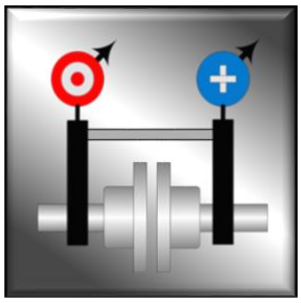


# RD Align

## Shaft Alignment - Reverse Dial Method

## Program Guide iPhone

Version 3.5 Build 36
Revised 06-Mar-2022

**This document can be downloaded from dmappcompany.com**

D&M App Company, LLC

# Table of Contents

## Disclaimer

RD-Align is intended for informational purposes. This App has been tested and no errors are known, but there is no warranty for the correctness of the results and for the availability of the calculations

The results from this App are to be used at the users own risk.

## Machine Alignments

The purpose of performing machine alignments is to reduce dynamic loads on the machine bearings. Rolling element-bearing life is approximately inversely proportional to the load$^3$ as shown in the equation.

$$Bearing_{Life} \approx \frac{1}{(Load^3)}$$

Therefore, if the load is doubled on the bearing, the life of the bearing is reduced approximately by 1/8. For example, a bearing with a 175,200-hour $L_{10}$ life (20 years) will be reduced to a $L_{10}$ life of 21,900 hours (2.5 years).

The goal of machine shaft alignment is to obtain the centerlines of two or more shafts in the same plane of action when viewed from any direction or angle during the desired or normal operating state. Machine shafts have offset misalignment or angular misalignment.

**Offset** – The distance between a single reference centerline and the parallel rotational centerlines of two or more shafts. Ideally, the centerlines of the shafts should coincide with each other. Pure offset misalignment indicates the shafts are parallel, but centerlines do not match. The offset is typically expressed in mils.

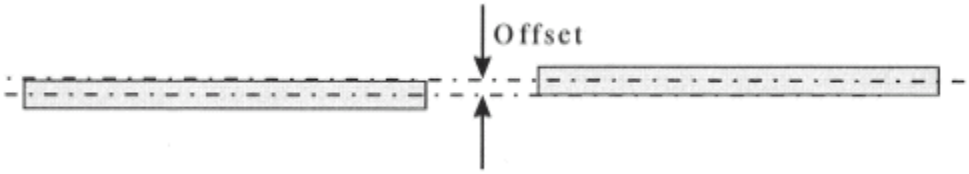



**Illustration 1 - Offset Alignment**

**Angularity** – The resulting angle between the shafts. Essentially the shafts are not parallel with each other. The angularity is expressed as mils/in and is typically referenced at the coupling point.

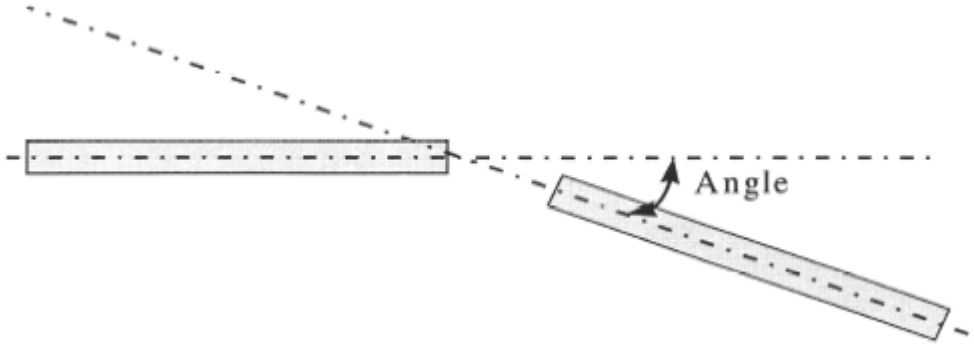



**Illustration 2 - Angularity Alignment**

A traditional discussion of machine alignment involves alignment tools and the acceptable standards for alignment (see Table 1). The reference point for measuring the machine misalignment is at the coupling.

**Table 1 - Common Alignment Standards**

| RPM | Offset – mils | | Angularity – mils/in | | Spacer Coupling – mils/in | |
|---|---|---|---|---|---|---|
| | Excellent | Fair | Excellent | Fair | Excellent | Fair |
| 600 | 5.0 | 9.0 | 1.0 | 1.5 | 1.8 | 3.0 |
| 900 | 3.0 | 6.0 | 0.7 | 1.0 | 1.2 | 2.0 |
| 1200 | 2.5 | 4.0 | 0.5 | 0.8 | 0.9 | 1.5 |
| 1800 | 2.0 | 3.0 | 0.3 | 0.5 | 0.6 | 1.0 |
| 3600 | 1.0 | 1.5 | 0.2 | 0.3 | 0.3 | 0.5 |
| 7200 | 0.5 | 1.0 | 0.1 | 0.2 | 0.15 | 0.25 |

However, if our goal is to minimize the loss of bearing radial internal clearance (RIC), we must consider other machine conditions. These assembly errors can introduce additional bearing loads and cause the mechanic to have a difficult time achieving shaft-to-shaft alignment. Therefore, alignment is more than using a tool to obtain correct shaft position. It is a process to minimize the misalignment effects at each machine's bearing position.

When considering bearing loads due to misalignment, common assembly errors must be investigated and corrected before final shaft alignment with alignment tools are used.

1. External machine loads that cause machine frame distortion:
    a. Improper or inconsistent tightening of machine fasteners to base. Mechanics must use a torque wrench to ensure consistent and proper tightening of machine components. Improper

tightening will cause machine case distortions and misalignment between a machine's internal bearings. Inconsistent tightening will create difficulty in achieving shaft-to-shaft alignment.

b. Pipe strain on casing. Piping should never impose any loads to the casing. The presence of loads will cause the machine case to distort, bearing misalignment, and difficulty in achieving shaft-to-shaft alignment.

c. Electrical connection strain on casing. Electrical connections at the junction box with hard conduit can cause the same problems as pipe strain.

d. Short leg and angular soft foot. Any 4-legged object will always have one leg shorter than the other 3. We must shim to correct the irregularity. An angular soft foot is due to the foot of the machine not parallel to the machine base. If these conditions are not corrected at the correct step in the alignment process, machine case distortion will occur causing bearing misalignment and difficulty in achieving shaft-to-shaft alignment.

e. Inadequate base stiffness. A machine base with inadequate stiffness can cause dynamic misalignment. This could also lead to machine resonance.

f. Slip fits for bearings and couplings. For a bearing or coupling to slip on the shaft, clearance must be present. When the bearing or coupling is locked to the shaft, misalignment will be introduced to the machine.

2. Internal machine loads that cause machine frame distortion:

a. Improper or inconsistent machine fasteners that assemble the machine. Mechanics must use a torque wrench to ensure consistent and proper tightening of machine components. Improper tightening will cause machine case distortions and misalignment between bearings internal to a machine.

b. Pulled threads for boss fit or located machines. For close-coupled machines, the mating parts, locating holes, etc., establish alignment. If they become damaged with burrs and no longer flat, the machine cannot be properly aligned. Case distortion and misalignment will occur when tightened.

c. Improperly installed or fitted bearings. Bearings are fabricated to established tolerances and must be installed in housings and on shafts according to ABMA guidelines. Too tight a fit will remove the RIC from the bearings. Too loose will allow the bearings to slip in their housings or on the shaft.

d. Shaft conditions. Machine shafting must be inspected and corrected for straightness, roundness, size, bent shaft, eccentric parts, parts bored at an angle, twisted shafts, bows caused by thermal growth, etc.

e. Thermal growth considerations. Typically, thermal growth is considered for machines that get very hot such as steam turbines. However, a typical machine with 10" height from the base to the shaft will need compensation for thermal growth if the temperature change is as low as 30°F. For example, 10" x 30°F x 0.0059 mil/in°F = 1.8mil. Understanding how thermal growth changes the machine is critical to achieve a precision alignment.

It is very uncommon for a machine to grow evenly in the vertical direction. A typical TEFC motor has a fan on the back end of the motor. The temperature on the back end of the motor will be lower than the temperature on the drive side. Often the motor is connected to something such as a pump. A condensate pump may have 180°F at the pump volute and only 120°F at the coupling. Temperatures in the plane of each foot must be measured to determine the correct thermal growth. The machine will be intentionally misaligned in a known manner such that it will grow into alignment when the machine is hot.

The common alignment practice will use typical standards shown in Table 1 with an alignment tool. Modern mechanics will usually use a laser alignment device. Although the laser is extremely accurate and quick, results may vary due to assembly errors and interpretation of the alignment standard. For example, consider an 1800-rpm machine, which utilize deep groove ball bearings. If the shaft diameter is 1", the RIC of the bearings will be approximately 0.001" or 1.0 mil (ABMA C3 bearing). The specification for an excellent alignment in Table 1 allows 2.0 mils offset and 0.3 mil/in angularity. The standard is referenced at the coupling. If the machine is 20" long from the coupling, the resulting outboard bearing location is 6.0 mils from the theoretical axis of the machine due to the angularity. The available internal clearance of the bearing is approximately 1.0 mil. The additional misalignment will create additional bearing load, increased vibration, and reduced life. The angularity of this alignment standard allows too much offset at the outboard bearings.

The iPhone App RD-Align is based on an alignment standard designed to retain bearing RIC. The standard is defined below.

1. <2000 rpm – Shaft misalignment not to exceed 0.002" at any measured shaft position.
2. ≥2000 rpm – Shaft misalignment not to exceed 0.001" at any measured shaft position.
3. The measured misalignment at each position must be of the same sign (+ or -) relative to the alignment centerline position.
4. Thermal growth must be considered and allowed for in the acceptance of the tolerances listed above. We may "misalign" the machine in a cold state, so it can run aligned under normal operating temperatures.

## App Description

Reverse Dial Alignment is a calculator used for performing shaft alignments of rotating equipment using the reverse dial indicator method. Several features include,

- Key Length Calculator – used to determine optimal length of key stock for coupling fits.
- Thermal Growth Calculator – used to determine cold alignment offsets. Machine will have misalignment at startup, but will "grow" into alignment once the machine reaches operating temperature.
- Vertical Alignment Calculator – used to calculate vertical movements at the feet of the DriveR and DriveN machines based on dial indicator readings. 5 movement options are provided.
- Horizontal Alignment Calculator – used to calculate horizontal movements at the feet of the DriveR and DriveN machines based on dial indicator readings. 5 movement options are provided.

## Compatibility

All phone devices are supported (iPhone 8 through iPhone 13 including the various varients). The App is optimized for the iPhone format. The app will also run on iOS based tablets. However, the format/layout has not been fully optimized for these formats. RD-Align Pro is specifically designed for tablets.

## General Usage Notes

RD Align is intended to assist in calculating vertical and horizontal alignment positions. It also maintains a historical record of past alignments performed.

**Alignment Database Screen** – opening screen for RD Align. Lists of past alignments are stored in the RD Align app.

**Machine Details Screen** – use this screen to enter machine description and alignment notes.

**Key Length Calculator Screen** – use this screen to determine correct key length for couplings. Proper key length is important to ensure engagement of the coupling to the shaft and preserve the balance quality. Correct key length is required to replace the equivalent material removed from the shaft and coupling to create the keyways. Placing them 180° apart ensures the residual unbalance affect cancels each other out.

**Machine Set Dimensions Screen** – use this screen to enter overall machine dimensions from a reference (DriveN dial indicator) and each machine foot. Accuracy is critical to achieve desired alignment results.

**Thermal Growth Calculator Screen** – use these screens to enter temperature information to calculate either thermal growth or shrinkage. Corrections to thermal growth can be ignored via the selector switch.

**Vertical Alignment Solutions Screen** – use this screen to enter the vertical dial indicator results and calculate alignment solutions.

**Horizontal Alignment Solutions Screen** – use this screen to enter the horizontal dial indicator results and calculate alignment solutions.

For the purpose of this document, feet positions for the DriveN and DriveR machines are defined as,

- Opposite Drive Side (ODS) foot
- Drive Side (DS) foot.

## Alignment Solutions

RD Align alignment solutions are based on a graphical approach. However, RD Align mathematically models the solution and calculates numbers for the solution. The Machine Set Dimensions Screen of RD Align has a drawing illustrating the critical dimensions of the machine set as shown in Illustration 3. The positions of the DriveR and DriveN feet in relation to the dial indicators are required to layout the graphical solution.

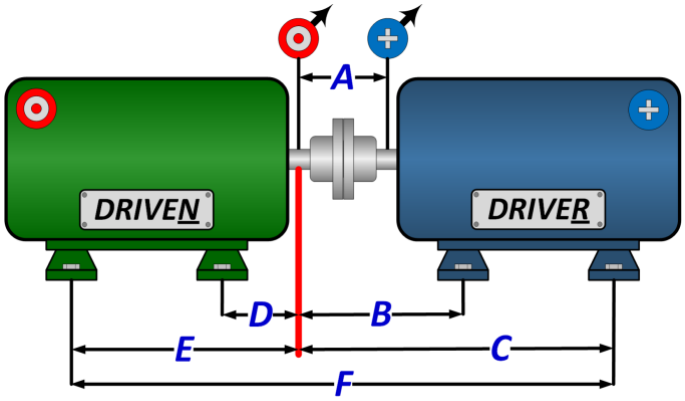



**Illustration 3 – Machine Set Dimensions**

Illustration 4 represents the base vertical solution for the example alignment named *RD Align Program Guide Example.* For simplicity, thermal growth is NOT included in these examples.

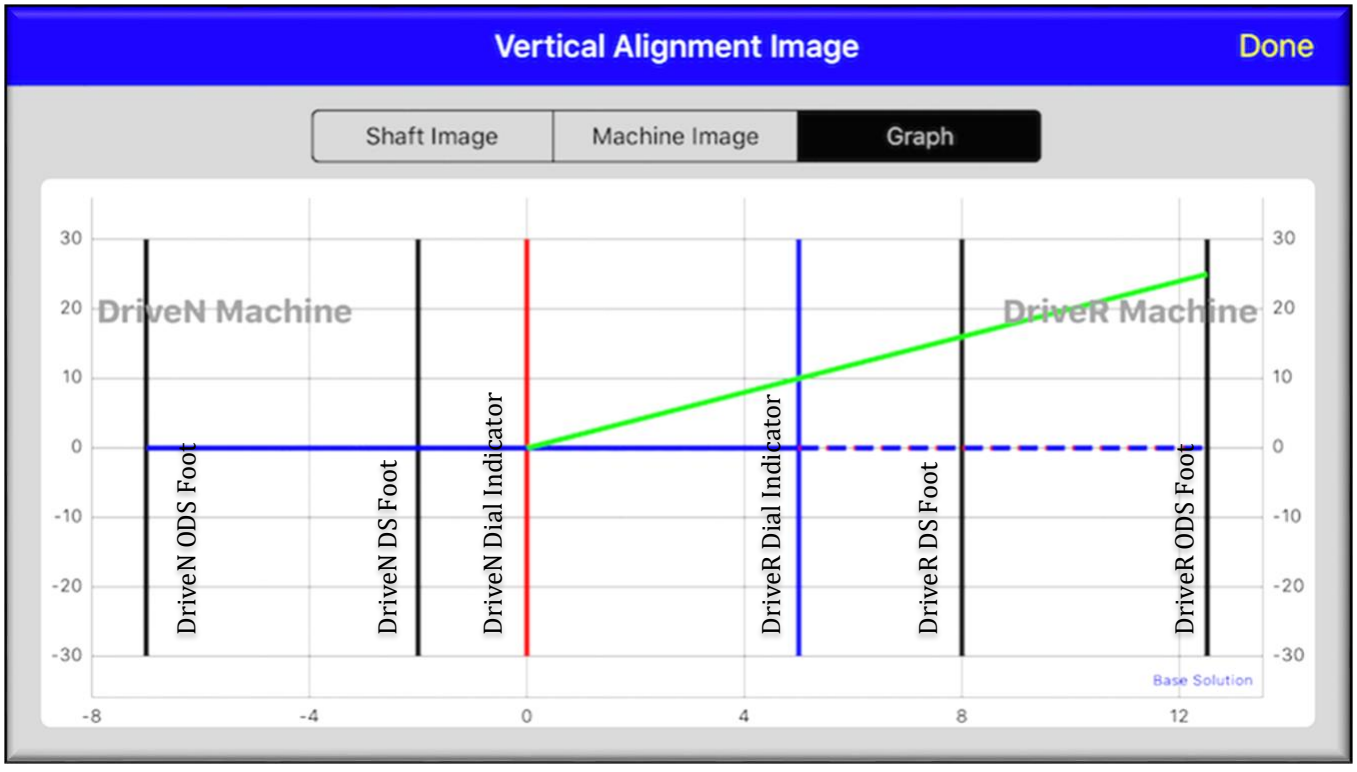



**Illustration 4 - Base Vertical Alignment Solution**

If the both machines were in perfect alignment, the horizontal blue line and green line would be perfectly aligned in the horizontal direction in the center of the graph. To determine the amount the DriveR machine must move, simply count the boxes from the green line to the horizontal axes. Remember each box is in mils. For this example, the DriveR machine must move down approximately 16 mils on DS foot and 25 mils on the ODS foot.

Often, the alignment solutions are difficult to implement due to an inability to actually move the machine. Sometimes the vertical alignment solution requires the motor to be lowered. If the motor is already on the base without shims, the motor cannot be lowered without grinding the base or machine feet. Sometimes in the horizontal direction, adequate clearance between the anchor bolt and hole in the machine foot is not available. Undercutting bolts or drilling/slotting motor feet is often done to enable the alignment to be completed. These solutions are frustrating and time consuming. RD Align provides 4 optional alignment solutions to avoid machine/base modifications.

RD Align utilizes a technique presented by Reliability Solutions, LLC. By drawing a straight line from a foot on the DriveR to a foot on the DriveN, an optional alignment line can be plotted as shown in Illustration 5.

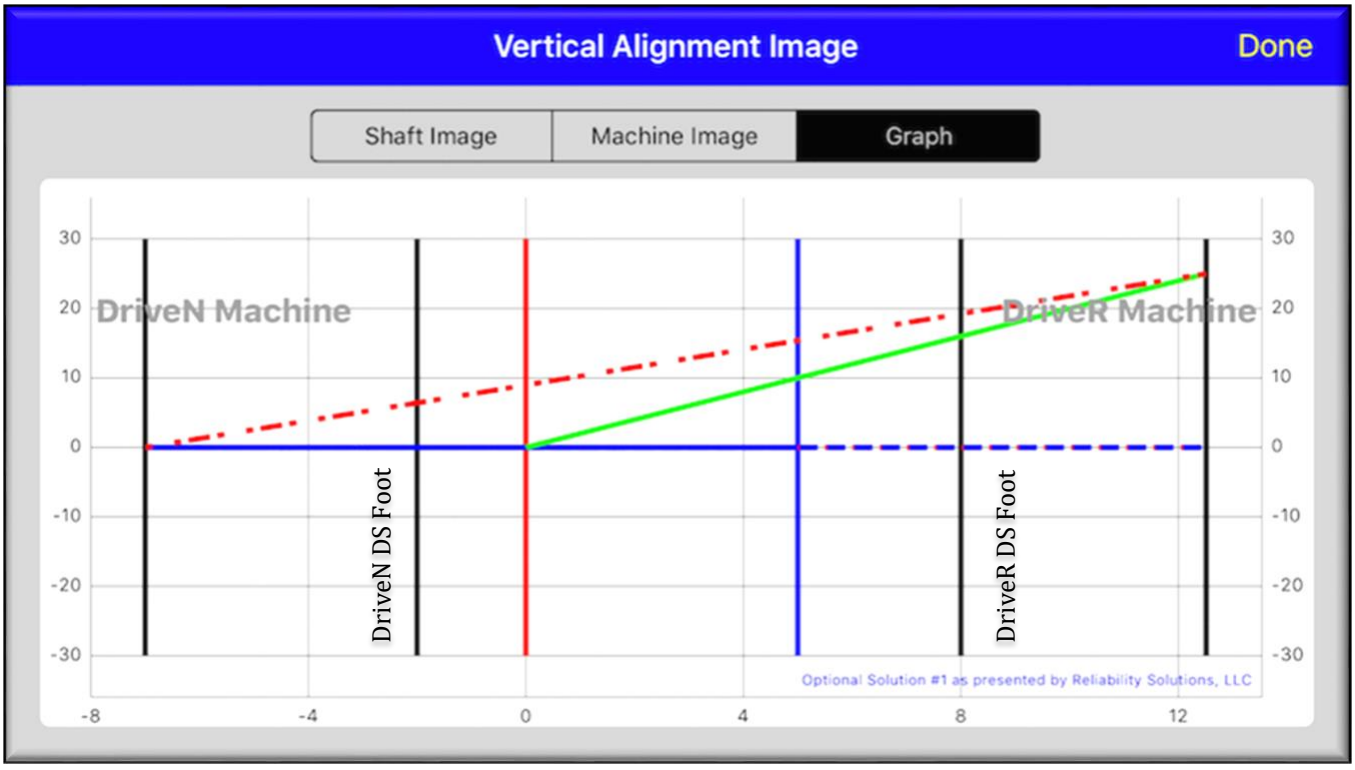



**Illustration 5 – Optional Vertical Alignment Solution #1**

- The red dashed line represents perfect shaft alignment from the DriveN opposite drive side foot to the DriveR opposite drive side foot.
- The horizontal blue line still represents the DriveN shaft position. The green line still represents the current misalignment of the DriveR shaft.

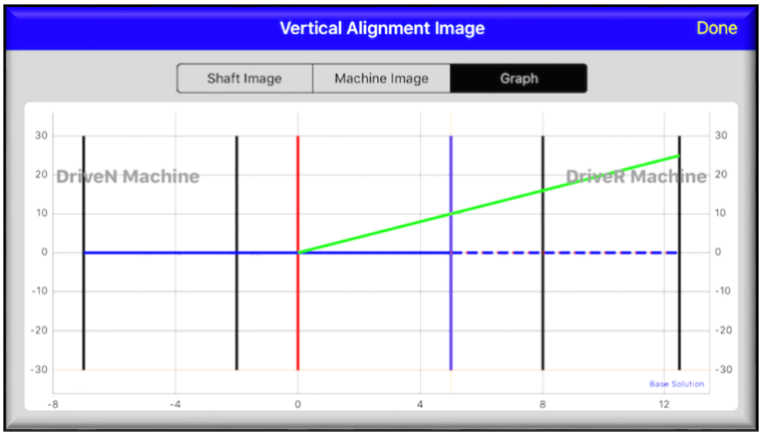
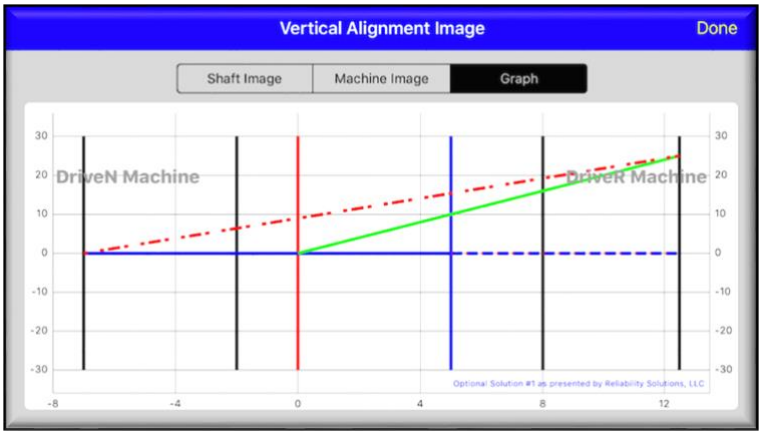
- To determine the option move amounts and direction, simply count the boxes from the current position of each foot to the desired position (red dashed line).
- For this example,

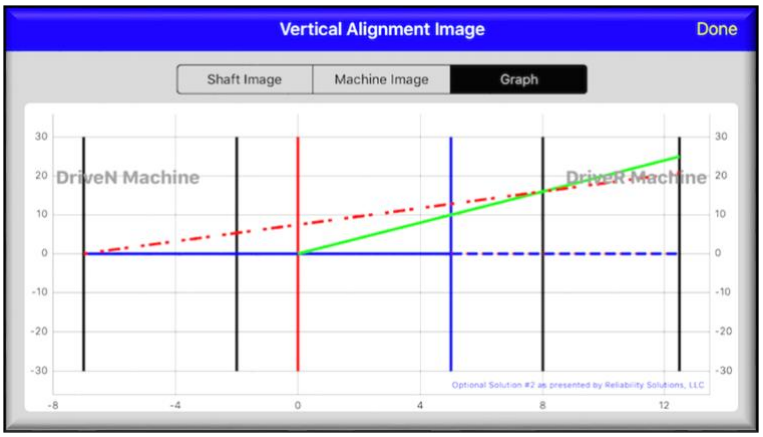
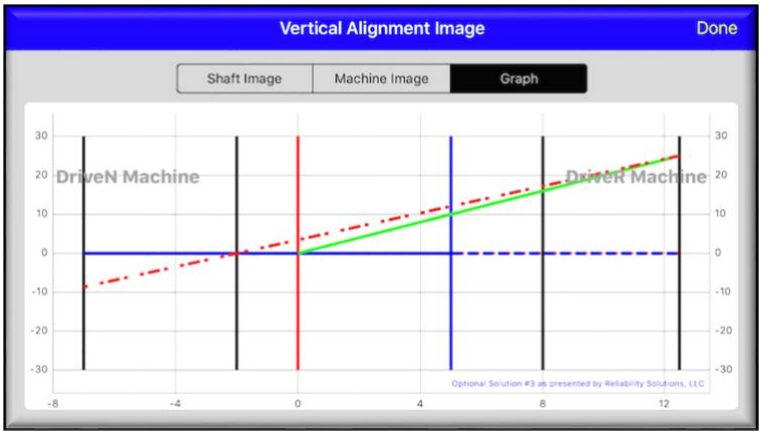
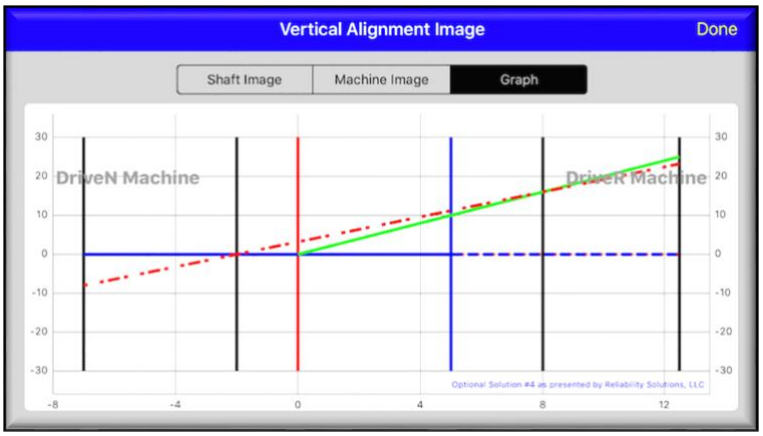
| Position | Distance | Direction |
|---|---|---|
| DriveN ODS | 0 | n/a |
| DriveN DS | 6 | Up |
| DriveR DS | 3 | Up |
| DriveR ODS | 0 | n/a |

Notice the DriveN machine will need to be moved as well as the DriveR machine. However, the amount of movement is very small. Since the machine set has 4 feet, any 4 combinations of the feet can be used to find a solution to any base/foot movement restriction.

The optional alignment solutions in RD Align are labeled as shown in Table 2.

**Table 2 – RD Align Alignment Solutions**

| Option | Description | Graphical Solution |
|---|---|---|
| ***Base*** | DriveN machine stationary. |  |
| ***OS #1*** | DriveN ODS foot stationary.<br>DriveN DS foot ***moveable***.<br>DriveR DS foot ***moveable***.<br>DriveR ODS foot stationary. |  |

| | | |
|---|---|---|
| ***OS #2*** | DriveN ODS foot stationary.<br>DriveN DS foot ***moveable***.<br>DriveR DS foot stationary.<br>DriveR ODS foot ***moveable***. |  |
| ***OS #3*** | DriveN ODS foot ***moveable***.<br>DriveN DS foot stationary.<br>DriveR DS foot ***moveable***.<br>DriveR ODS foot stationary. |  |
| ***OS #4*** | DriveN ODS foot ***moveable***.<br>DriveN DS foot stationary.<br>DriveR DS foot stationary.<br>DriveR ODS foot ***moveable***. |  |

Comment on 3 Planes of feet on driven machine.

RD Align assumes each machine, DriveR and DriveN, have 2 planes of feet. However, some pumps have a third plane of feet as shown in the illustration 6. There are 2 (1&2) planes of feet under the pump volute and third plane at the support bracket (3). RD Align can still be used for this type of pump. Combine feet (1) and (2) to one dimension centered between (1) and (2). Position (3) now becomes the second dimension as shown in Illustration 7. The alignment solutions will be correct, however, all 4 feet at dimension 1 will have to be moved together.

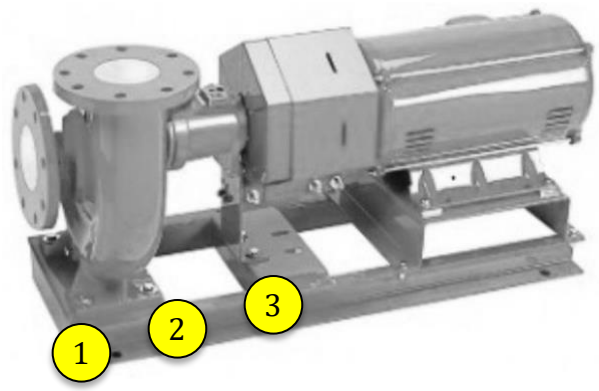



**Illustration 6**

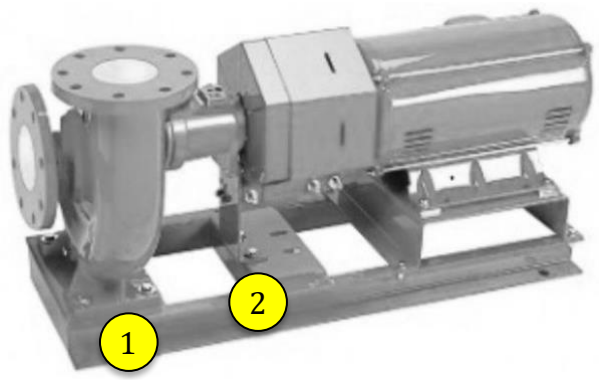



**Illustration 7**

## Screen Descriptions

# Alignment Database Screen

***Help Button***

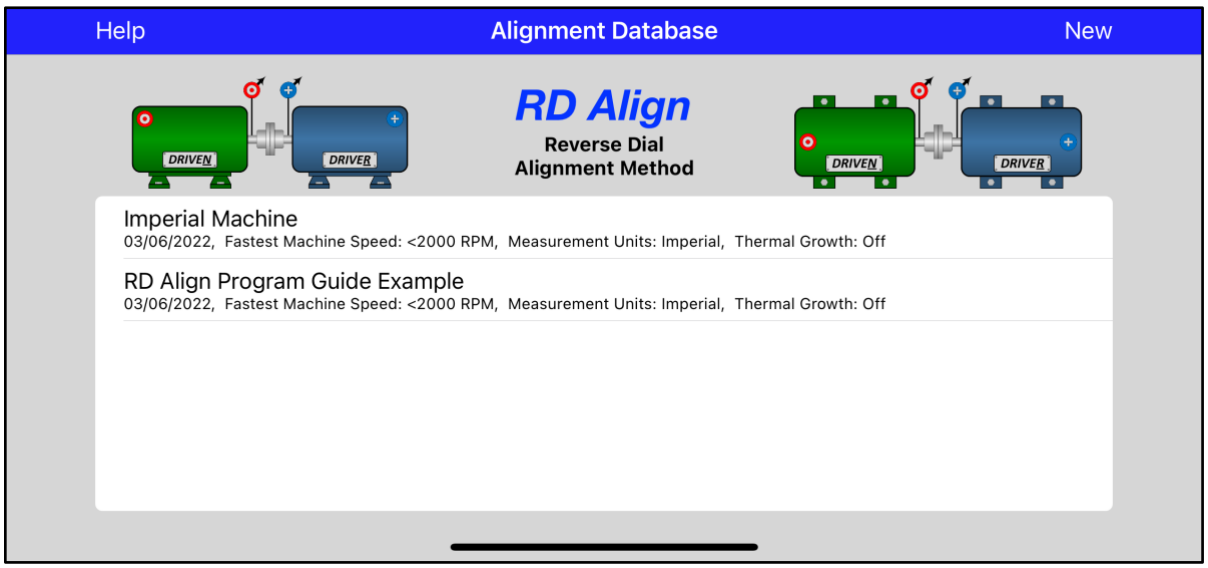
Touching HELP provides an opportunity to provide D&M App Company feedback.

The user should review important disclaimer information.

A detailed description of the RD Align app and alignment principles is distributed with the App.

***New Record Button***

Touching NEW creates a new alignment record. Machine Data screen will Appear for data entry and access to additional calculations.




***Alignment Records***

Previous records of machine alignments. Each record is saved on the device only. If the App is deleted, the data will be lost.

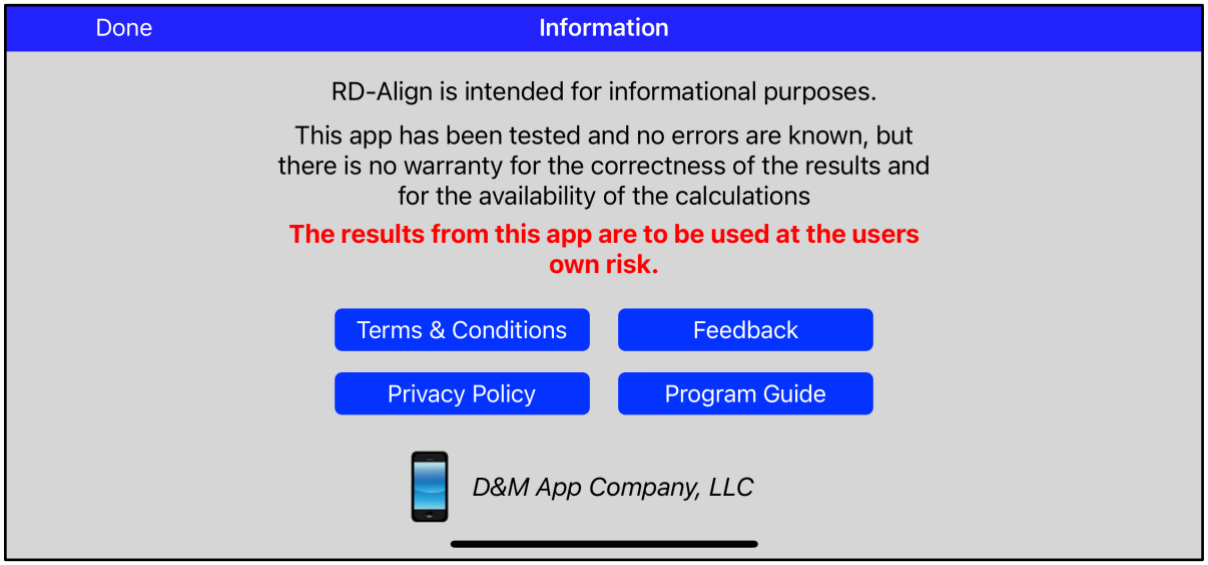
Touching a record will allow review and editing of the records data. Touching a record will allow access to the Machine Details screen.

Swiping to the left and touching DELETE can delete records.

# Help Screen

***Done Button***

Touching the DONE will return the App to the Alignment Database screen.




***Feedback Button***

Touching SUBMIT FEEDBACK will open an email notice to D&M App Company.

Errors and feedback for additional features will be considered.

***View Program Guide Button***

Touching VIEW PROGRAM GUIDE will open the RD Align Program Guide for review.

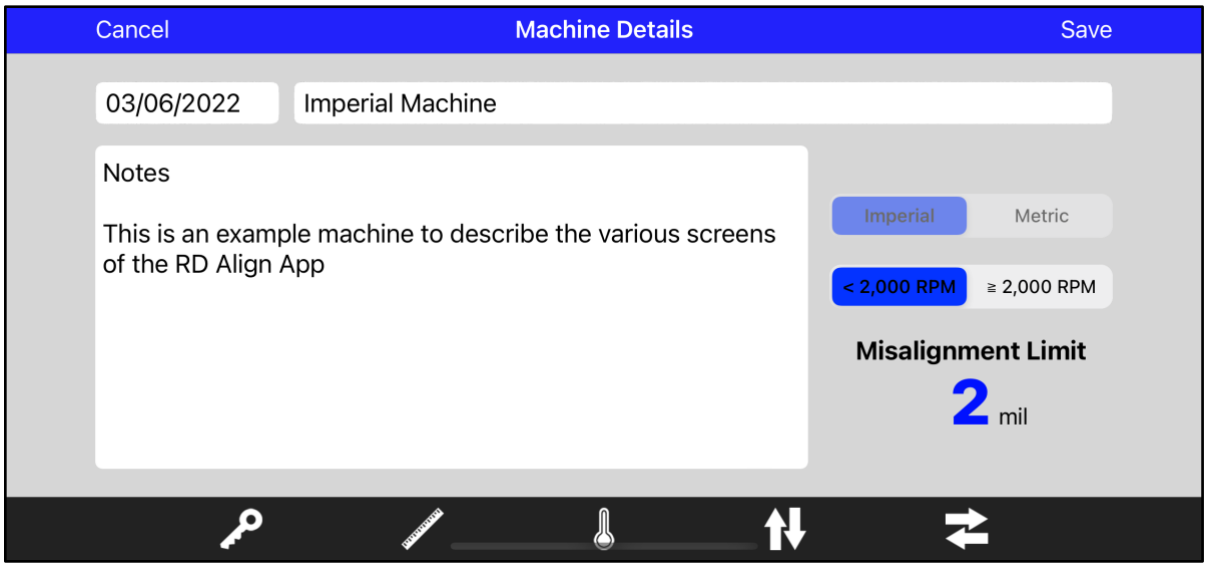
# Machine Details Screen

***Cancel Button***
Touching CANCEL will return the App to the Main screen. No data will be saved.

***Save Button***
Touching SAVE will save any new or modified data.

**If the RD Align is closed prior to saving, the data will be lost.**

Touching SAVE will also return the App to the Main screen.




***Machine Speed Class Selector***
Touch the MACHINE SPEED selector to choose the speed of the fastest machine in the equipment set.

This will determine the alignment tolerance.

***Units Selector***
Touch the UNITS selector to choose either Metric or Imperial units.

**Once the selection is made, it cannot be changed.**

***Alignment Tolerance***
Based on machine speed, the alignment tolerance will update.

# Machine Details Screen (continued)

***Date Field***

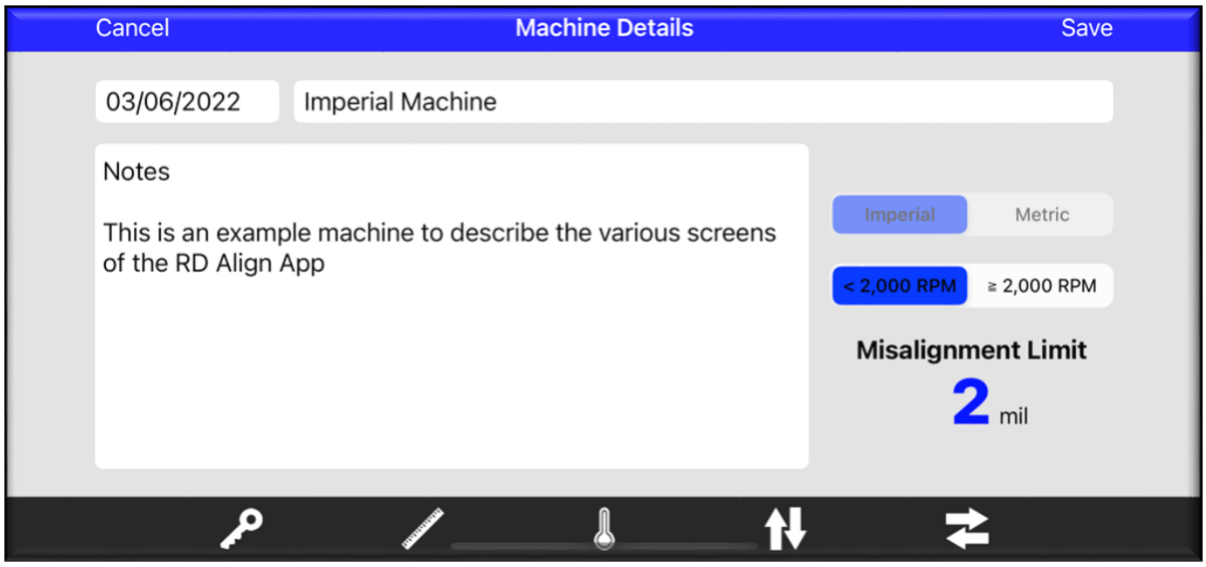
The DATE FIELD is available to record the date the alignment activity was performed. The field will default to the current date when the initial data was entered. The date can be changed if needed.

***Machine ID Field***

The MACHINE ID field is available to describe or identify the machine.

***Notes Field***

The NOTES field is available to record notes pertaining to this alignment record. This field will scroll as needed.




***Key Length Calculator***

Touch the KEY to open the Key Length Calculator screen.

***Machine Dimensions***

Touch the RULER to open the Machine Dimensions screen

***Thermal Growth***

Touch the THERMOMETER to open the Thermal Growth Calculator screen

***Vertical Alignment***

Touch the VERTICAL ARROWS to open the Vertical Alignment Solution screen

***Horizontal Alignment***

Touch the HORIZONTAL ARROWS to open the Horizontal Alignment Solution screen

# Key Length Calculator Screen

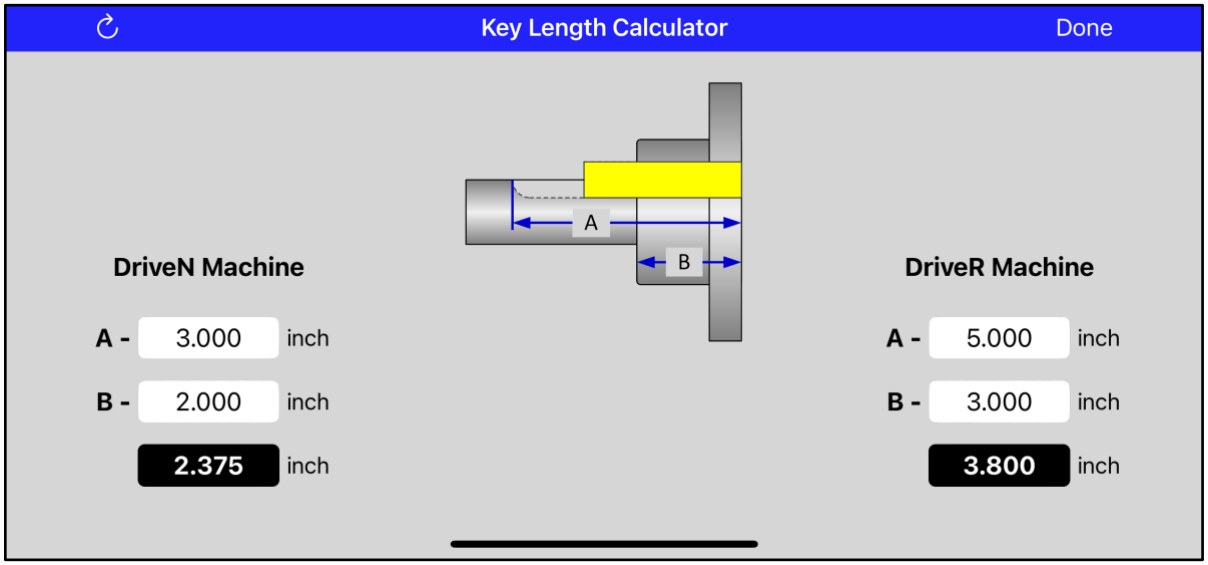
***Key Length Calculator***
Use this calculator to determine the correct key length based on the keyways in both the shaft and coupling.

Note: keys should be placed 180° apart.

Correct key length is required to preserve balance quality.

***Clear Button***
Touching the CLEAR button will quickly remove all entries on the screen.

***Done Button***
Touching the DONE button will return the App to the Machine Details screen.




***Dimension Entries***
Touch each field to enter dimensions for "A" and "B" per the drawing.

Key lengths for the DriveR and DriveN machines can be determined.

***Calculation***
The calculated key length will upate automatically as the "A" and "B" dimensions are entered.

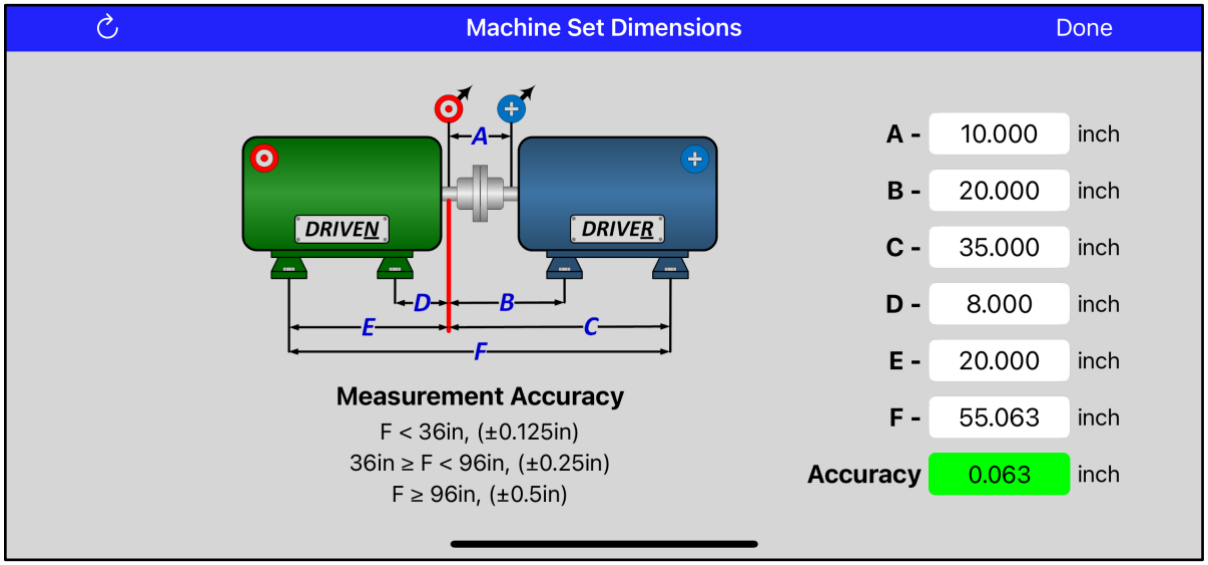
***Key Lengths***
The calculated key lengths appear here.

# Machine Set Dimensions Screen

***Clear Button***
Touching the CLEAR button will quickly remove all entries on the screen.

***Machine Set Dimensions***
Touch each field to enter dimensions for "A" through "F" per the drawing.

***Done Button***
Touching the DONE button will return the App to the Machine Details screen.




***Calculation***
The measurement accuracy calculation will automatically update as the machine dimensions are entered.

***Accuracy Display***
The accuracy is calculated and the difference is shown.

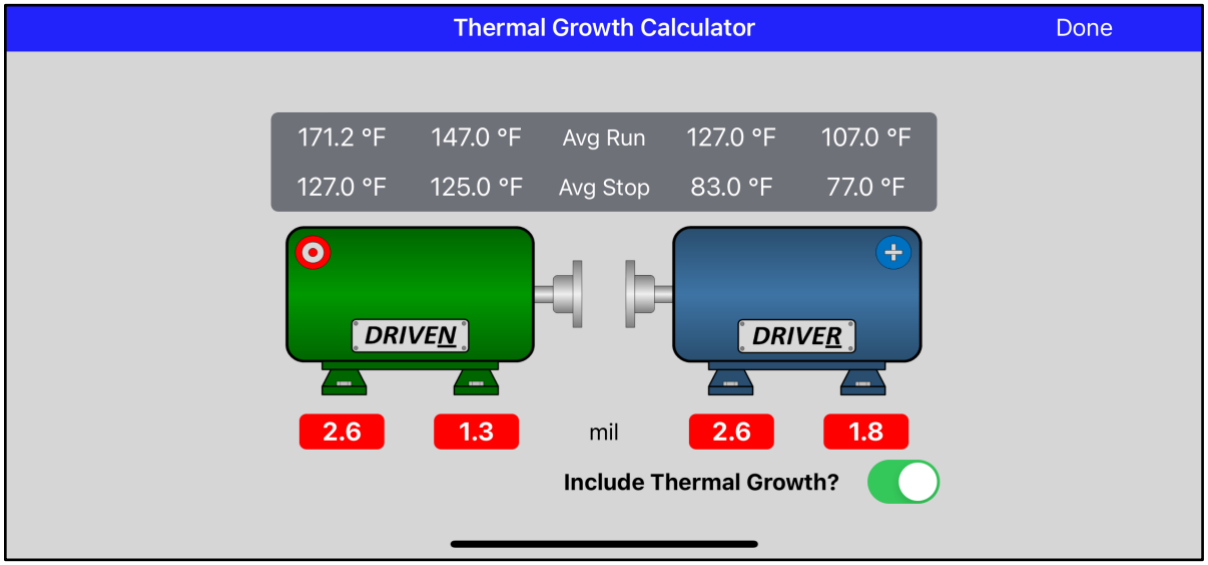
If the accuracy is less than the tolerance for the machine size, the color will be green.

If the accuracy exceeds the tolerance for the machine size, the color will be red.

# Thermal Growth Calculator Screen

***Average Temperatures***
Average temperatures for the DriveR and DriveN machines are summarized for running and stopped conditions.

***Done Button***
Touching the DONE button will return the App to the Machine Details screen.




***Thermal Growth Change***
Results of thermal growth are displayed under each machine foot.

Red is growth. The machine will rise when it is in operation.

Blue is shrinkage. The machine will contract when it is in operation

***Thermal Growth Selector***
Thermal growth can be included or excluded in the alignment calculation with this switch.

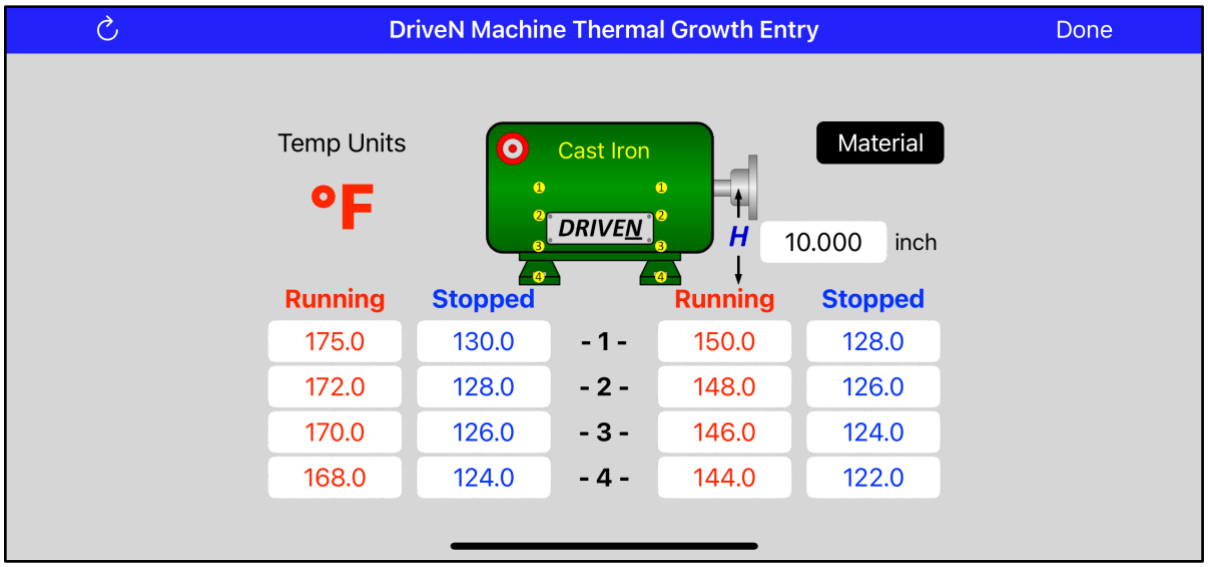
# DriveN Machine Thermal Growth Entry Screen

***Clear Button***
Touching the CLEAR button will quickly remove all entries on the screen.

***Material Selection***
Touching MATERIAL opens a pop-up to select the appropriate material of the machine.

The selected material is displayed in the machine image.

***Done Button***
Touching the DONE button will return the App to the Thermal Growth Calculator screen.




***Shaft Height Field***
Touch the "H" field to enter the shaft height from the base to the shaft ceterline.

***Temperature Fields***
Touch each field to enter running and stopped temperatures per the drawing.

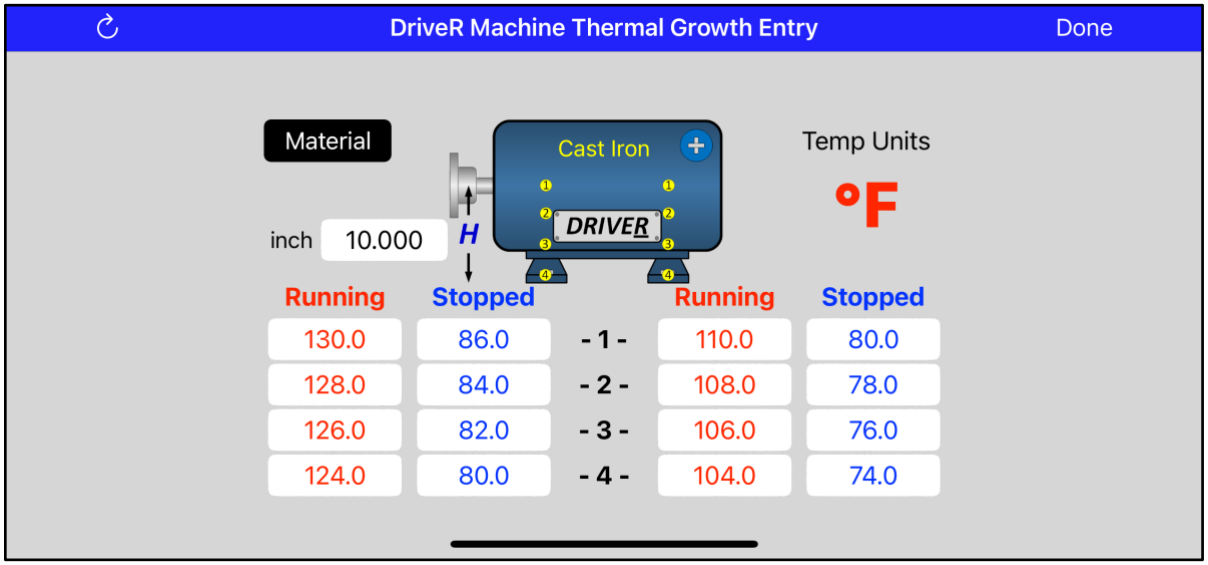
# DriveR Machine Thermal Growth Entry Screen

***Material Selection***
Touching MATERIAL opens a pop-up to select the appropriate material of the machine.

The selected material is displayed in the machine image.

***Clear Button***
Touching the CLEAR button will quickly remove all entries on the screen.

***Done Button***
Touching the DONE button will return the App to the Thermal Growth Calculator screen.




***Shaft Height Field***
Touch the "H" field to enter the shaft height from the base to the shaft ceterline.

***Temperature Fields***
Touch each field to enter running and stopped temperatures per the drawing.

# Vertical Alignment Solutions Screen

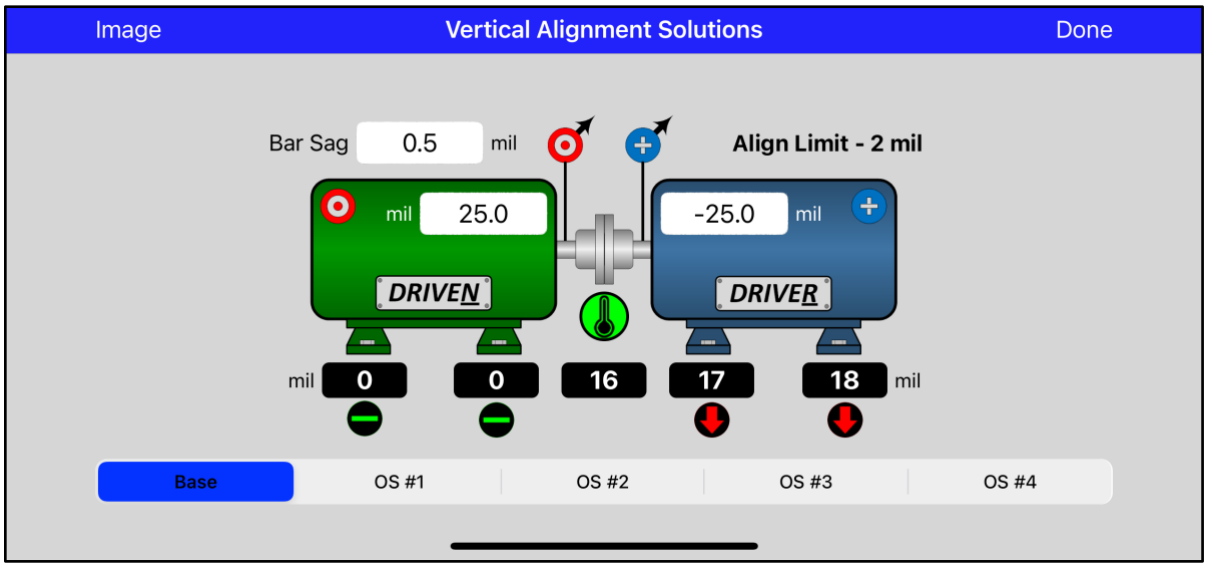
***Image Button***
Touching IMAGE will display a visual representation of the two machine shafts relative to each other.

***Bar Sag***
Touch the BAR SAG field to record the measured bag sag for reference.

***Dial Indicator Readings***
Touch the DriveR and DriveN dial indicator fields to record the indicator readings.

***Done Button***
Touching DONE will return the App to the Machine Details screen.

***Thermal Growth Indicator***
Thermal growth compensation is on if indicator is GREEN.




***Base Solution***
The move quantities shown below the machine feet indicate the amount of misalignment.

The example in the illustration indicates the DriveR machine is sitting 11mil low on the DS foot and 40 mil low on the ODS foot.

***Optional Solutions***
Touch the SOLUTIONS selector for 4 optional alignment solutions if a machine is bolt bound.

OS #1, DriveN ODS - DriveR ODS
OS #2, DriveN ODS - DriveR DS
OS #3, DriveN DS - DriveR ODS
OS #4, DriveN DS - DriveR ODS

***Move Indicators***
Move indicators are shown below feet move quantities.

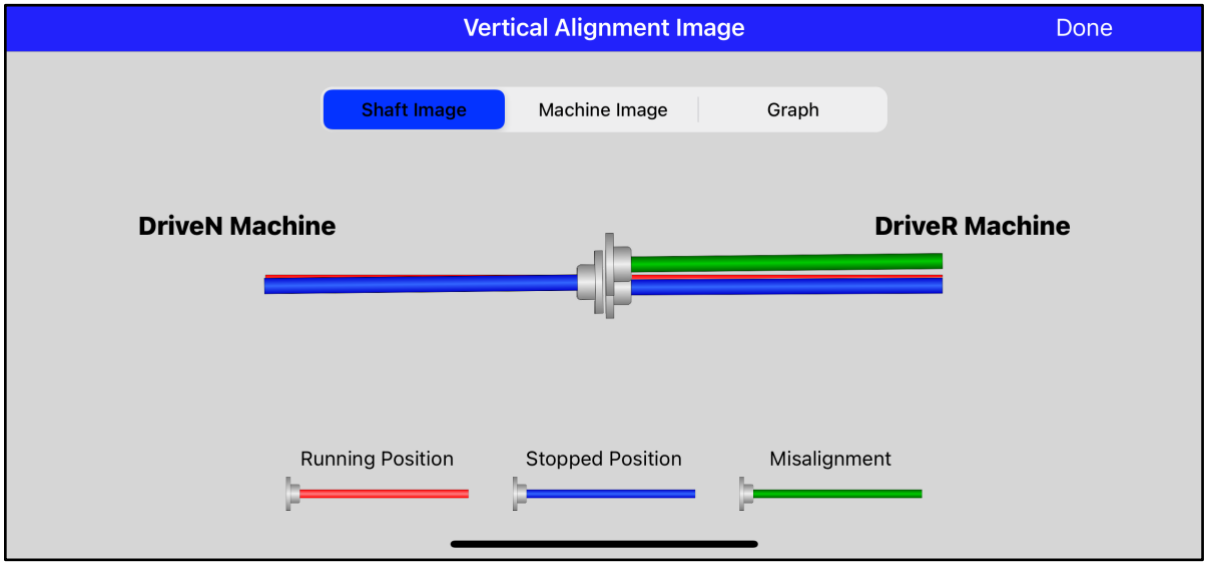
Arrow up – add shims
Arrow down – remove shims
Dash – no move

Green – alignment in spec
Red – alignment out of spec

# Vertical Alignment Image Screen (continued)

***Shaft Image***
All positions of the stopped, running, and misalignment shafts are presented.

***Done Button***
Touching DONE will return the App to the Vertical Alignment Solutions screen.




***Running Position***
The red shafts represent the running position of both the DriveN and DriveR machine shafts.

Once the machine is operating at normal temperatures, the machine will grow or shrink from the blue shaft position to the red shaft position.

***Stopped Position***
The blue shaft represents the stopped position of both the DriveN and DriveR machine shafts.

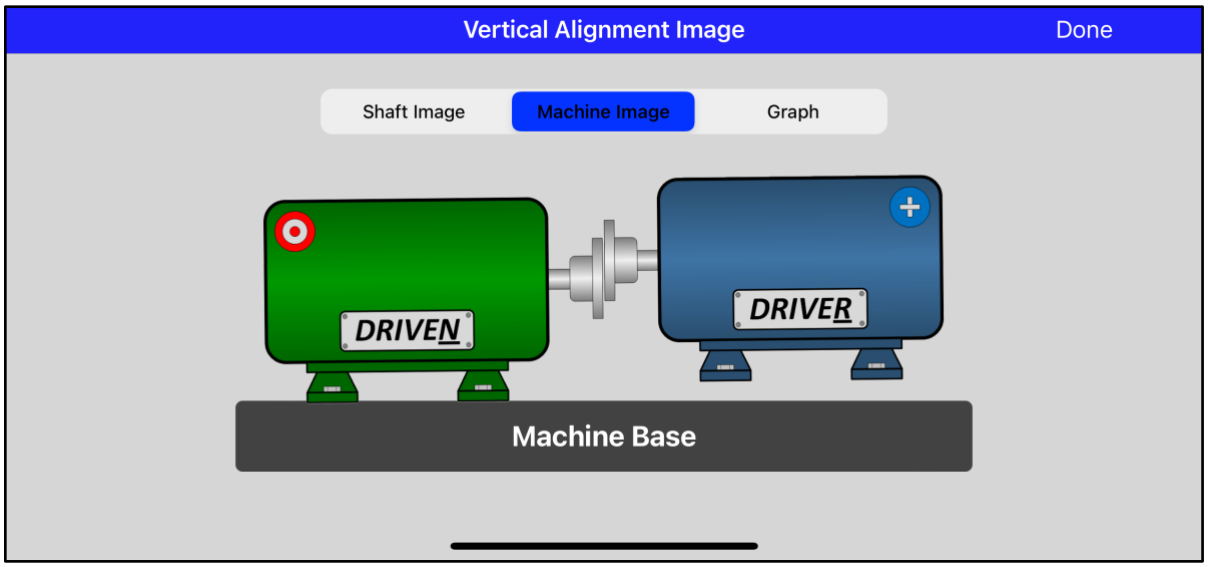
Ideally, the misalignment shaft should be positioned exactly over the stopped position of the DriveR machine.

***Misalignment Position***
The green shaft represents the misalignment of the DriveR machine.

# Vertical Alignment Image Screen (continued)

***Machine Image***
Touching the MACHINE IMAGE selector reveals a visualization of the machine images

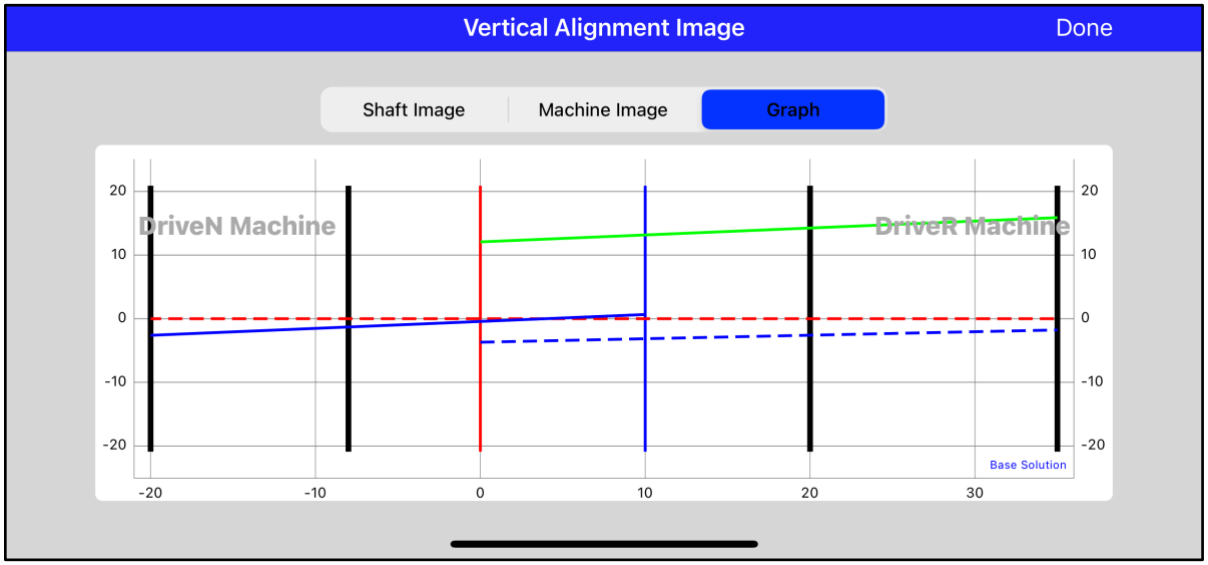
***Done Button***
Touching DONE will return the App to the Vertical Alignment Solutions screen.



# Vertical Alignment Image Screen (continued)

***Graph Image***
Touching the GRAPH selector reveals the graphical alignment solution

***Done Button***
Touching DONE will return the App to the Vertical Alignment Solutions screen.




Units for the horizontal axis are "inches" for the imperial system and "centimeters" for the metric system.

Units for the vertical axis are "mils" for the imperial system and "mm" for the metric system.

Red horizontal lines represent hot shaft positions. Blue horizontal lines represent cold shaft positions. The green line represents the current position of the DriveR machine shaft relative to the DriveN machine shaft.

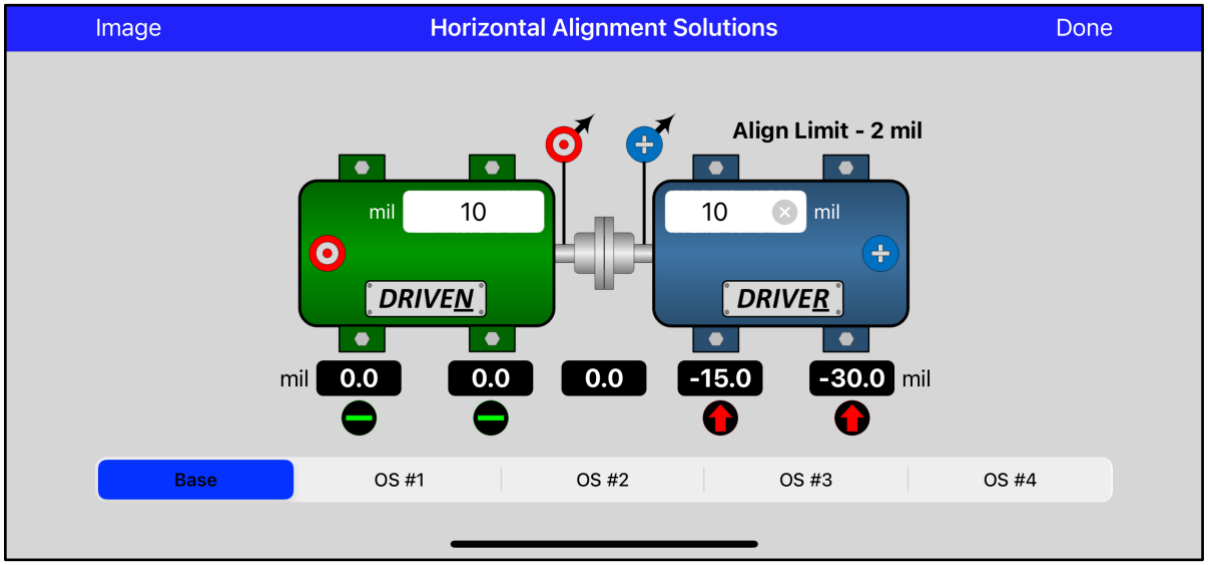
The graph is interactive. Pinch to zoom in. Reverse pinch to zoom out. The horizontal and vertical axes will automatically adjust as needed.

# Horizontal Alignment Solutions Screen

***Image Button***
Touching IMAGE will display a visual representation of the two machine shafts relative to each other.

***Dial Indicator Readings***
Touch the DriveR and DriveN dial indicator fields to record the indicator readings.

***Done Button***
Touching DONE will return the App to the Machine Details screen.




***Base Solution***
The move quantities shown below the machine feet indicate the amount of misalignment.

The example in the illustration indicates the DriveR machine is sitting 10.0 mil left on the DS foot and 17.5 mil left on the ODS foot.

***Optional Solutions***
Touch the SOLUTIONS selector for 4 optional alignment solutions if a machine is bolt bound.

OS #1, DriveN ODS - DriveR ODS
OS #2, DriveN ODS - DriveR DS
OS #3, DriveN DS - DriveR ODS
OS #4, DriveN DS - DriveR DS

***Move Indicators***
Move indicators are shown below feet move quantities.

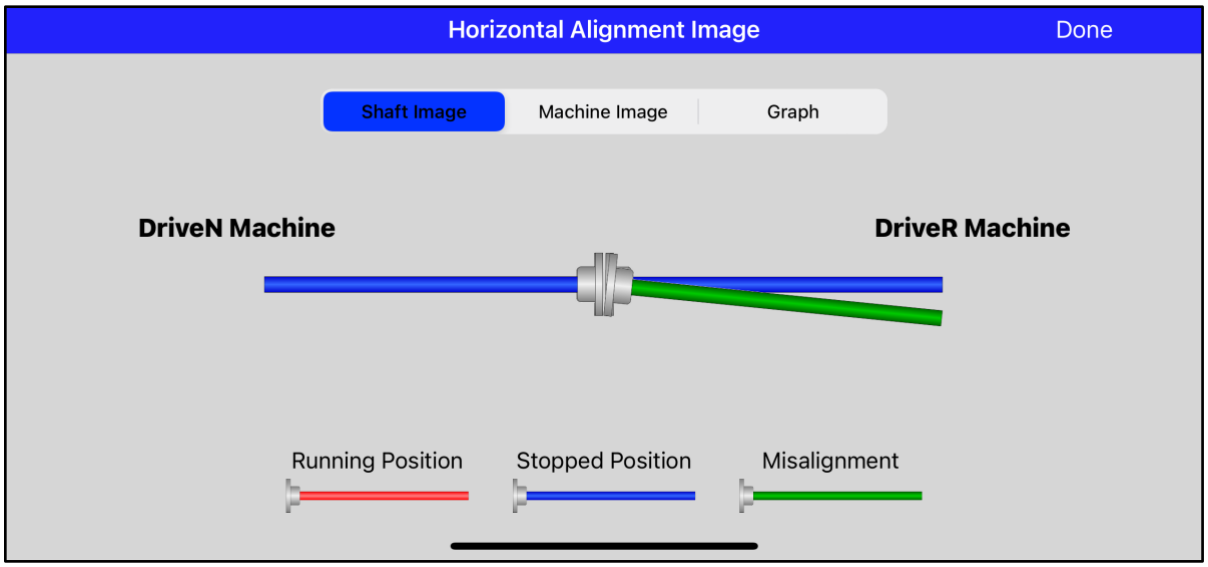
Viewing DriveR to DriveN
Arrow left – move left
Arrow right – remove right
Dash – no move

Green – alignment in spec
Red – alignment out of spec

# Horizontal Alignment Image Screen

***Shaft Image***
All positions of the stopped, running, and misalignment shafts are presented.

***Done Button***
Touching DONE will return the App to the Horizontal Alignment Solutions screen.




***Running Position***
The red shafts represent the running position of both the DriveN and DriveR machine shafts.

Once the machine is operating at normal temperatures, the machine will grow or shrink from the blue shaft position to the red shaft position.

***Stopped Position***
The blue shaft represents the stopped position of both the DriveN and DriveR machine shafts.

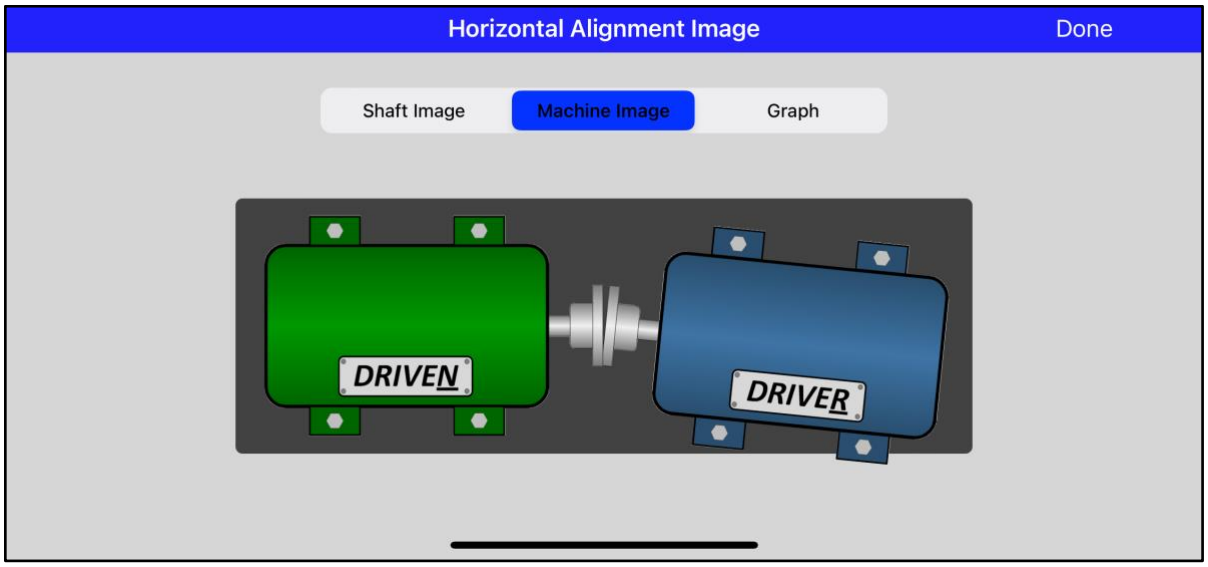
Ideally, the misalignment shaft should be positioned exactly over the stopped position of the DriveR machine.

***Misalignment Position***
The green shaft represents the misalignment of the DriveR machine.

# Horizontal Alignment Image Screen (continued)

***Machine Image***
Touching the MACHINE IMAGE selector reveals a visualization of the machine images

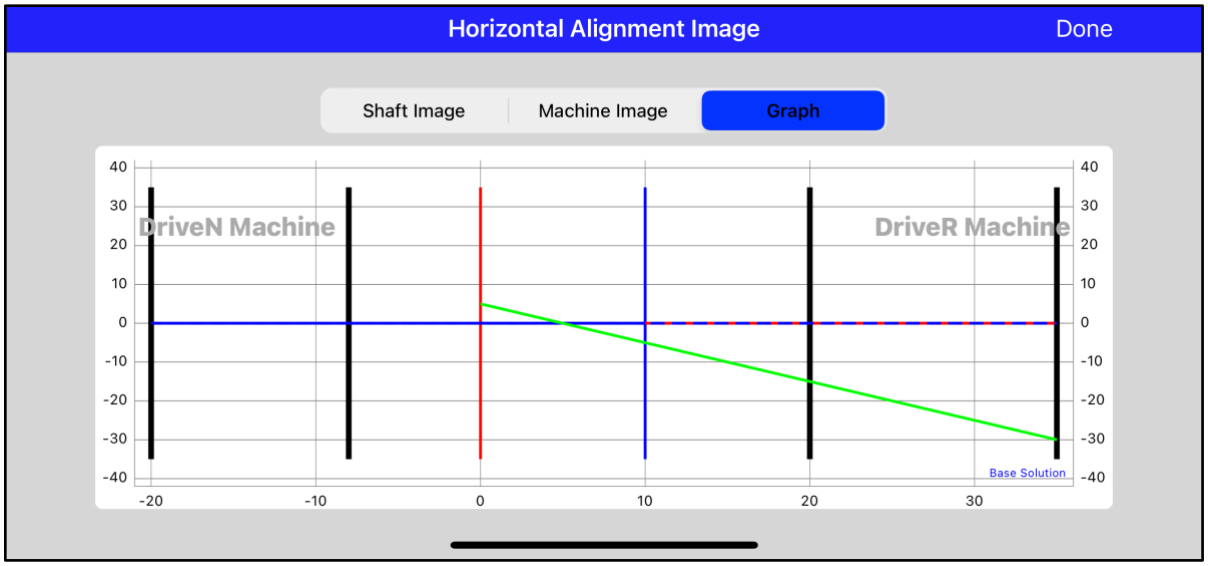
***Done Button***
Touching DONE will return the App to the Horizontal Alignment Solutions screen.



# Horizontal Alignment Image Screen (continued)

***Graph Image***
Touching the GRAPH selector reveals the graphical alignment solution

***Done Button***
Touching DONE will return the App to the Vertical Alignment Solutions screen.



Units for the horizontal axis are “inches” for the imperial system and “centimeters” for the metric system.

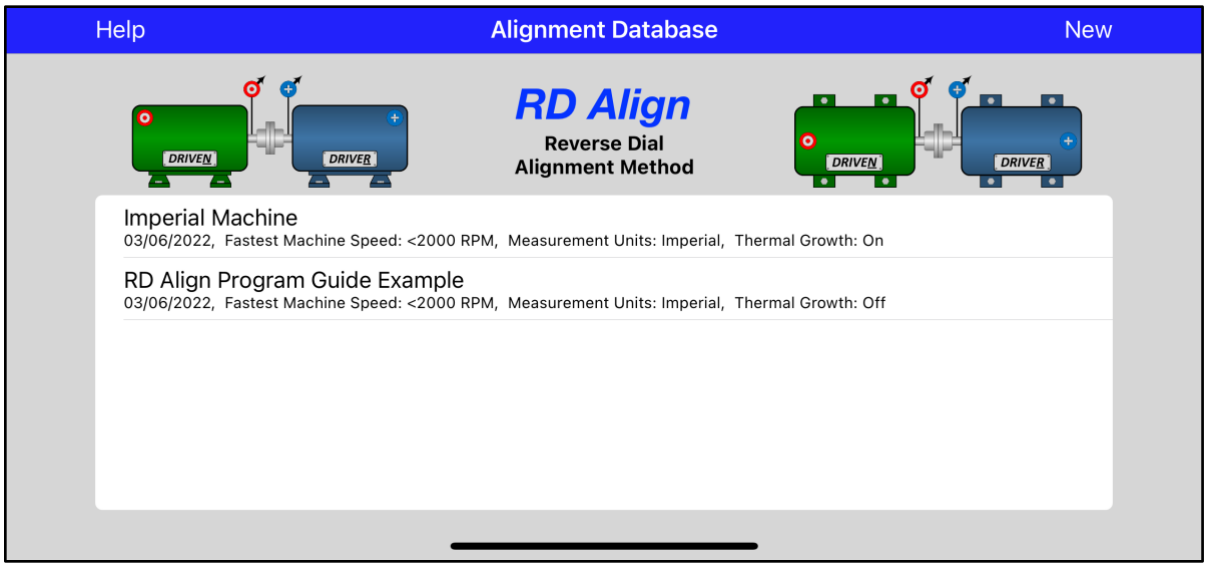
Units for the vertical axis are “mils” for the imperial system and “mm” for the metric system.

Red horizontal lines represent hot shaft positions. Blue horizontal lines represent cold shaft positions. The green line represents the current position of the DriveR machine shaft relative to the DriveN machine shaft.

The graph is interactive. Pinch to zoom in. Reverse pinch to zoom out. The horizontal and vertical axes will automatically adjust as needed.

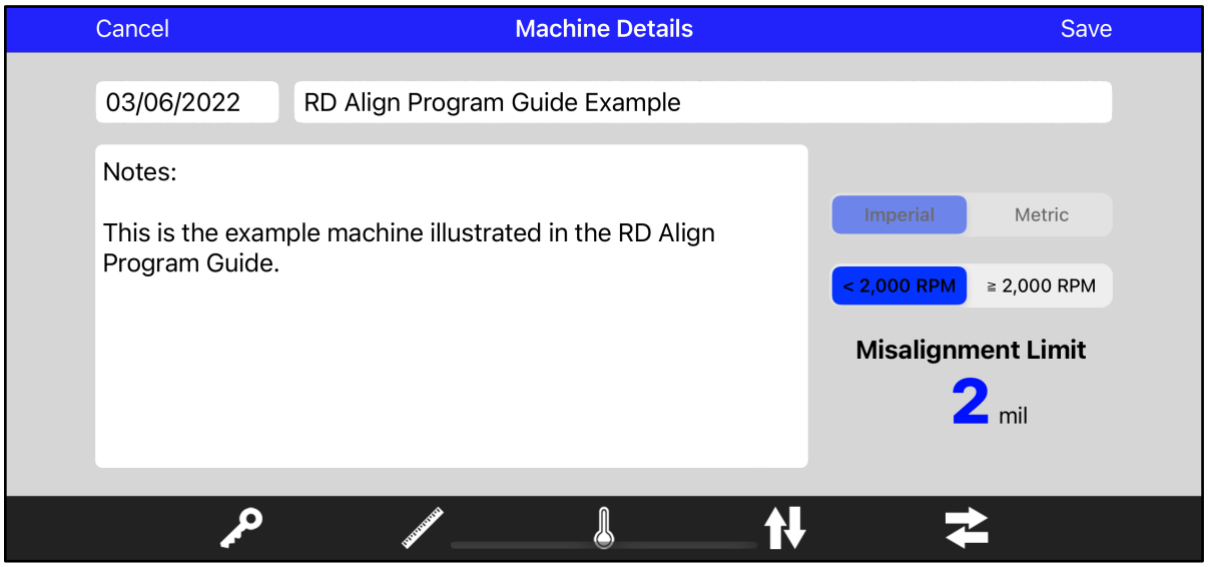
## Example Alignment

# Step 1 – Saved and New Alignment Records



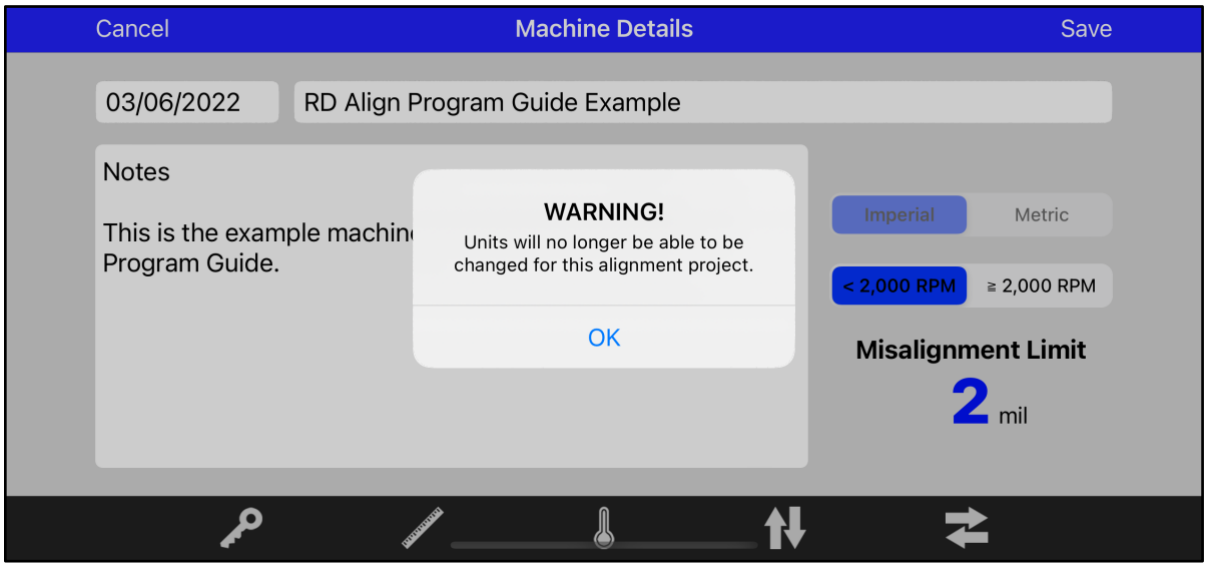

- The Alignment Database screen will be presented on the iPhone when the RD Align App is started.
- This screen shows a list of previously saved alignment projects.
- To return to a previous alignment, touch the previous project.
- If a new project is desired, touch NEW.
- For this example, we will work through the ***RD Align Program Guide Example.*** Touch this project.

# Step 2 – New Alignment Record



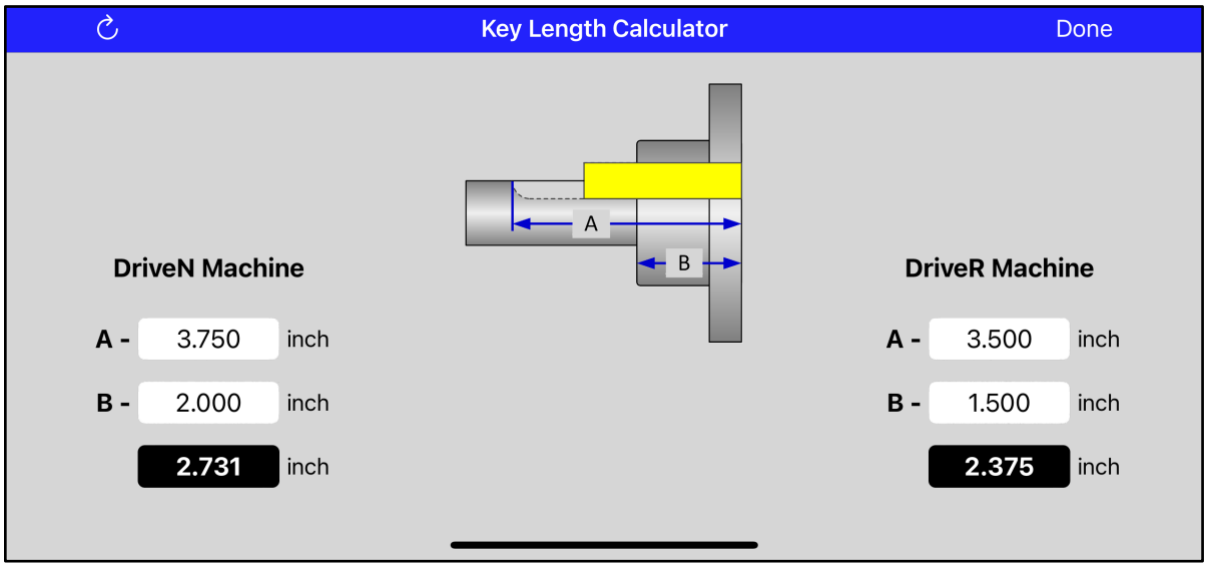

- The Machine Details screen is the main screen presented for an alignment record.
- The date populates with today's date, but can be edited if needed.
- Touch the MACHINE ID box. A keyboard will appear. Type how you would like to identify the alignment record. For this example, we will use *RD Align Program Guide Example*.
- The NOTES field is a field to enter any particular notes, observations, difficulties, etc. about this alignment project. A keyboard will appear when the NOTES field is touched.
- Select the UNITS selector for the alignment units. For this example, we will use IMPERIAL, which are the default units.
- Identify the speed of the fastest machine of the equipment set and select the appropriate SPEED SELECTOR. For this example, the motor has a nameplate speed rating of 1750 RPM. The default selection is <2000 RPM.

# Step 2 – New Alignment Record (continued)



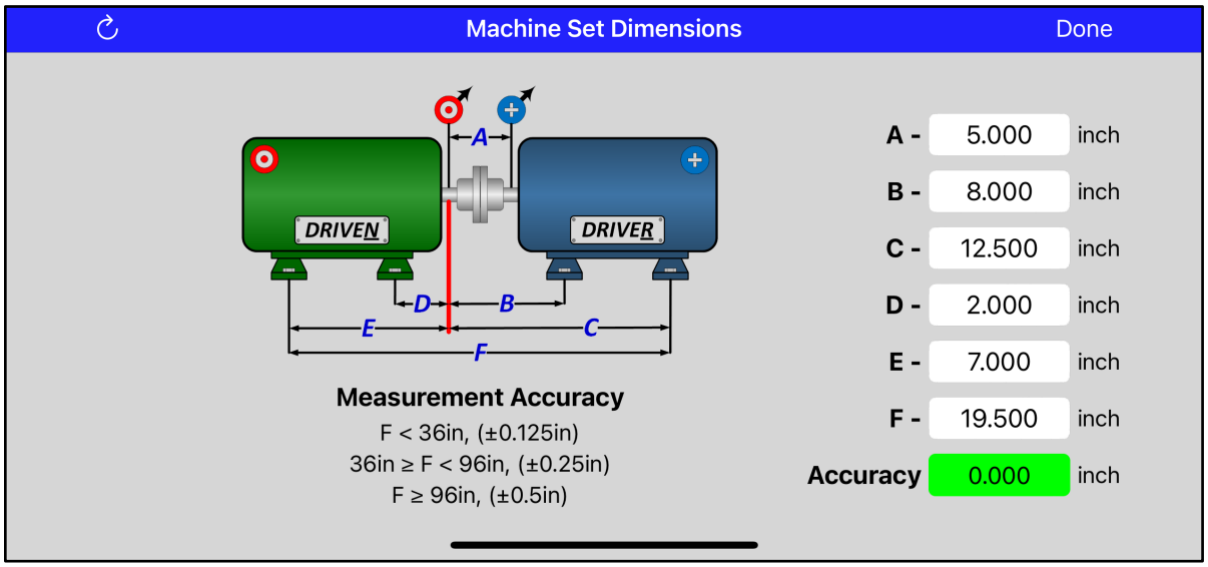

- Touch the KEY icon at the bottom of the screen.
- Touching the KEY icon (or any other icon at the bottom of the screen) will reveal this pop up warning.
- RD Align will ***not*** convert from Imperial to Metric or vice versa. You must select the units you want to perform the alignment with.
- Touch OK to proceed.

# Step 3 – Key Length Calculator



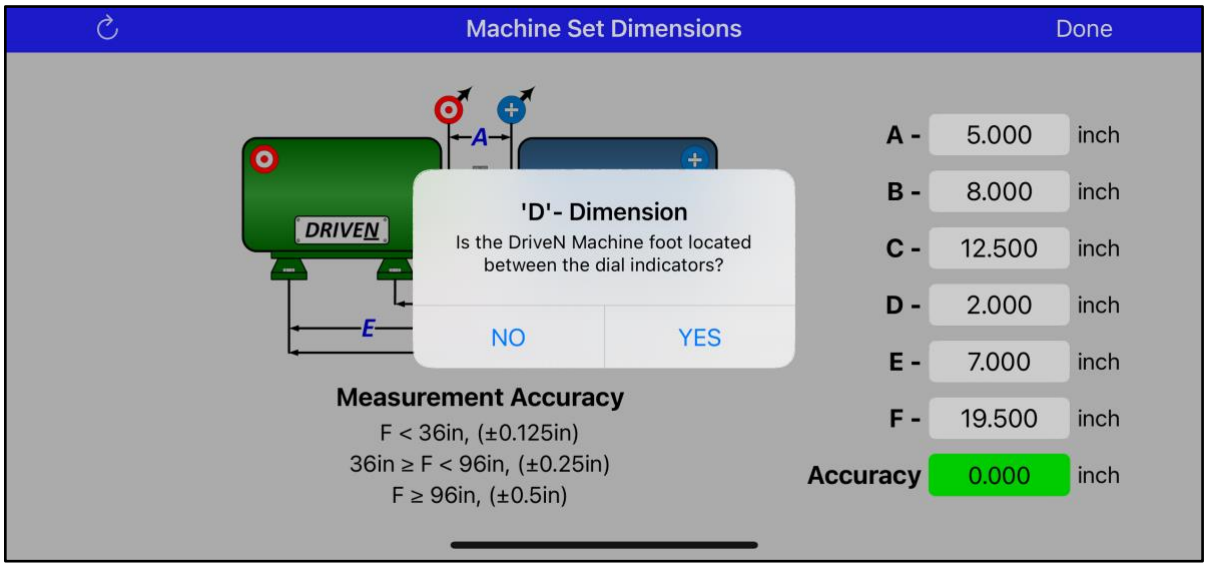

- Touching the KEY icon on the Machine Details screen will present this screen. This is an optional step and does not impact the alignment solution, but is needed to preserve the balance quality of the equipment set.
- Touch the appropriate fields to enter the shaft keyway length and the fitment keyway length. A number pad will appear for each field.
- Since we are using Imperial units, the dimensions must be entered as inches.
- The correct key length solution is automatically calculated after entering the dimensions.
- Both the DriveR and DriveN machine's key length should be calculated and proper key material selected. In this example, the DriveN machine's key length is about 2 3/4" and the DriveR machine's key length is 2 3/8".
- Touch DONE to return to the Machine Details screen.

# Step 4 – Machine Dimensions



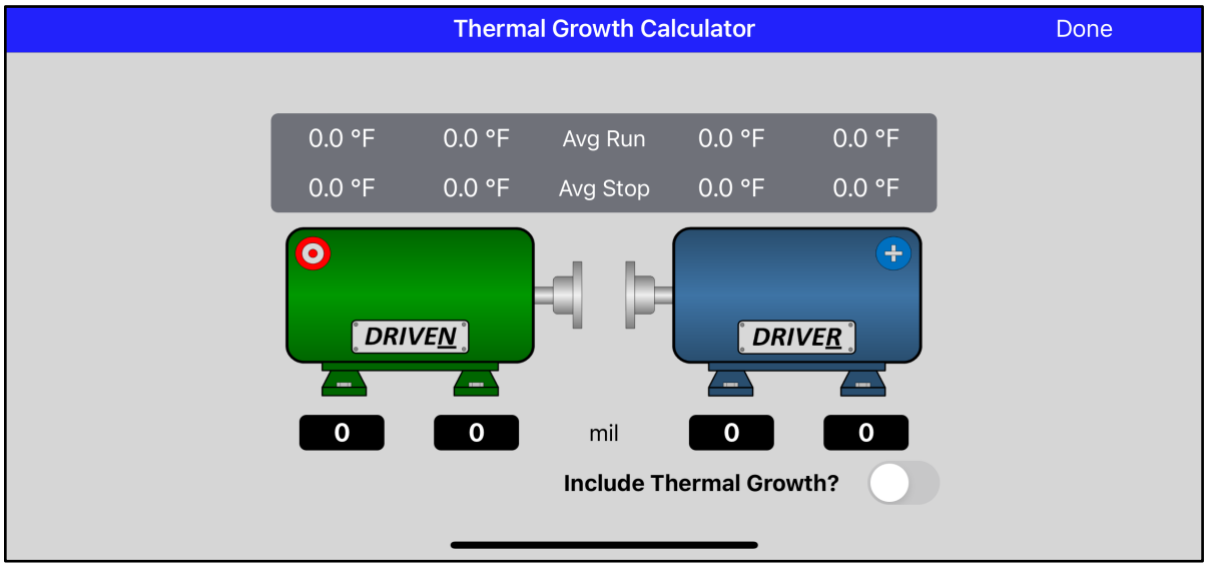

- Touching the RULER icon on the Machine Details screen will present this screen.
- Carefully inspect the provided drawing and measure the dimensions for each box listed. A, B, C, D, E, and F.
- Touch each dimension box. A number pad will appear. Enter the dimension in the box.
- Dimension F is a verification dimension. The measurements must be within the tolerance specified depending on overall machine length. Failure to maintain these tolerances will impact alignment calculation accuracies. If the verification dimension is not within the correct tolerance, the accuracy solution background box will appear RED. If the verification dimension is within the correct tolerance, the accuracy solution background box will appear GREEN.
- Touch DONE to return to the Machine Details screen.

# Step 4 – Machine Dimensions (continued)




- After entering or changing the "D" dimension value, a question box will appear.
- The "D" dimension should be the total distance from the DriveN dial indicator to the DriveN drive side foot no matter which side of the dial indicator the foot is actually located.
- However, RD Align must know where the foot is located. The foot will be located outside the dial indicators or between them.

# Step 5 – Thermal Growth



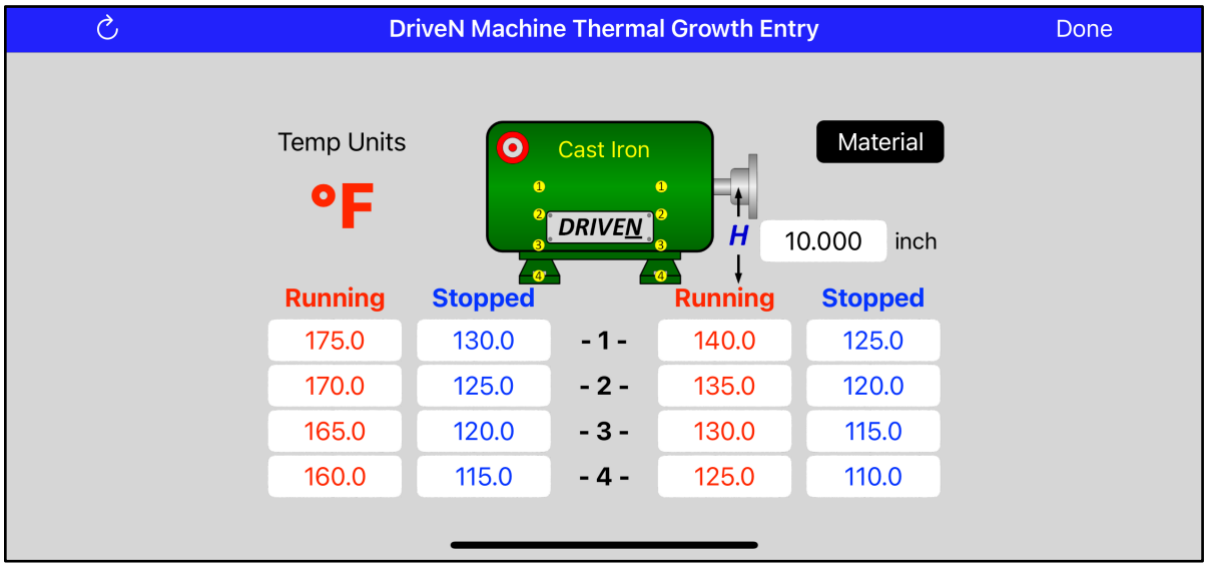

- Touching the THERMOMETER icon on the Machine Details screen will present this screen.

- Thermal growth alignment compensation is not required. However, machine performance and longevity is greatly increased when it is included. By compensating for thermal growth, the machine will actually be misaligned in a controlled manner. As the machine warms up (or cools down for refrigeration), the machine will grow into alignment.

- This screen is the summary screen for measured temperatures cold and hot. The same procedure is repeated for both the DriveR and DriveN machines.

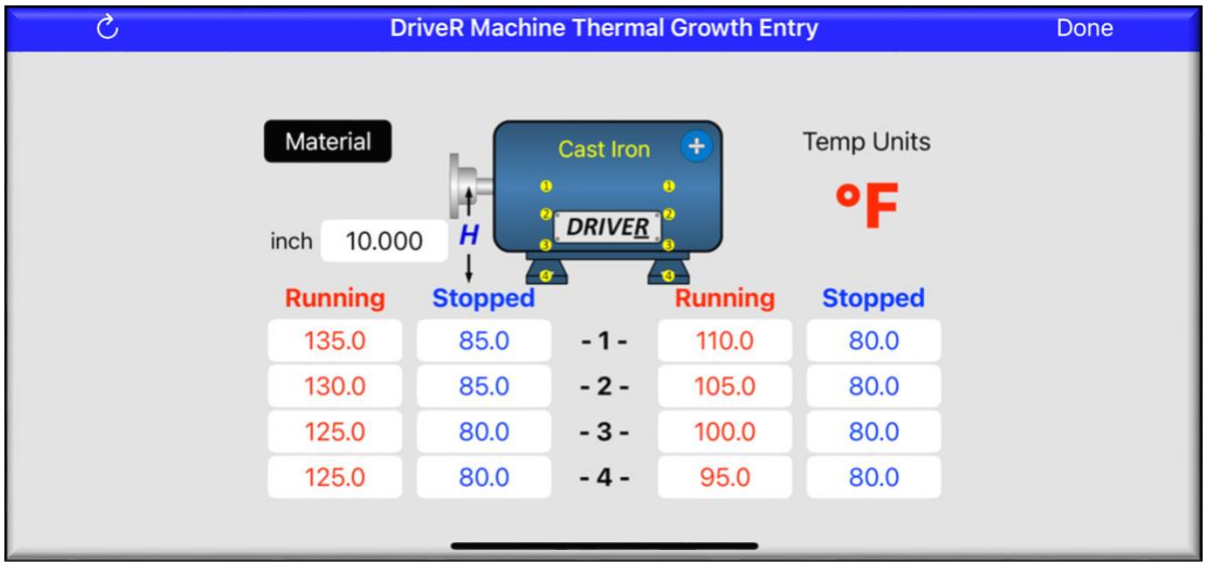
- Touch the DriveN machine to enter temperature measurements for that machine.

# Step 5 – Thermal Growth (continued)



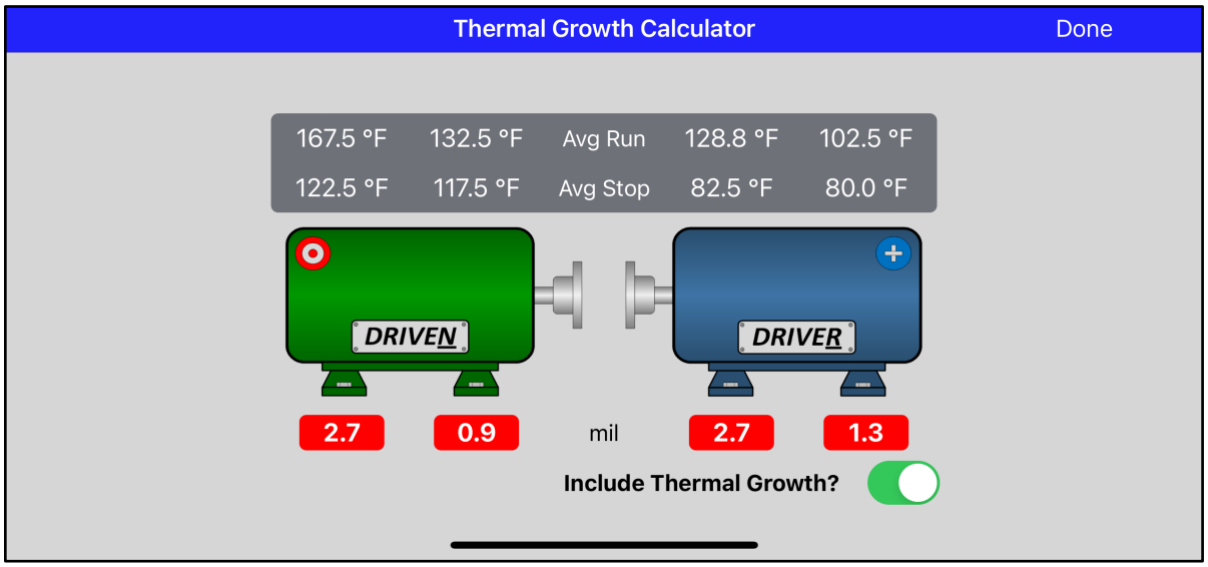

- Touch the DriveN machine image on the Thermal Growth Calculator screen will present this screen.
- Measure the temperature of the machine case in line with the feet at 4 positions as shown on the diagram from the centerline of the shaft to the foot with an infrared thermometer or equivalent device. Both running and stopped temperatures are needed. Most machines, the running temperature will be hotter than stopped. But refrigeration equipment may be the opposite.
- Touch each box and enter the temperature from the number pad. Both inboard and outboard casing temperatures are needed.
- Touch the MATERIAL button to select the corresponding material for the machine case.
- Touch the SHAFT HEIGHT BOX to enter the height of the shaft from the centerline to the same height at the machine foot.
- Since we are using Imperial units, all temperatures must be in Fahrenheit and the shaft height dimension must be in inches.
- Touch DONE to return to the Thermal Growth Calculator screen.

# Step 5 – Thermal Growth (continued)



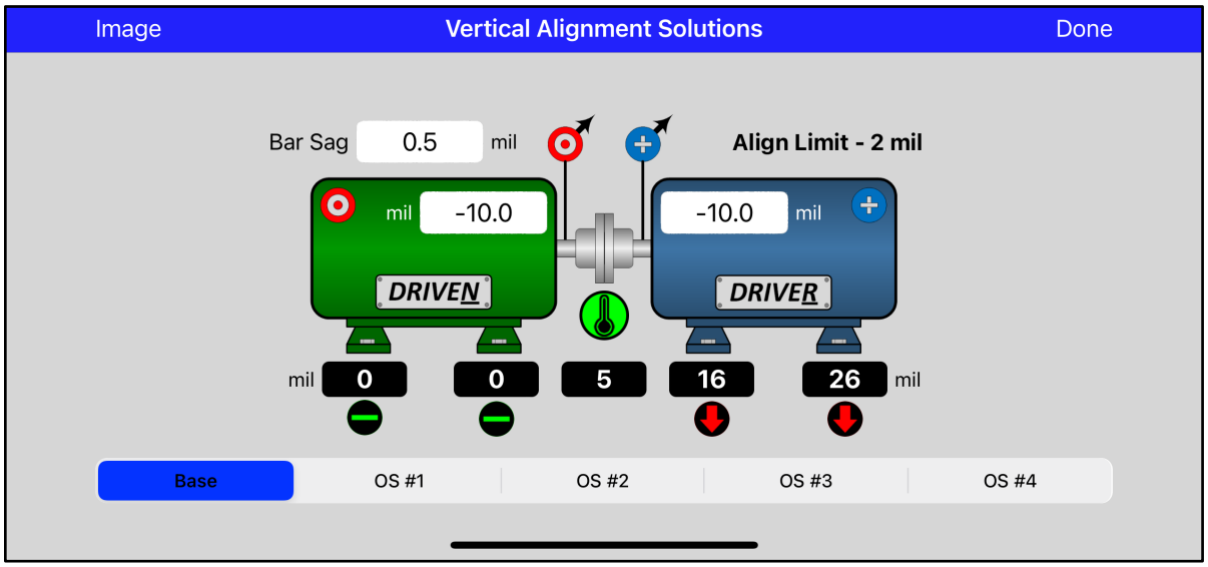

- Touching the DriveR machine image on the Thermal Growth Calculator screen will present this screen.
- Repeat the temperature measurement and entry process for the DriveN machine.
- Touch DONE to return to the Thermal Growth Calculator screen.

# Step 5 – Thermal Growth (continued)




- With both the DriveN and DriveR machine running and stopped temperatures added, RD will calculate the movements needed to correct for thermal growth.
- Touch the selector icon at the bottom of the screen indicated by *Include Thermal Growth?* Thermal growth will be included when the selector background is Green.
- If thermal growth is not included, touch the selector icon to off.
- Touch DONE to return to the Machine Details screen.

# Step 6 – Vertical Alignment




- Touch the VERTICAL ARROWS icon on the Machine Details screen to display the Vertical Alignment Solutions screen.

- Prior to installation of the reverse dial alignment jig on the machine, install the same setup on a section of pipe. Zero the indicators when they are positioned on the top of the pipe, which is simulating the shaft. Rotate the alignment jig 180°. Carefully read the values on the indicators. Both indicators should have the same value. This is the bar sag. Record the value in the box in the upper left corner of the screen.

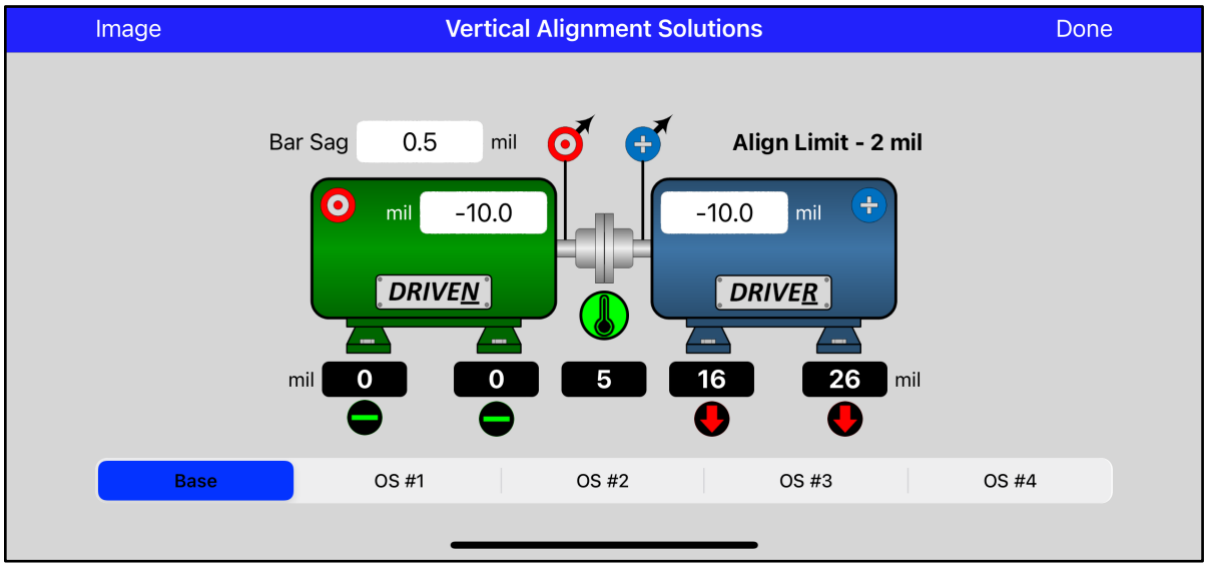
- Install the reverse dial alignment jig on the machine. Set both dial indicators to the measured bar sag at the top or 0° position. Rotate the alignment jig 180°. Carefully read the values on the indicators.

- Touch the DriveN indicator box and record the target indicator value with the number pad. All dial indicator readings are in mils. 1mil = 0.001”

- Repeat for the DriveR machine

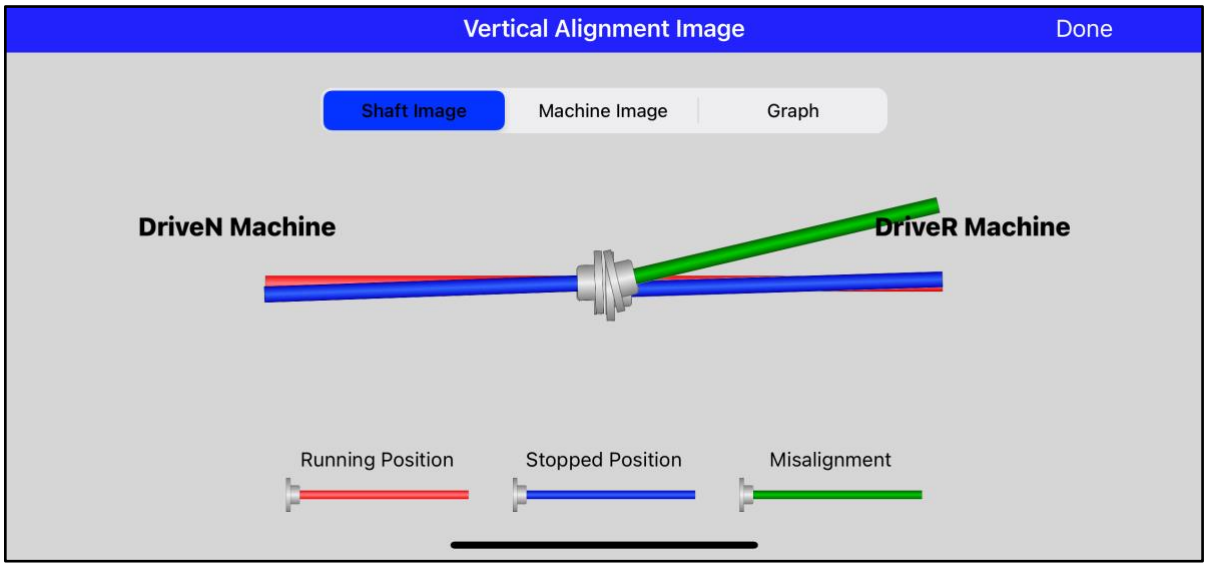
- Touch the icon labeled BASE. The standard alignment solution will be presented under the feet for each machine and an approximation of the misalignment at the coupling.

# Step 6 – Vertical Alignment (continued)



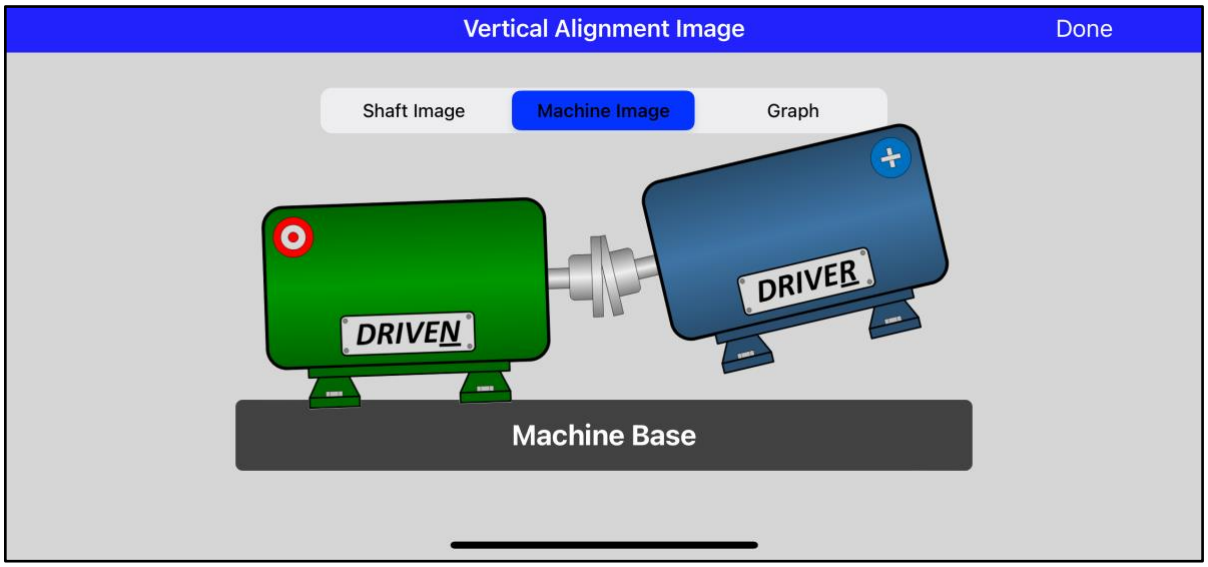

- If the alignment solution is within the allowable tolerance, the move indicators under the feet will be GREEN and show a horizontal bar. No move will be needed.
- For this example, the machine set is not aligned within tolerance. RD Align calculated a solution to lower the inboard DriveR machine feet 16 mils and the outboard feet 26 mils. Remove the correct amount of shim stock and retake the measurements.
- To see a visualization of the shaft positions, touch IMAGE in the upper left corner.
- RD Align will also calculate 4 alternate alignment solutions. The machine does not have to be aligned parallel to earth. Just in a straight line. Any combinations of 2 feet can be held stationary and the remaining moves will be calculated on the remaining 2 feet. This means the DriveN machine will need to be moved.
- Often times, the alternate solutions are smaller moves and may be easier to control the machine movement. These moves also eliminate the need to elongate boltholes, reducing bolt diameters, or grinding the base/foot.
- Touch DONE to return to the Machine Details screen.

# Step 6 – Vertical Alignment (continued)



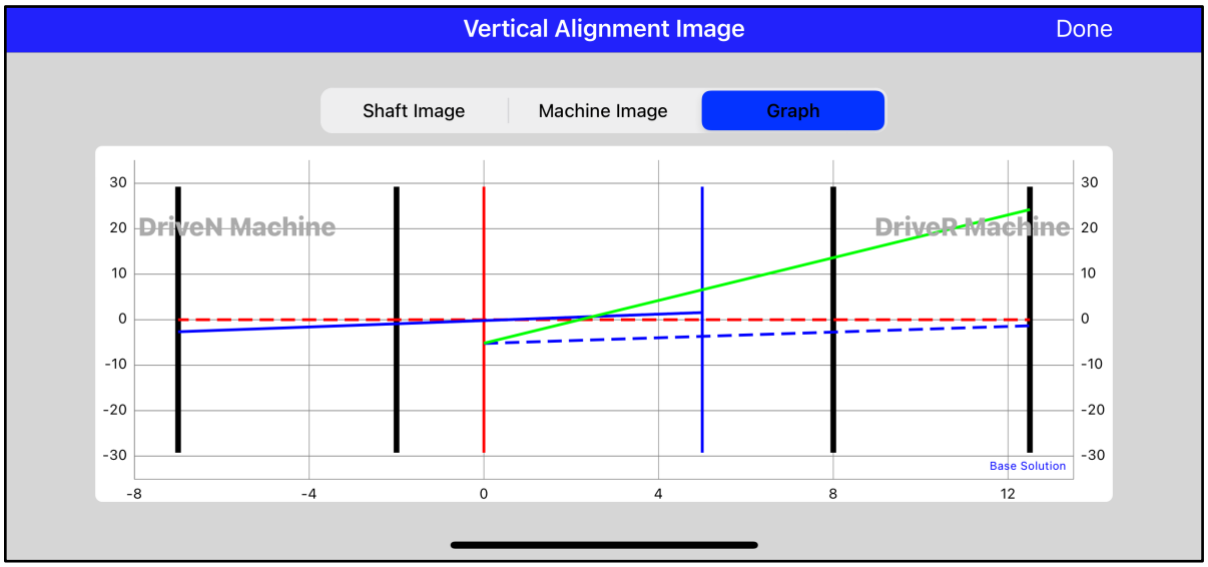

- Touching the IMAGE icon on the Vertical Alignment Solutions screen will present this screen.
- The RED shaft is the position of the shaft when the machine is running.
- The BLUE shaft is the position of the shaft when the machine is stopped and during the alignment process.
- The GREEN shaft represents the current misalignment.
- Touching the top selector MACHINE IMAGE is a visual representation of the machines current alignment position. The image can be toggled back and forth if desired.
- Note the 4 optional alignment solutions will not be visually represented. Only the actual position of the shafts/machine.
- Touch DONE to return to the Vertical Alignment Solutions screen.

# Step 6 – Vertical Alignment (continued)



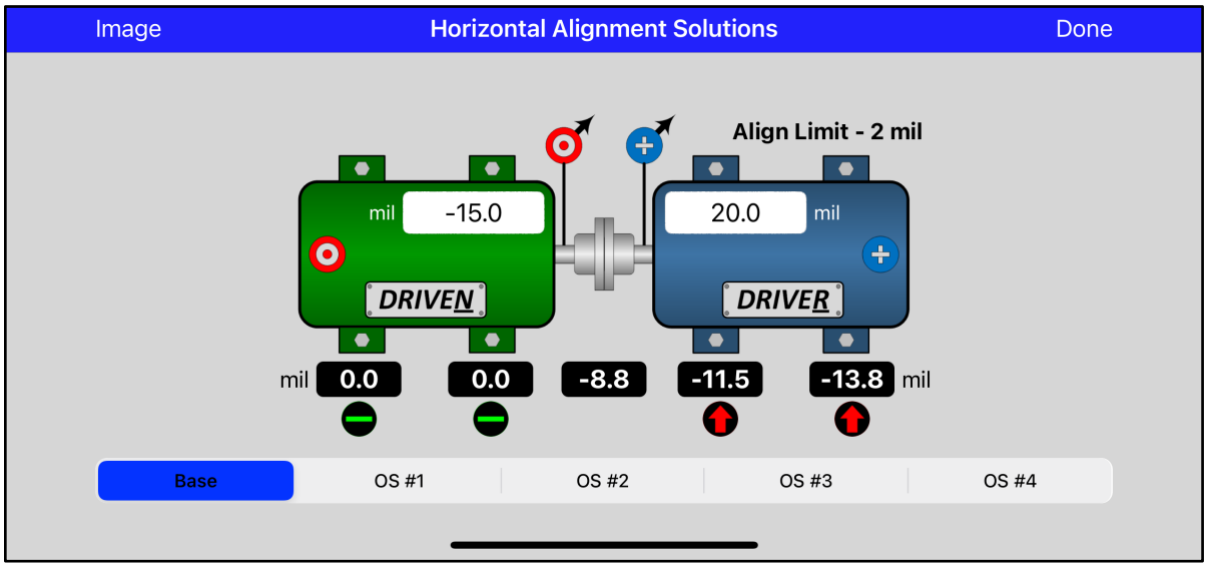

- Touch MACHINE IMAGE to see a visual representation of the machines as they appear on the machine base
- Touch DONE to return to the Vertical Alignments Solution screen.

# Step 6 – Vertical Alignment (continued)



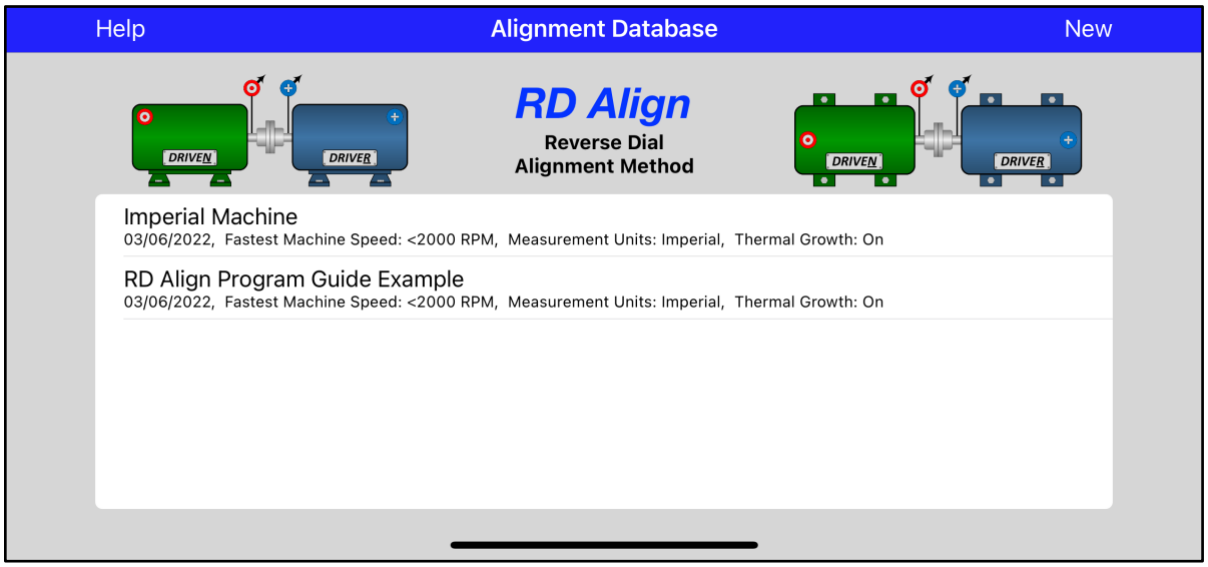

- Touch GRAPH to see the graphical solution of the machine set alignment.
- "Pinch" the image to zoom in or zoom out.
- Touch DONE to return to the Vertical Alignments Solution screen.

# Step 7 – Horizontal Alignment




- Touch the HORIZONTAL ARROWS icon on the Machine Details screen to display the Horizontal Alignment Solutions screen.
- The horizontal process works the same as the vertical. However, no bar sag is recorded.
- Touch DONE to return to the Machine Details screen.

# Step 8 – Save Alignment Record




- Touch the SAVE icon in the upper right corner of the Machine Details screen.
- The alignment record will be saved.
- RD ALIGN will return to the Alignment Database screen.

- To delete a record, touch and swipe left to reveal an option to delete the record. Touch DELETE to delete the record.