method you use, alignment needs to be done in four steps

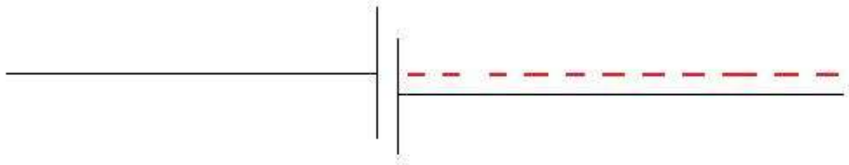
Angular misalignment in the Horizontal Plane

Top View



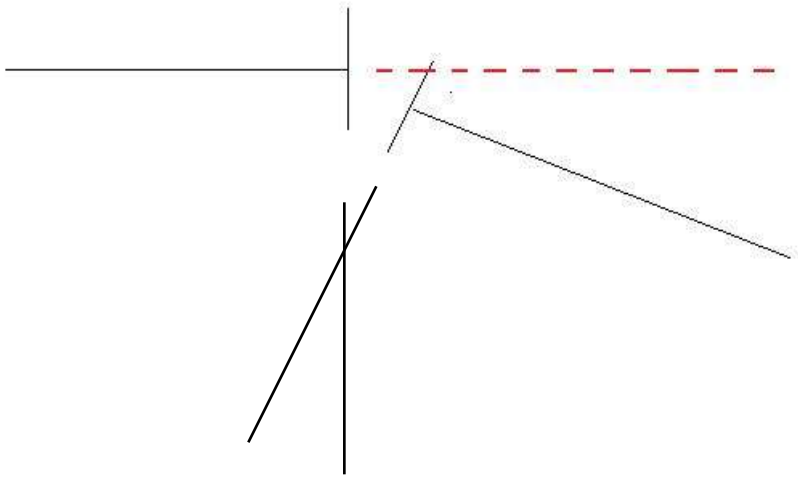
Parallel Offset in the Horizontal Plane

Top View



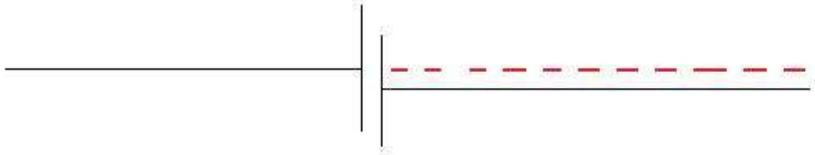
Angular misalignment in the Vertical Plane

Side View



Parallel Offset in the Vertical Plane

Side View



The End

Any Questions?