RD-Align Pro

Shaft Alignment - Reverse Dial Method

Multiple Machines / Multiple Feet

Program Guide version 1.2

Revised 01-Mar-2018

This document can be downloaded from dmappcompany.com

D&M App Company, LLC

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Disclaimer

RD-Align Pro 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.

If an error is found, we would appreciate feedback to investigate and correct the issue.

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.

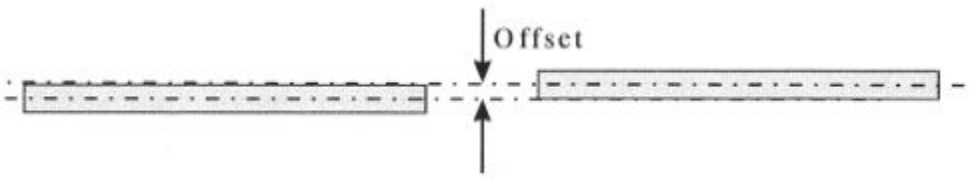


Illustration 1 - Offset Alignment

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.

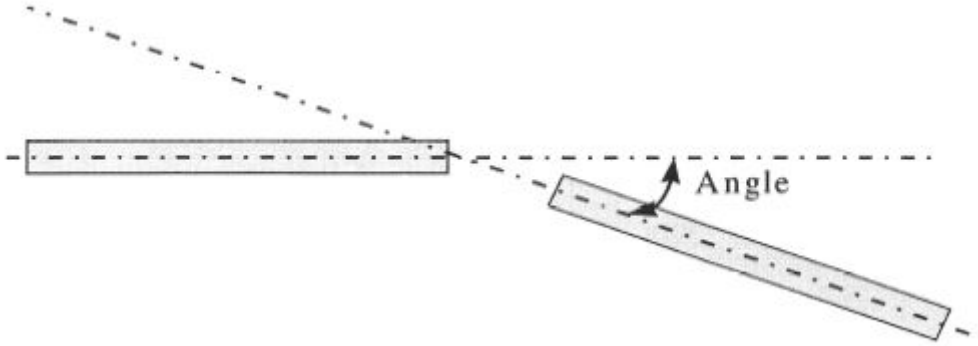


Illustration 2 - Angularity Alignment

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

RD-Align Pro is a calculator used for performing shaft alignments of rotating equipment using the reverse dial indicator method. Several features include,

- Machine Set Screen – used to define the machine set name, speed, units, number of machines, number of feet per machine, date of alignment project and other notes about the alignment activity.
- 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 of each machine set based on dial indicator readings. Customizable optional solutions are also available for the total machine set.

- Horizontal Alignment Calculator – used to calculate horizontal movements of each machine set based on dial indicator readings. Customizable optional solutions are also available for the total machine set.

Compatibility

RD-Align Pro is designed for Apple iPads. All 64bit devices are supported.

General Usage Notes

RD-Align Pro is intended to assist in calculating vertical and horizontal alignment positions for a multiple machine set. Alignment solutions can be determined for a minimum of 2 machines and a maximum of 5 machines. In addition, each machine can have as few as 2 feet pairs and a maximum of 5 feet pairs. It also maintains a historical record of past alignments performed.

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

Machine Set Details Screen – use this screen to enter machine description, alignment notes, measurement units, fastest machine speed, machine quantity, and number of feet per machine.

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 Pro alignment solutions are based on a graphical approach. However, RD-Align Pro mathematically models the solution and calculates numbers for the solution. The Machine Set Dimensions Screen of RD-Align Pro 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.

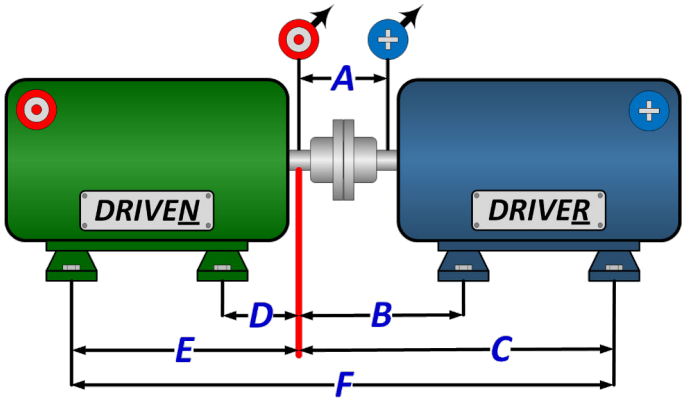


Illustration 3 – Machine Set Dimensions

Illustration 4 represents the base vertical solution for hypothetical alignment project. For simplicity, thermal growth is NOT included in these examples.

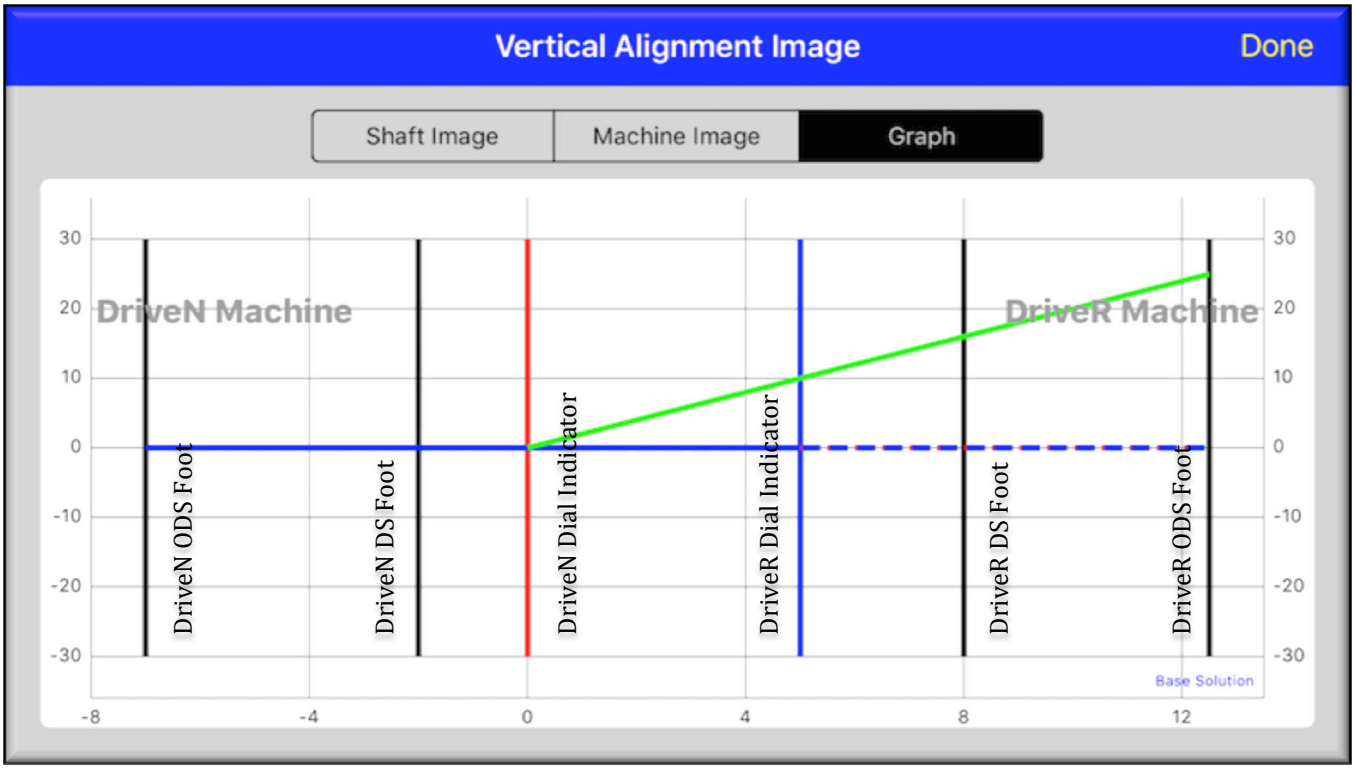


Illustration 4 - Base Vertical Alignment Solution

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 distance from the green line to the horizontal axes. Remember vertical scale 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 Pro provides 4 optional alignment solutions to avoid machine/base modifications.

RD-Align Pro 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.

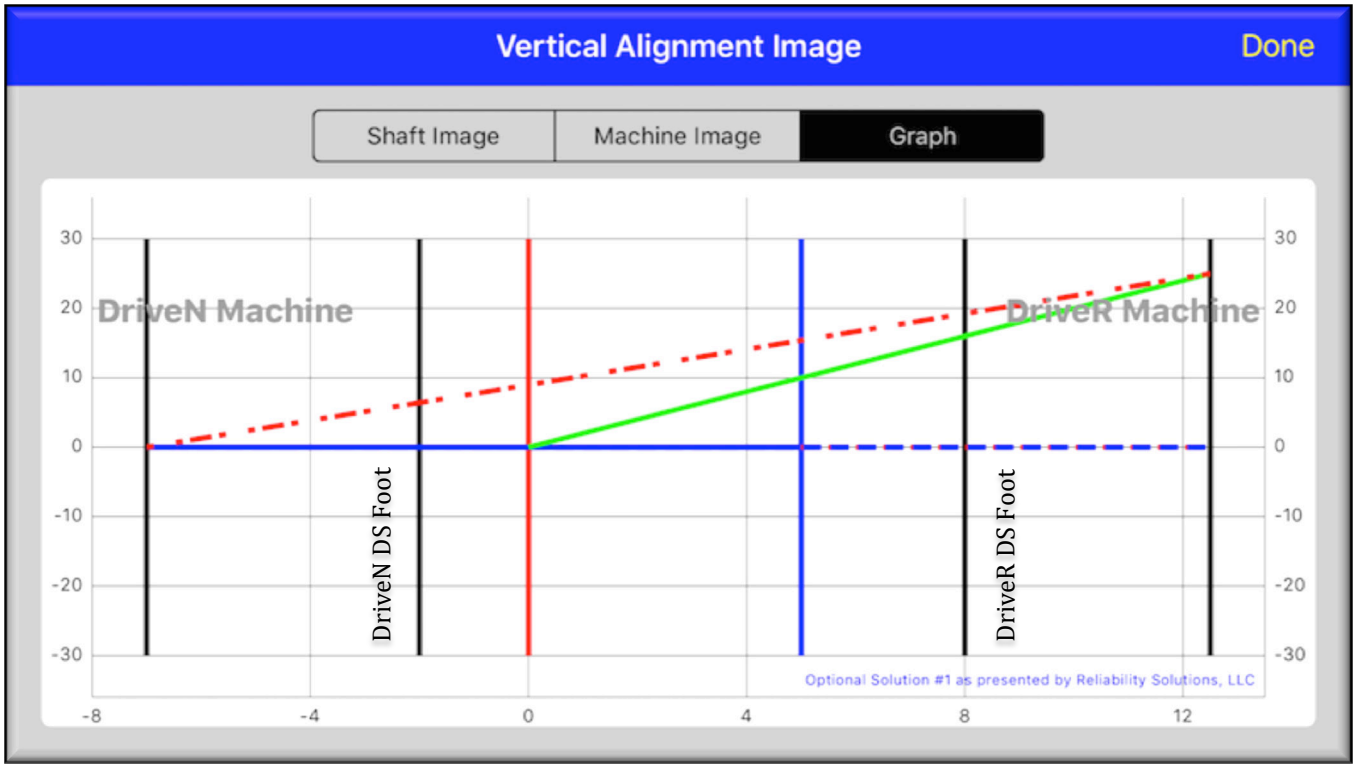


Illustration 5 – Optional Vertical Alignment Solution #1

- 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.

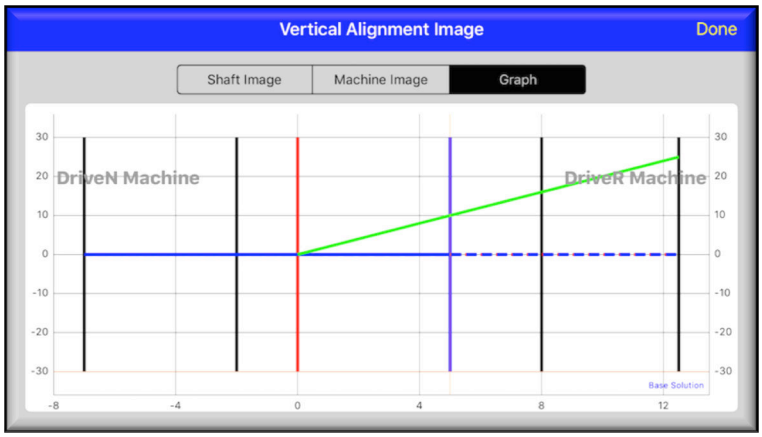
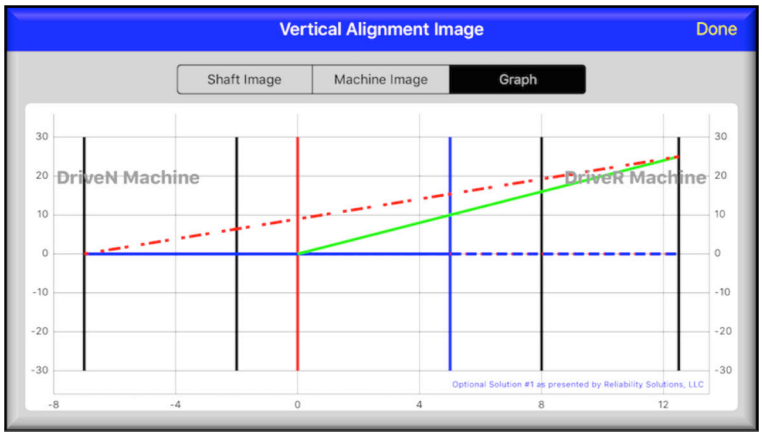
- To determine the option move amounts and direction, simply count the boxes from the current position of each foot to the desired position (red dashed line).
- For this example,

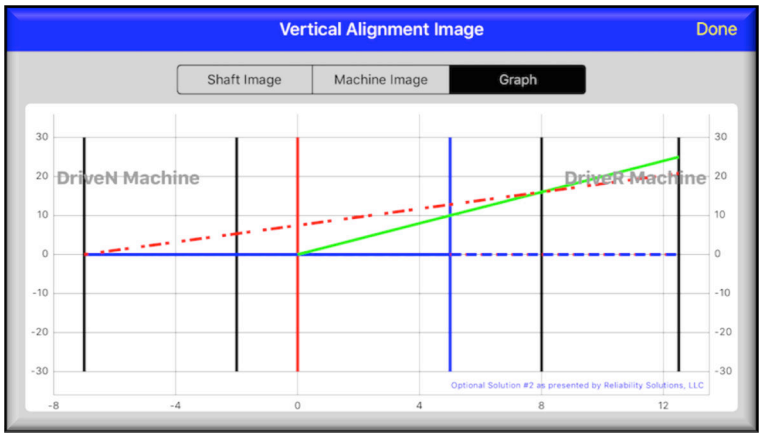
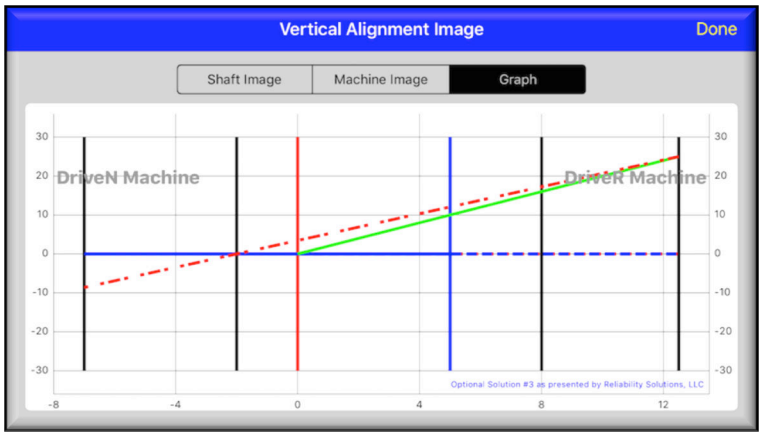
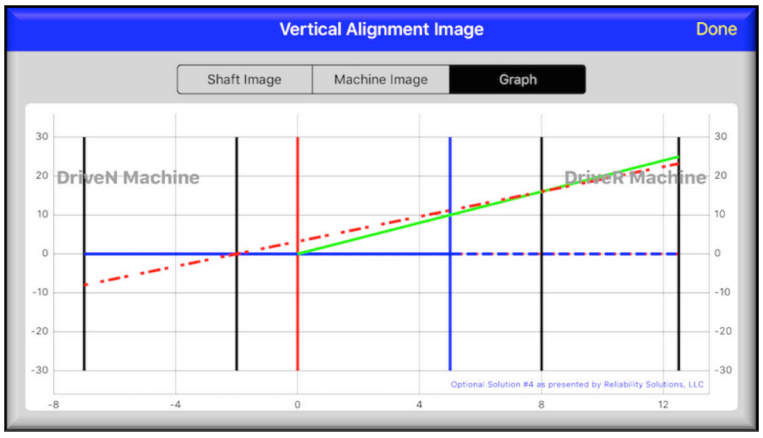
Position	Distance	Direction
DriveN ODS	0	n/a
DriveN DS	6	Up
DriveR DS	3	Up
DriveR ODS	0	n/a

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 pairs of 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 Pro 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. DriveN DS foot ***moveable***. DriveR DS foot ***moveable***. DriveR ODS foot stationary.	

OS #2	DriveN ODS foot stationary. DriveN DS foot ***moveable***. DriveR DS foot stationary. DriveR ODS foot ***moveable***.	
OS #3	DriveN ODS foot ***moveable***. DriveN DS foot stationary. DriveR DS foot ***moveable***. DriveR ODS foot stationary.	
OS #4	DriveN ODS foot ***moveable***. DriveN DS foot stationary. DriveR DS foot stationary. DriveR ODS foot ***moveable***.	

RD-Align Pro has the ability to provide solutions for a 5 machine set with 5 pairs of feet per machine. Any pair of feet from different machines can provide an optional solution.

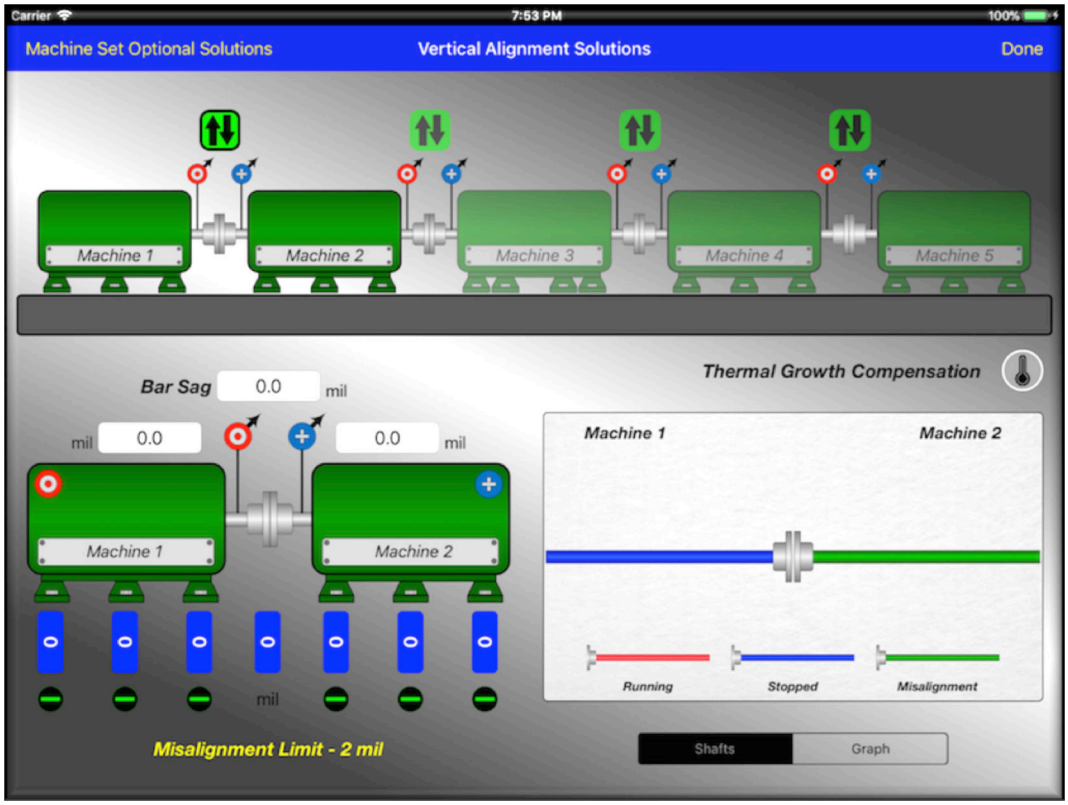
Screen Descriptions

General Layout

RD-Align Pro is designed to provide alignment solutions for multiple machine sets. Information is collected via smaller machine sets of 2 machines.

The general layout of each screen is the same. The top half of the screen is illustrates the total machine set. The bottom of the screen illustrates the working machine set for data collection or solution.

Touching the symbols above the coupling image in the total machine set image selects the working machine set.



The screen shown above depicts a 5-machine set with 3 pairs of feet per machine. The working sub machine set is for Machin1 and Machine 2. The vertical arrow button above the coupling image is highlighted indicating this is the active set. The machine names are shown on the working set as well.

Alignment Database Screen

Help Button

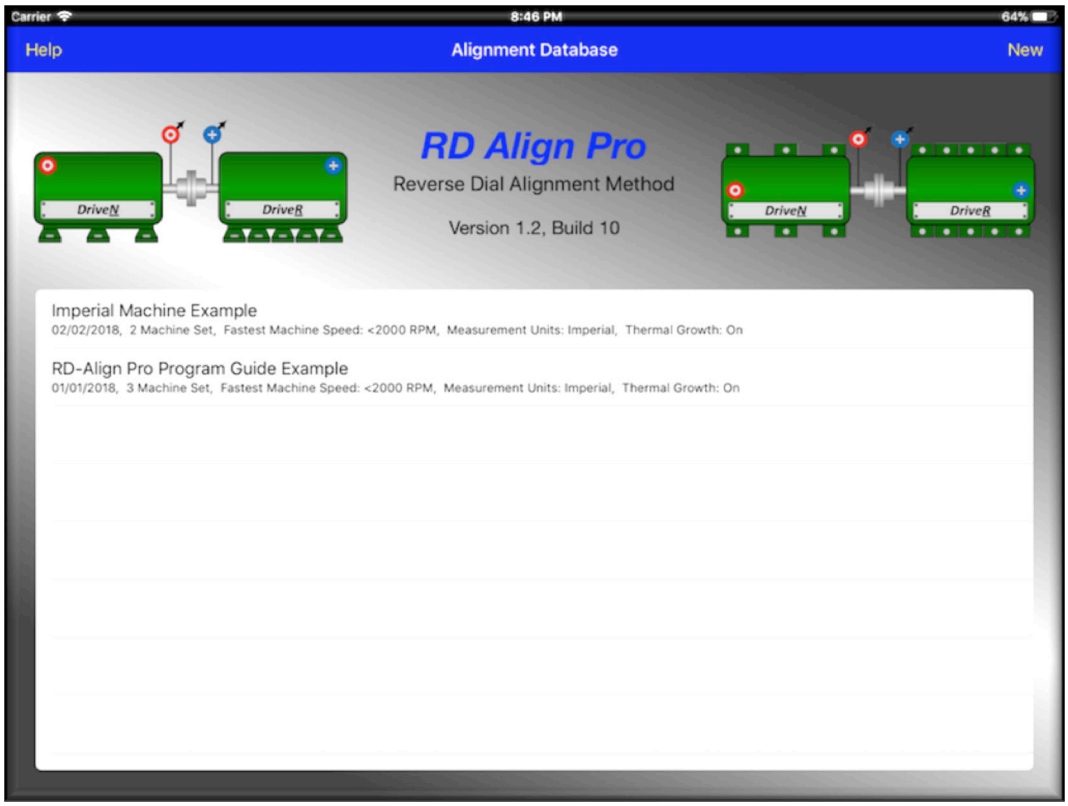
Touching HELP provides an opportunity to provide D&M App Company feedback.

The user should review important disclaimer information.

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

New Record Button

Touching NEW creates a new alignment record. Machine Set Details 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 Set Details screen.

Swiping to the left and touching DELETE will delete the record.

Help Screen

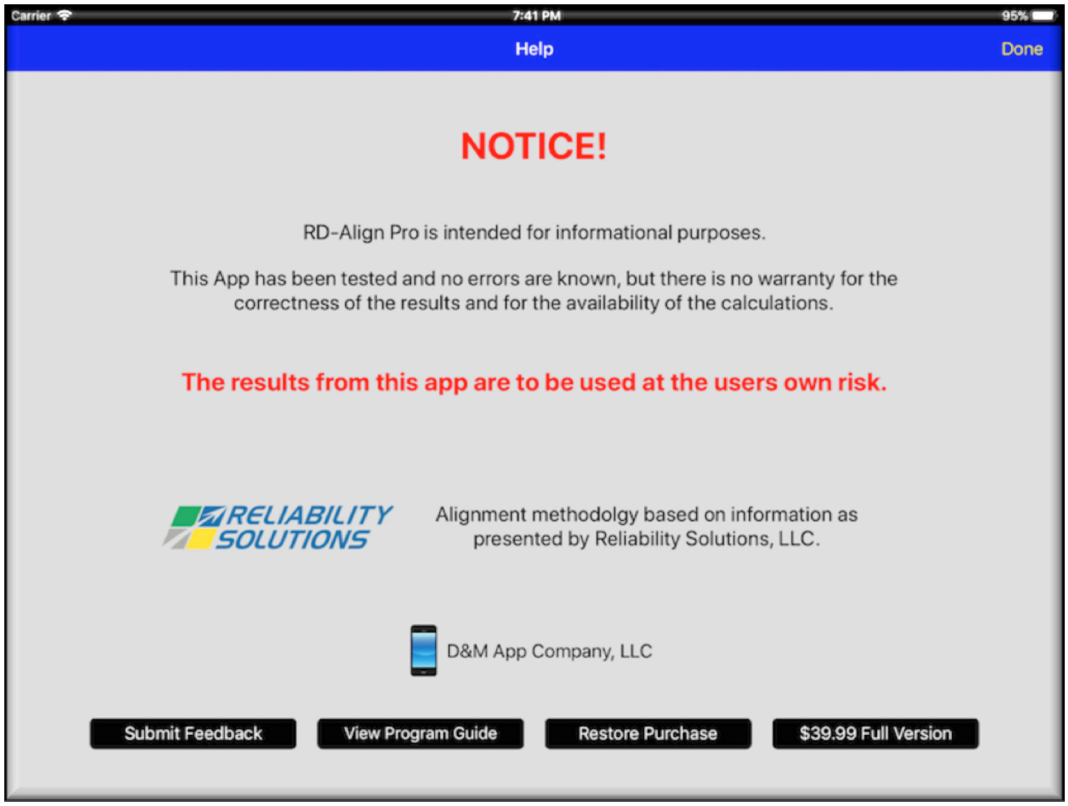
Feedback Button

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

Errors and feedback for additional features will be considered.

Done Button

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



View Program Guide Button

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

The guide can also be downloaded from D&M App Company's web site.

Restore Purchase

If the full version of the App was previously purchased and the App was reinstalled on the same or new device, touch this button to restore the purchase.

Full Version

The base version of RD-Align Pro allows 2 machines with 2 pairs of feet/machine.

The full version provides solutions for 5 machines with 5 pairs of feet/machine.

Machine Set Details Screen

Cancel Button

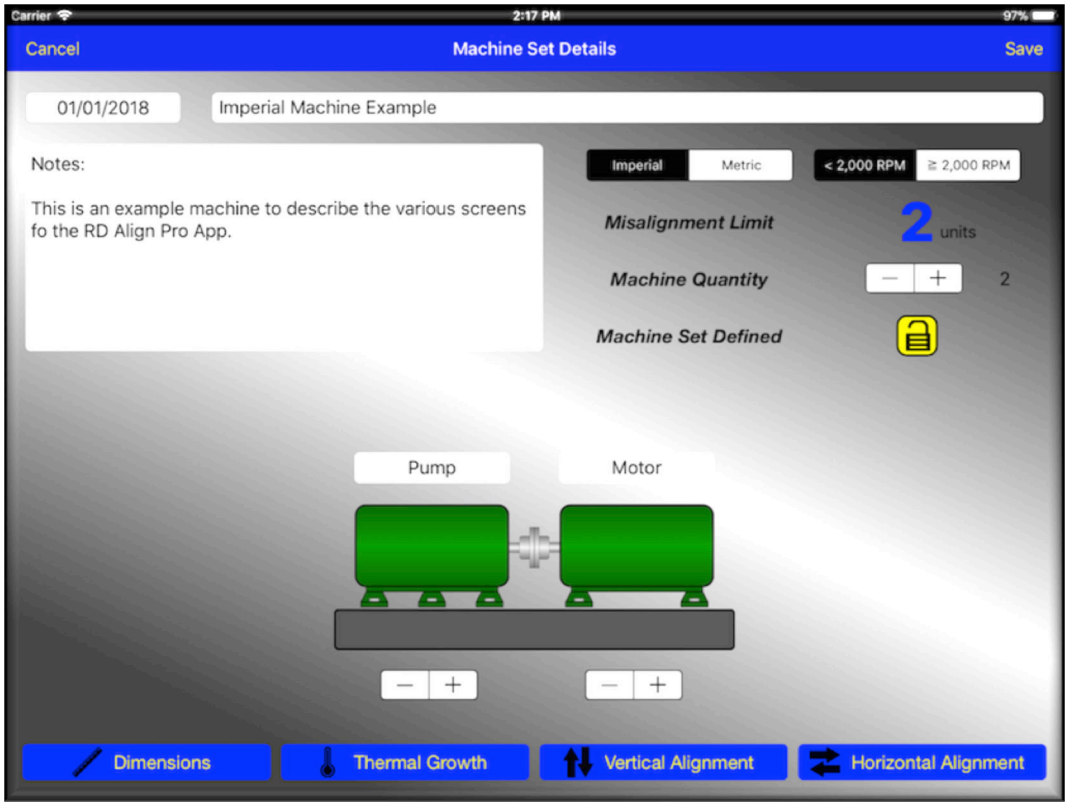
Touching CANCEL will return the App to the Main screen. No data will be saved.

Save Button

Touching SAVE will save any new or modified data.

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

Touching SAVE will also return the App to the Alignment Database 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 for the machine set.

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 Set Details Screen (continued)

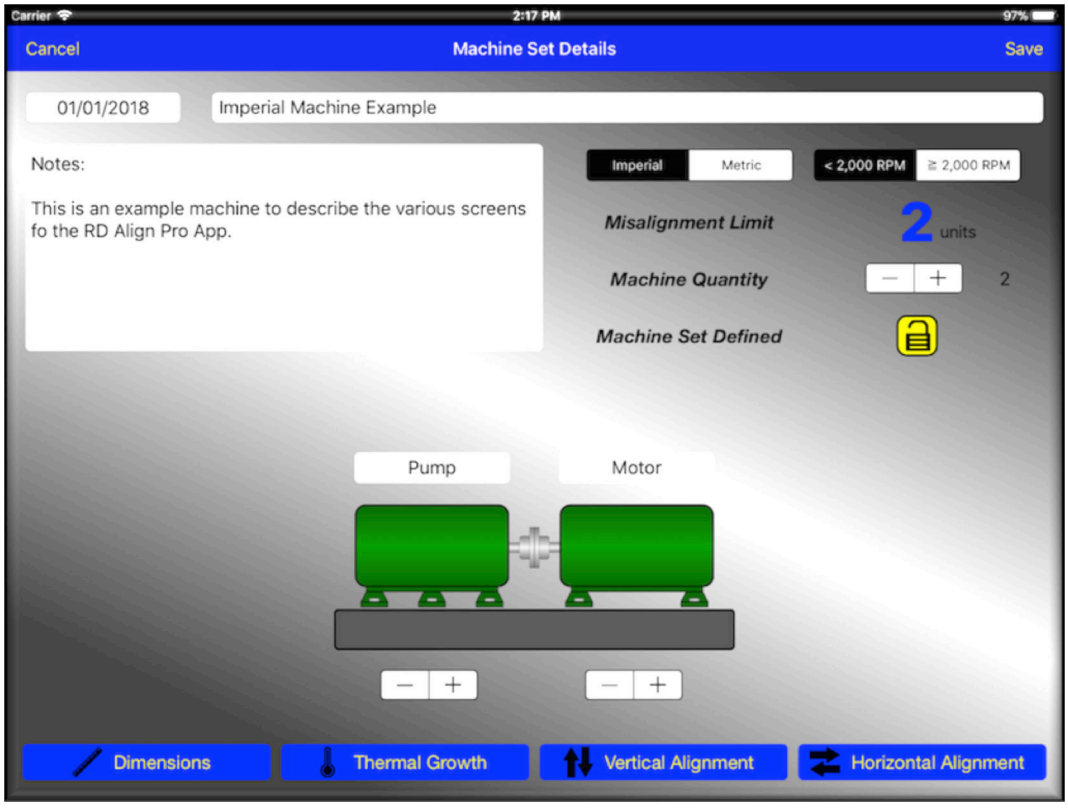
Date Field
The DATE FIELD is available to record the date the alignment activity was performed. The field will default to the current date when the initial data was entered. The date can be changed if needed.

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

Machine Names
Touch each machine name to customize a machine name. 10 characters max.

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

Machine Set Defined
Indicator will show unlocked or locked. Once locked no changes to the machine set can be made.



Machine Dimensions
Touch the RULER to open the Machine Set Dimensions screen.

Thermal Growth
Touch the THERMOMETER to open the Thermal Growth Calculator screen.

Machine Quantity Stepper
Touch the stepper to increase the number of machines from 2min to 5max.

Machine Feet Steppers
Touch the stepper under each machine to increase the pairs of feet/machine from 2min to 5max.

Vertical Alignment
Touch the VERTICAL ARROWS to open the Vertical Alignment Solution screen.

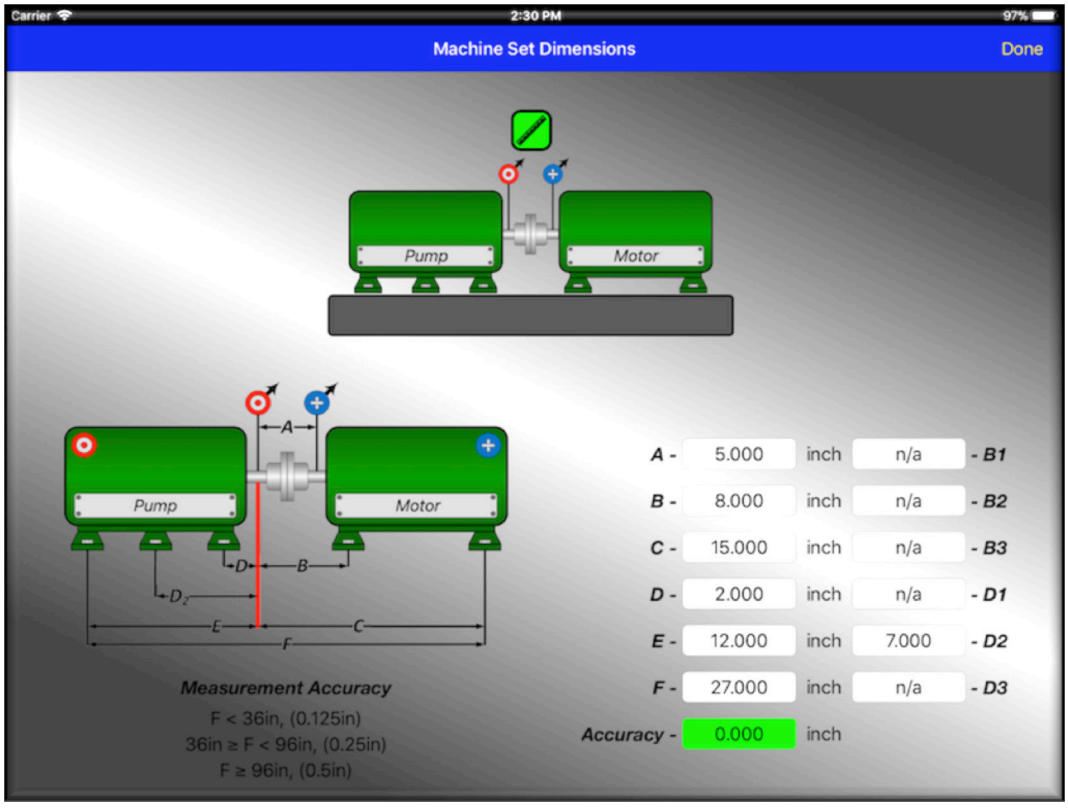
Horizontal Alignment
Touch the HORIZONTAL ARROWS to open the Horizontal Alignment Solution screen.

Machine Set Dimensions Screen

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

Dimension Entries
RD-Align Pro performs a sensibility check of the dimensions. If an error is detected, the entry box will turn yellow. ***All yellow boxes must be corrected before leaving the this screen***.

Done Button
Touching the DONE button will return the App to the Machine Set 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.

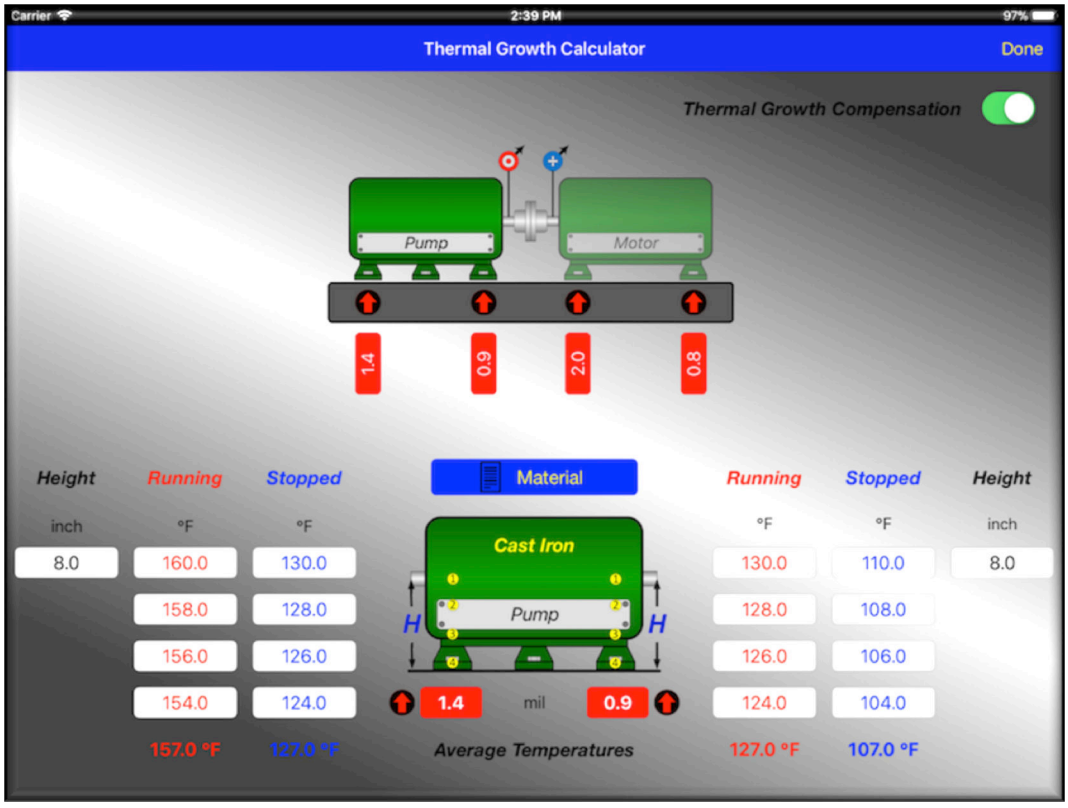
If the accuracy exceeds the tolerance for the machine size, the color will be red.

Thermal Growth Calculator Screen

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

Machine Selection
Touch each machine to select the machine to enter temperature, shaft height, and machine materials.

Done Button
Touching the DONE button will return the App to the Machine Set 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

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

Vertical Alignment Solutions Screen

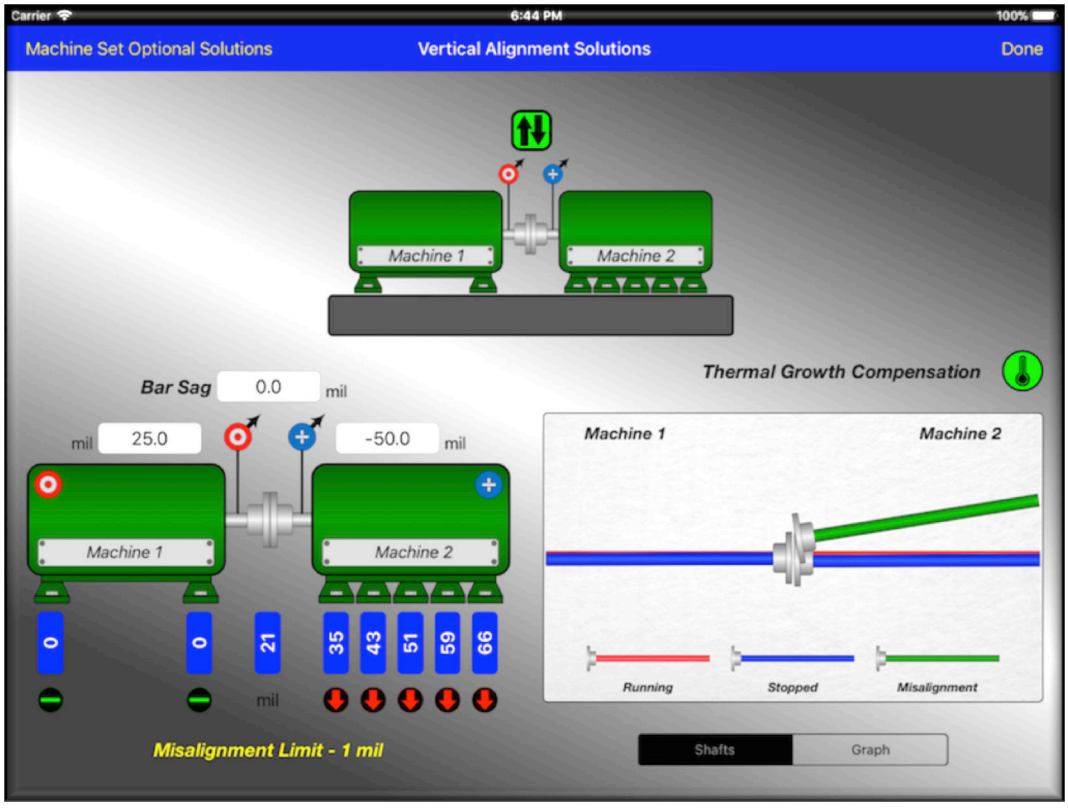
Machine Set Optional Solutions
Touching will display a visual representation of the machine set and allow changes to reference machine and select optional solutions.

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 Set Details screen.

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



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.

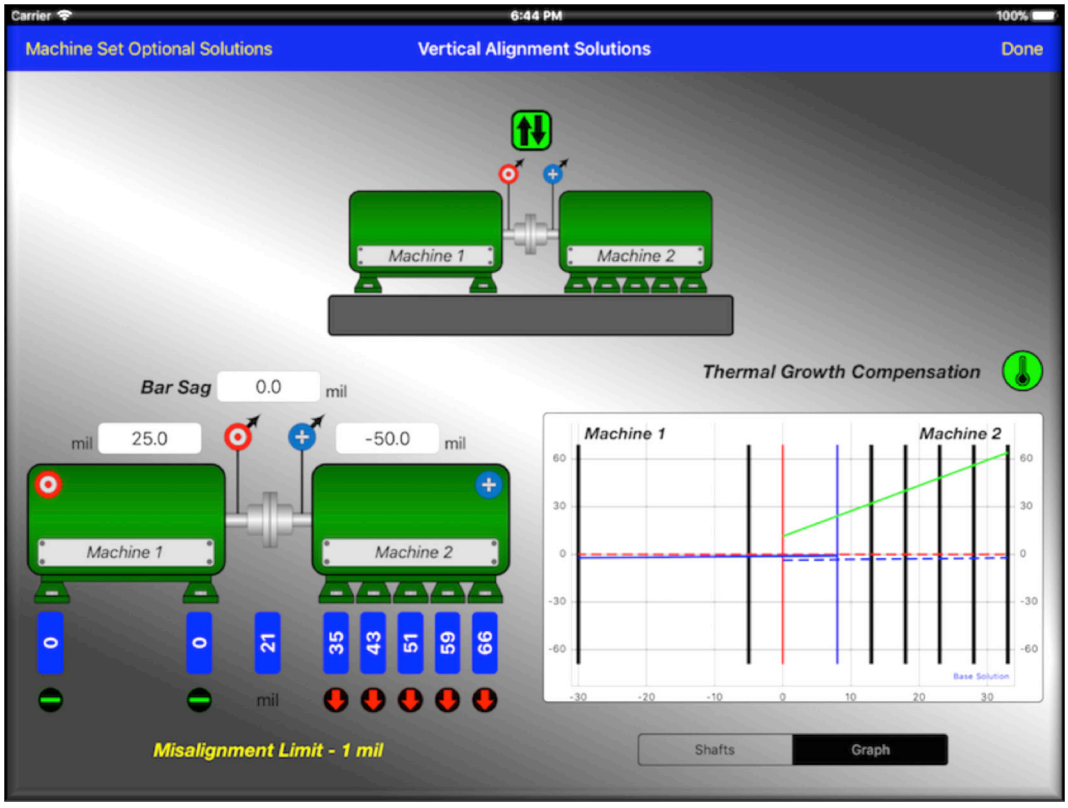
Misalignment Position
The green shaft represents the misalignment of the DriveR machine.

Vertical Alignment Image Screen (continued)

Machine Set Selector
Touch the GREEN machine set selector to change machine sets.

All machine sets must have dial indicator positions before proceeding to the Machine Set Optional Solutions

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



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

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

Graphical Solution
Touching GRAPH reveals the graphical solution of the working machine set.

Machine Set Optional Solutions

Machine Set Image

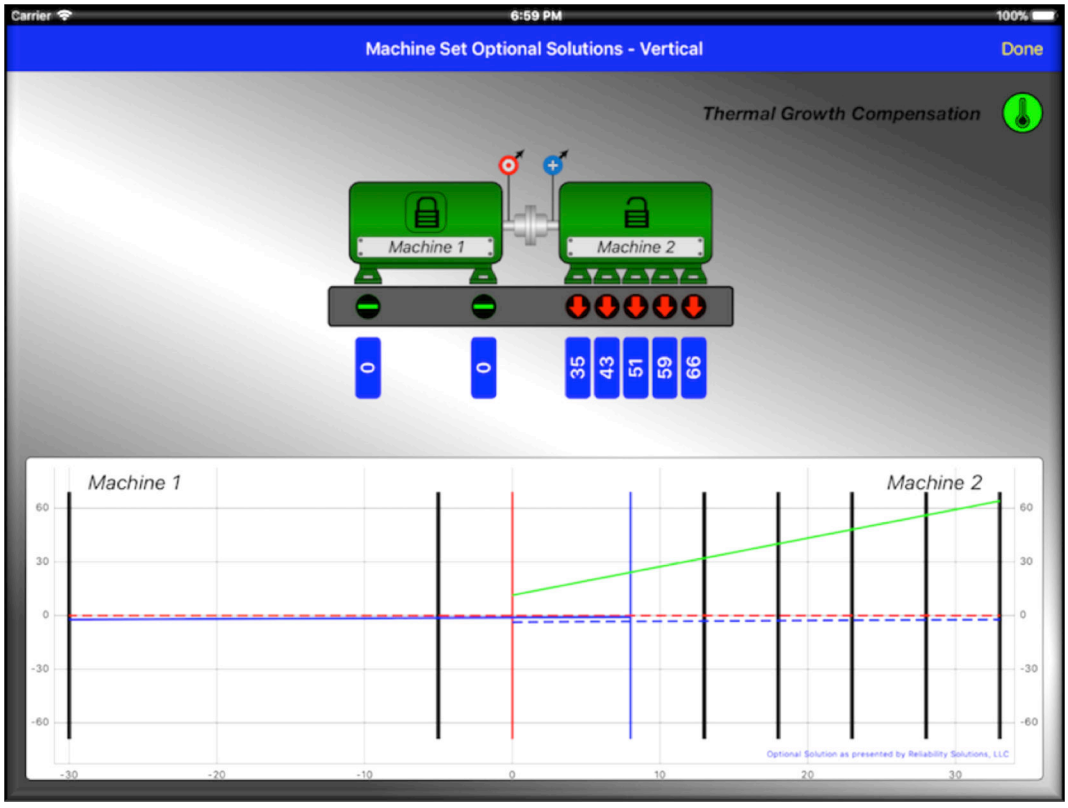
The top half of the screen will illustrates the whole machine train with move amounts and direction indicators under the corresponding foot.

Machine Lock

Each machine has a lock symbol. Touching the lock will change the reference machine. The graphical solution will change based on the reference machine selected.

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.

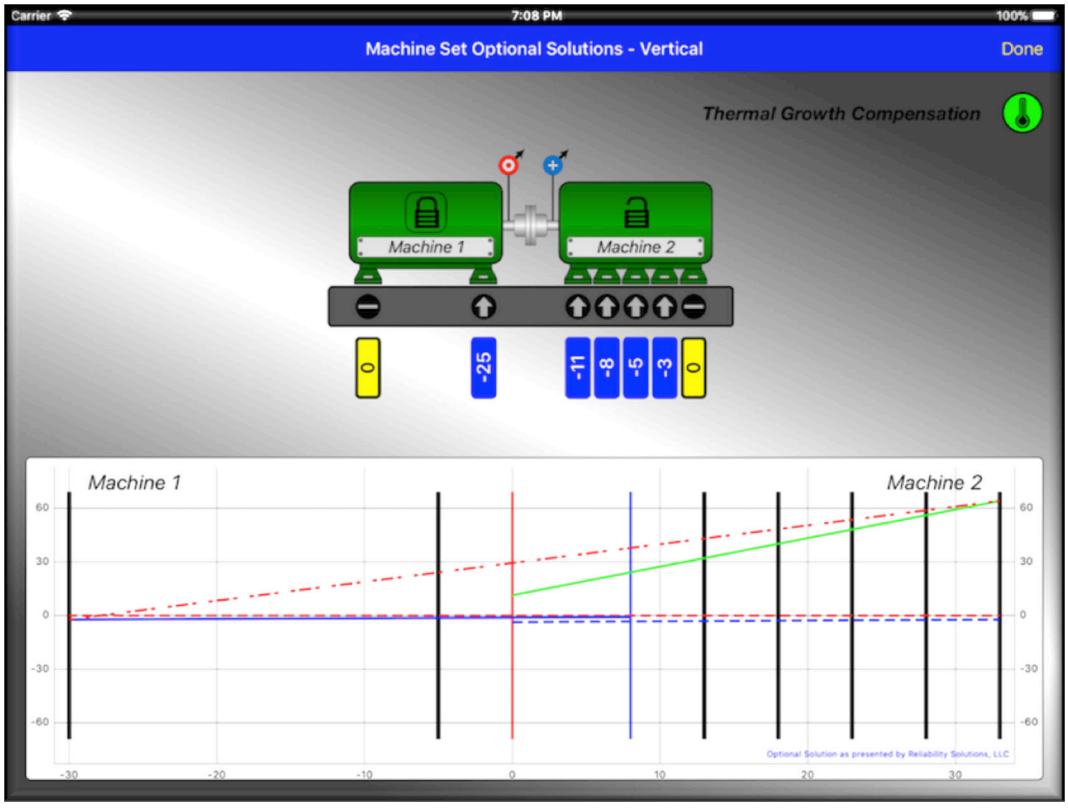
Units for the vertical axis are “mils” for the imperial system and “mm” for the metric system.

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

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

Machine Set Optional Solutions (continued)

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



Optional Solutions
An optional solution can be obtained by selecting two machine feet.

The selected feet cannot be on the same machine

The selected feet pairs are highlighted in yellow.

The optional solution line will be added to the graphical solution.

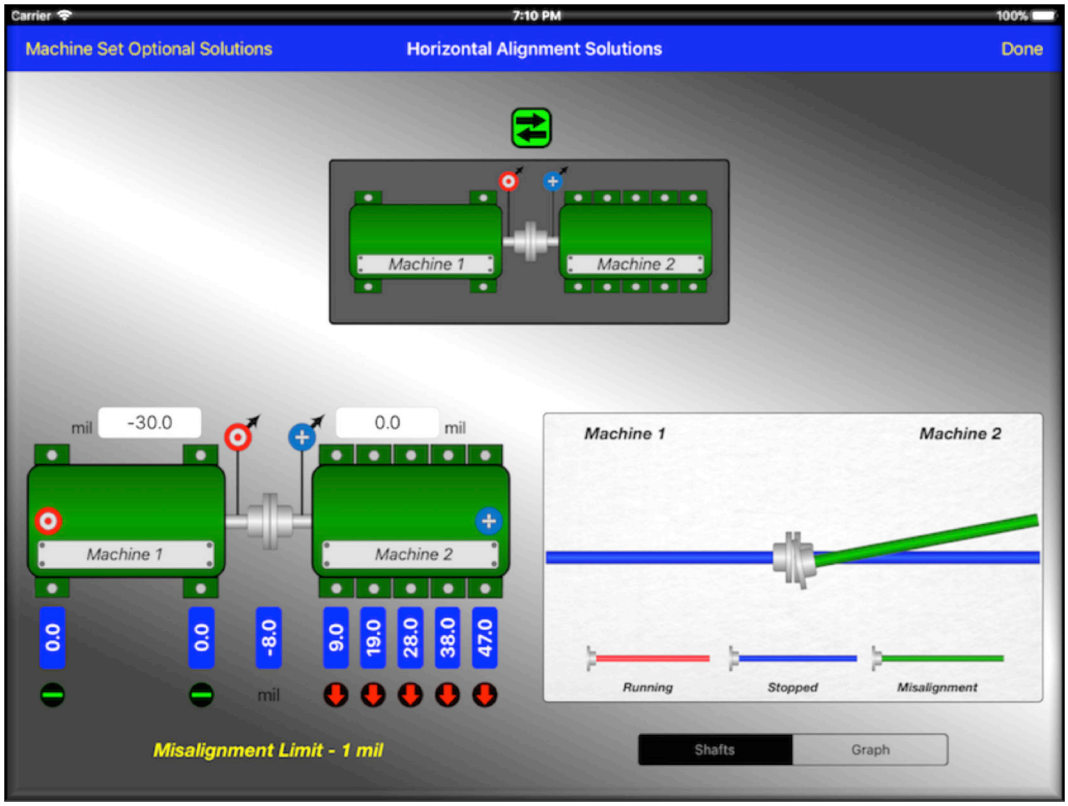
The move quantities and directions will be updated under each feet pairs for the machines.

Horizontal Alignment Solutions Screen

Machine Set Optional Solutions
Touching will display a visual representation of the machine set and allow changes to reference machine and select optional solutions.

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 Set Details 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 Solutions Screen (continued)

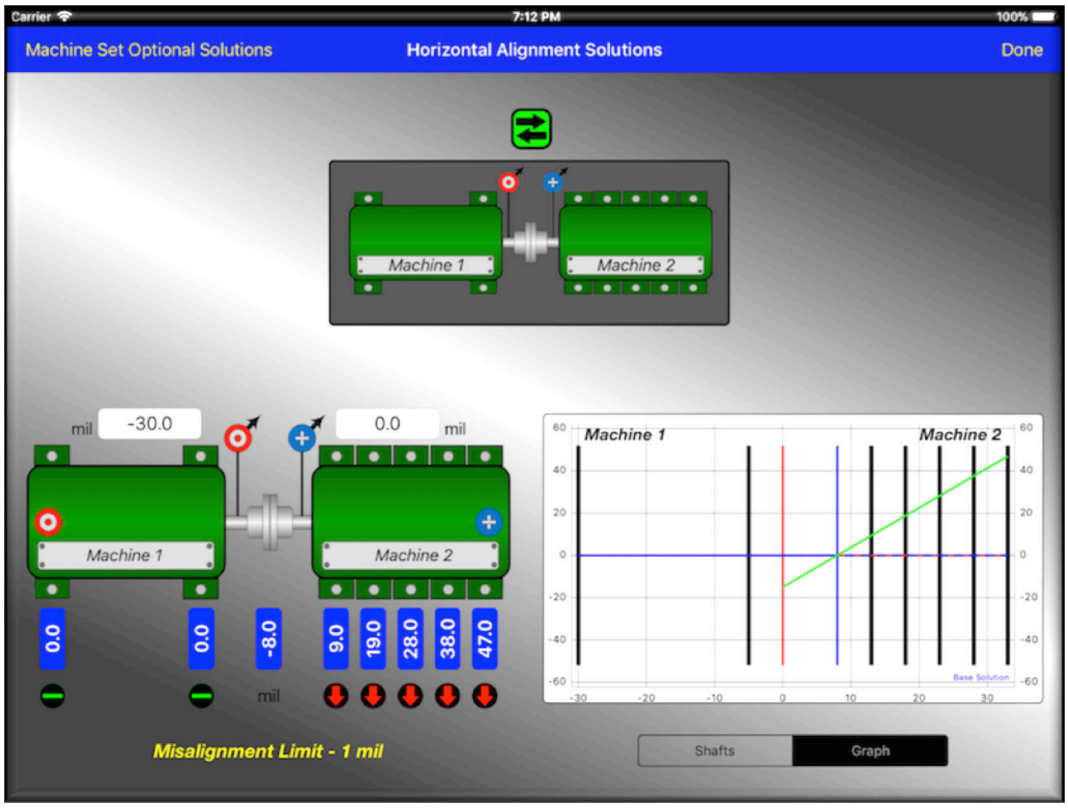
Machine Set Selector

Touch the GREEN machine set selector to change machine sets.

All machine sets must have dial indicator positions before proceeding to the Machine Set Optional Solutions.

Done Button

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



Base Solution

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

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

Graphical Solution

Touching GRAPH reveals the graphical solution of the working machine set.

Machine Set Optional Solutions

Machine Set Image

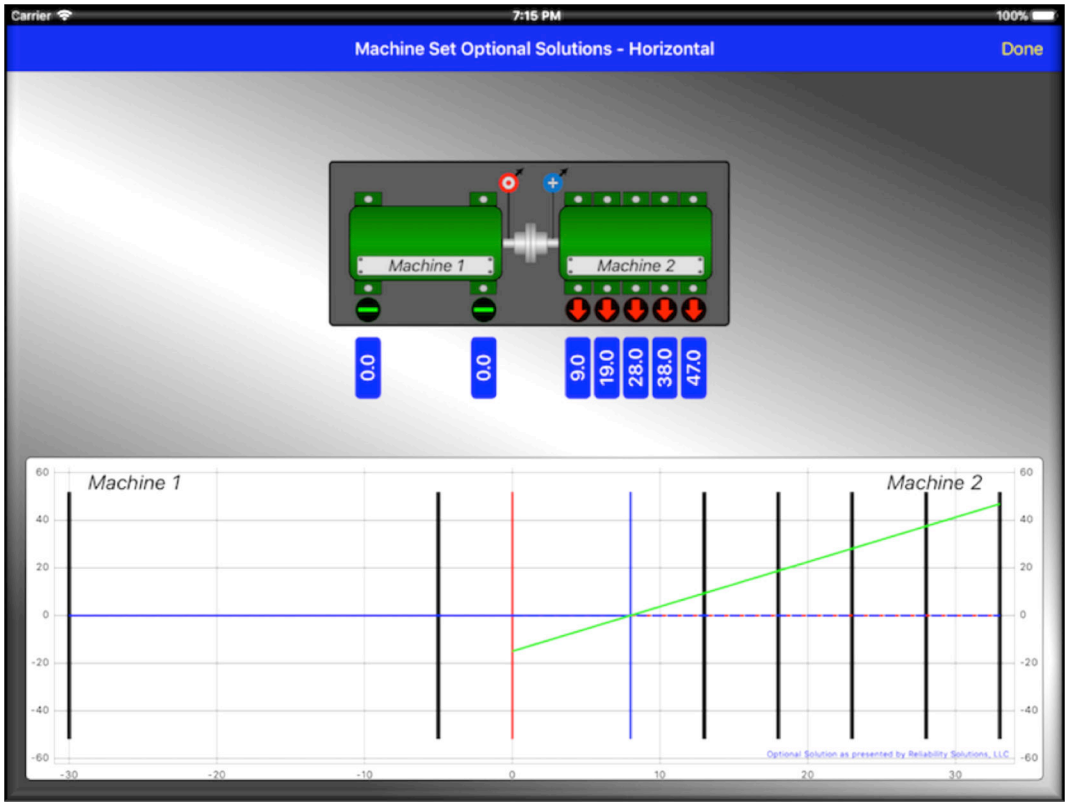
The top half of the screen will illustrates the whole machine train with move amounts and direction indicators under the corresponding foot.

Machine Lock

Each machine has a lock symbol. Touching the lock will change the reference machine. The graphical solution will change based on the reference machine selected.

Done Button

Touching DONE will return the App to the Horizontal 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.

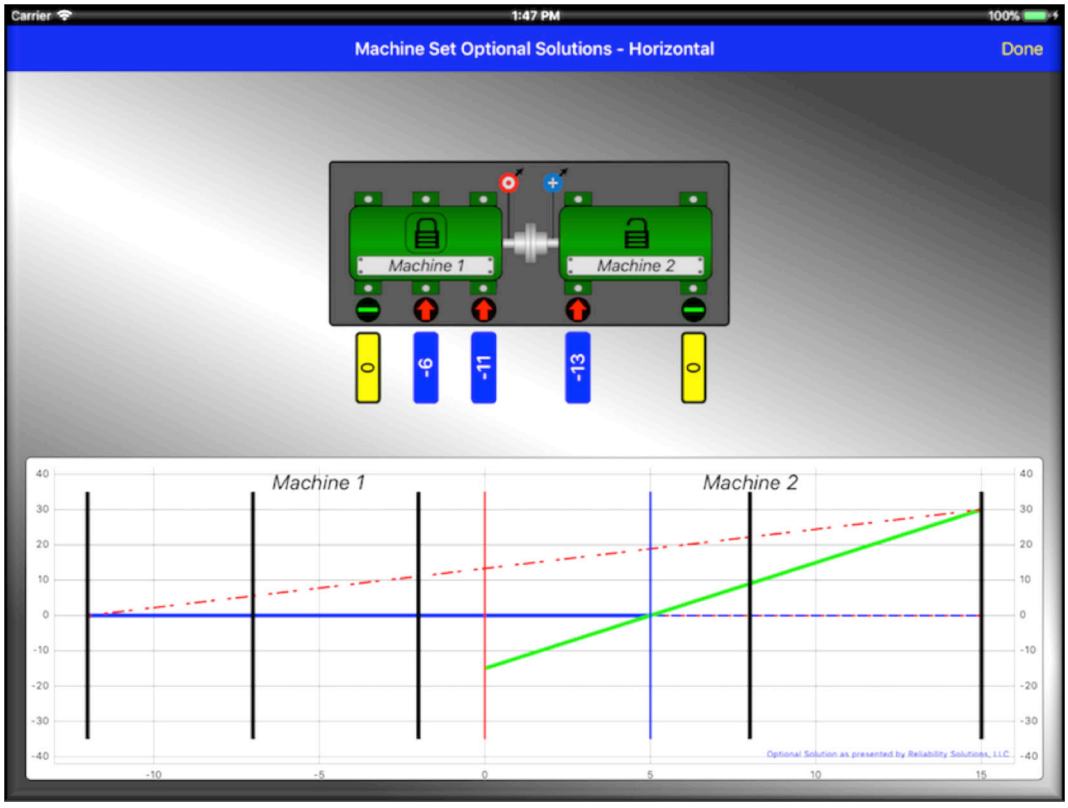
Red horizontal lines represent hot shaft positions. Blue horizontal lines represent cold shaft positions. The green line represents the current position of the shaft relative to the adjacent machine shafts.

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

Machine Set Optional Solutions (continued)

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

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



Optional Solutions
An optional solution can be obtained by selecting two machine feet.

The selected feet cannot be on the same machine.

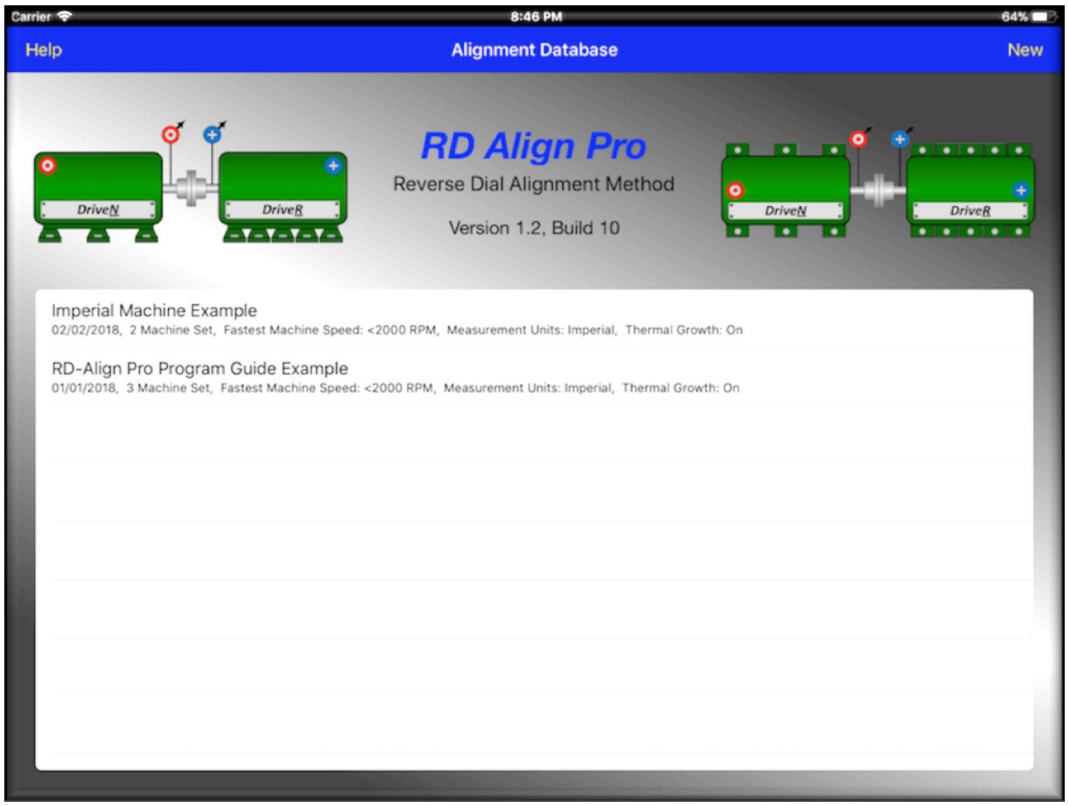
The selected feet pairs are highlighted in yellow.

The optional solution line will be added to the graphical solution.

The move quantities and directions will be updated under each feet pairs for the machines.

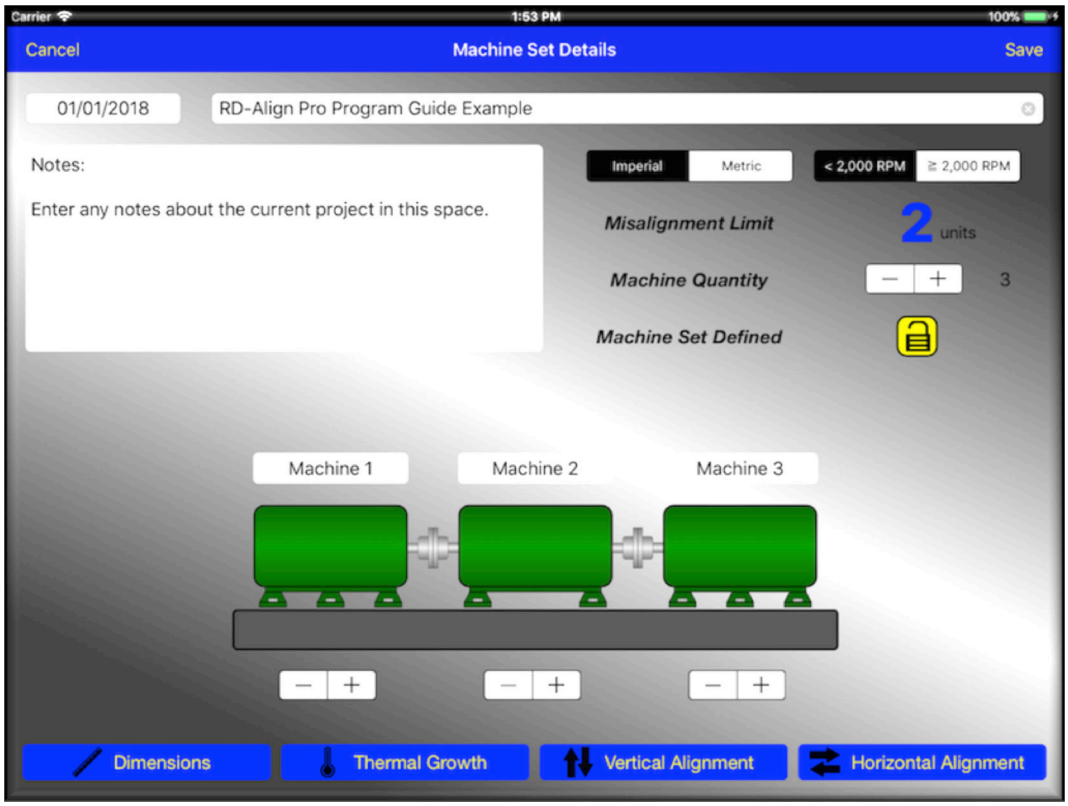
Example Alignment

Step 1 – Saved and New Alignment Records



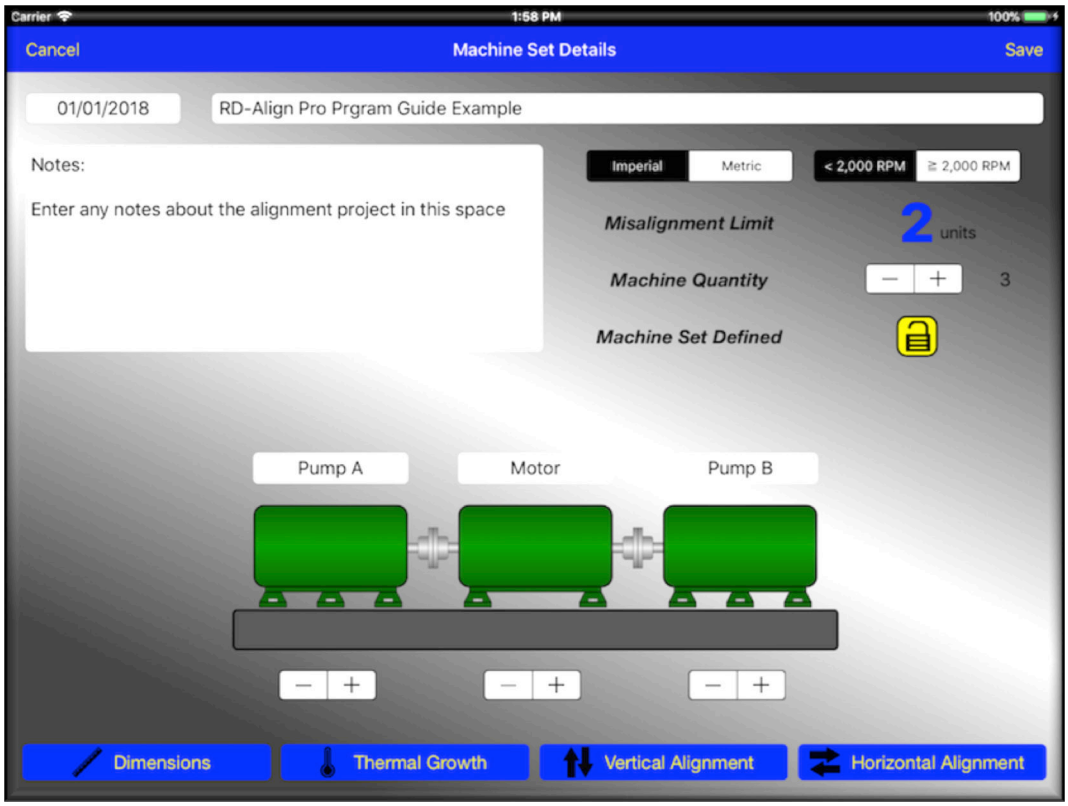
- The Alignment Database screen will be presented on the iPad when the RD-Align Pro App is started.
- This screen shows a list of previously saved alignment projects.
- To return to a previous alignment, touch the previous project.
- If a new project is desired, touch NEW.
- For this example, we will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

Step 2 – New Alignment Record



- The Machine Set 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 Pro 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.
- Use the MACHINE QUANTITY stepper to add or subtract machines. Minimum of 2 and a maximum of 5. For this project we will set the number of machines to 3.

Step 2 – New Alignment Record (continued)



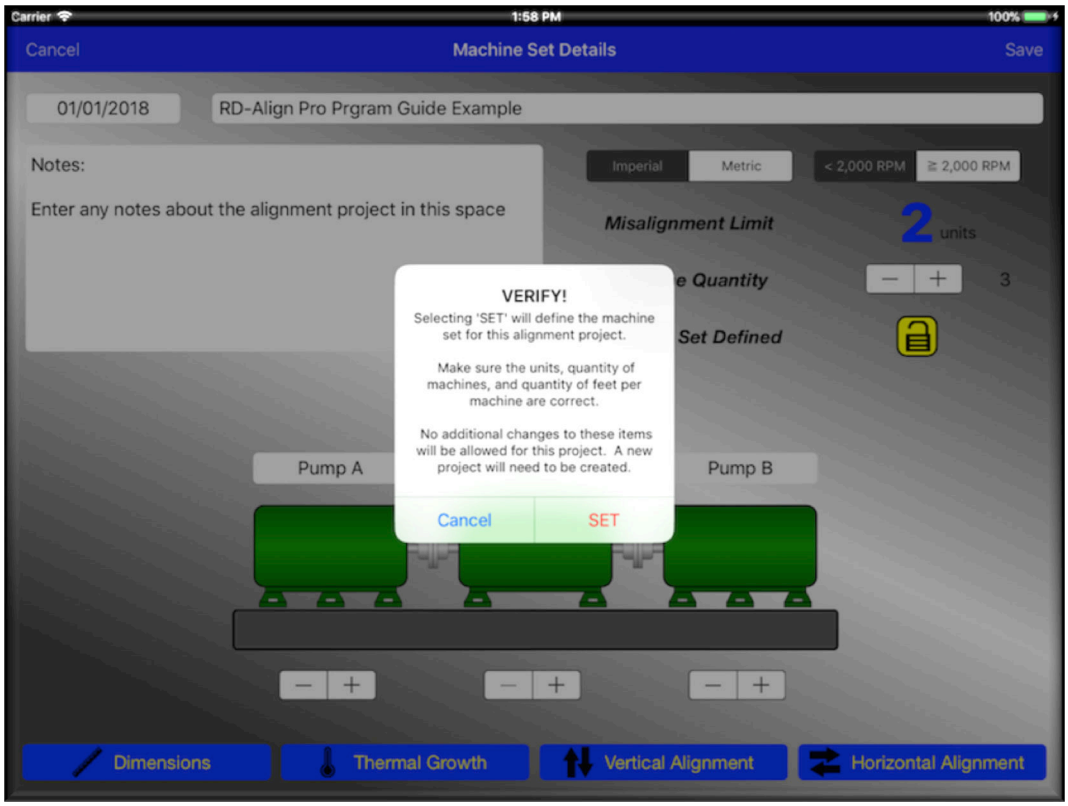
- The machine names can be changed if desired. For this example, we rename the machines to Pump A, Motor, and Pump B.

- Use the FOOT QUANTITY stepper under each machine to increase or decrease the number of pairs of feet per machine. For this example, Pump A will have 3 pairs of feet, the Motor will have 2 pairs of feet, and Pump B will have 3 pairs of feet.

- Note the yellow lock symbol. This indicates the machine set configuration has not been locked yet. Changes from Imperial to Metric units, machine quantities, and feet quantities can still be modified when the lock symbol is unlocked and yellow.

- If SAVE is touched or any of the 4 buttons located at the bottom of the screen is touched, a warning will appear.

Step 2 – New Alignment Record (continued)

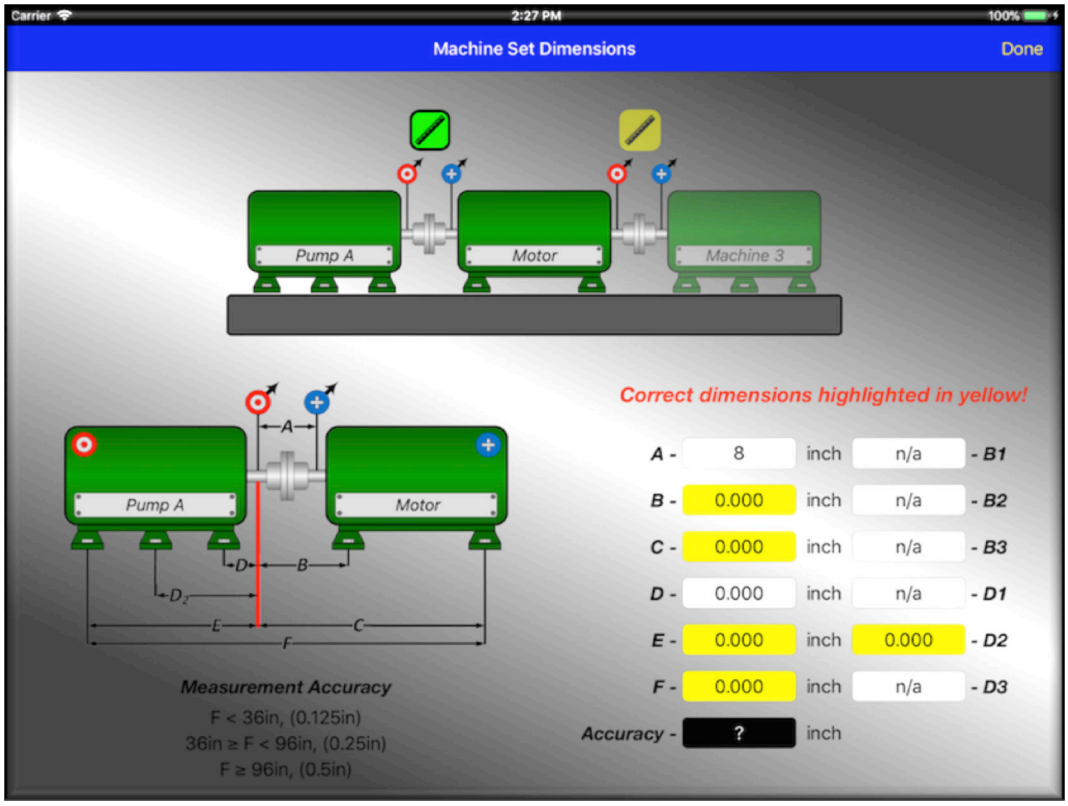


- This is the last chance to verify the machine set is defined like the user wants. The user is presented with 2 options.
    - CANCEL – the warning will disappear and additional changes can be made.
    - SET – the machine set will be locked and NO additional changes to units, machine quantity, or feet pairs on the machines will be allowed. The project will need to be started again to make changes.
- After SET is touched, the yellow lock will change from an open lock to a closed lock and change color to gray. This is illustrated on the next page.
- Although units, machine quantity, and feet pairs cannot change once the design is locked, the date, machine set name, notes, machine speed, machine names are available to continued changes.

Step 3 – Enter Machine Set Dimensions

- The Machine Set Details screen is the launch screen for entering machine set dimensions, thermal growth data, vertical alignment solutions, and horizontal alignment solutions.
- Touch DIMENSIONS to enter the machine set dimensions.
- Touch THERMAL GROWTH to enter the thermal growth data for each machine.
- Touch VERTICAL ALIGNMENT to enter and view the vertical alignment solutions.
- Touch HORIZONTAL ALIGNMENT to enter and view the horizontal alignment solutions.
- Although any of the four buttons can be touched and viewed, if no machines set dimensions are entered, no solution can be calculated.
- Touch DIMENSIONS to enter the machine set dimensions.

Step 3 – Enter Machine Set Dimensions (continued)



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

- Carefully inspect the drawing in the lower left of the screen and enter the values in the box for each dimension listed. A, B, C, D, D2, E, and F.

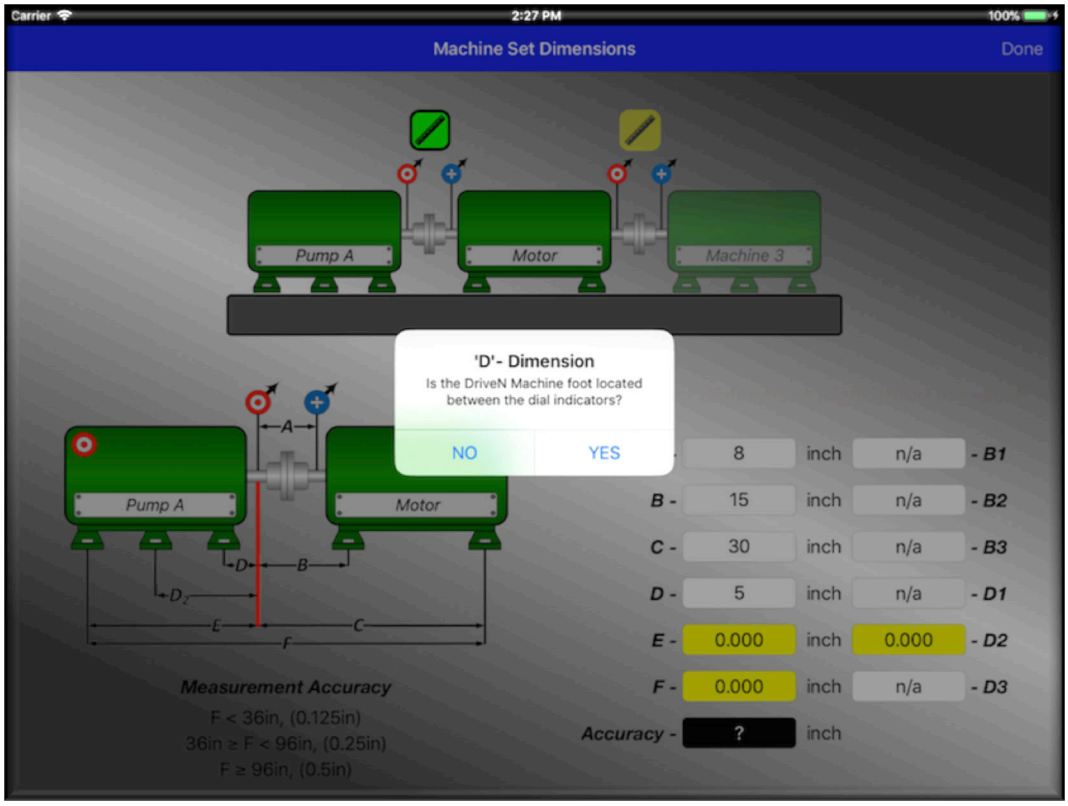
- Touch each dimension box. A keyboard will appear. Enter the dimension in the box.

- Touch box B and enter 8. Notice boxes, B, C, E, D2, and F turn yellow. RD-Align Pro performs a check to ensure the dimensions are sensible. For example, dimension C must be greater than dimension B. NOTE, **ALL** yellow boxes **MUST** be eliminated before proceeding to any other step!

- Continue to enter these dimensions

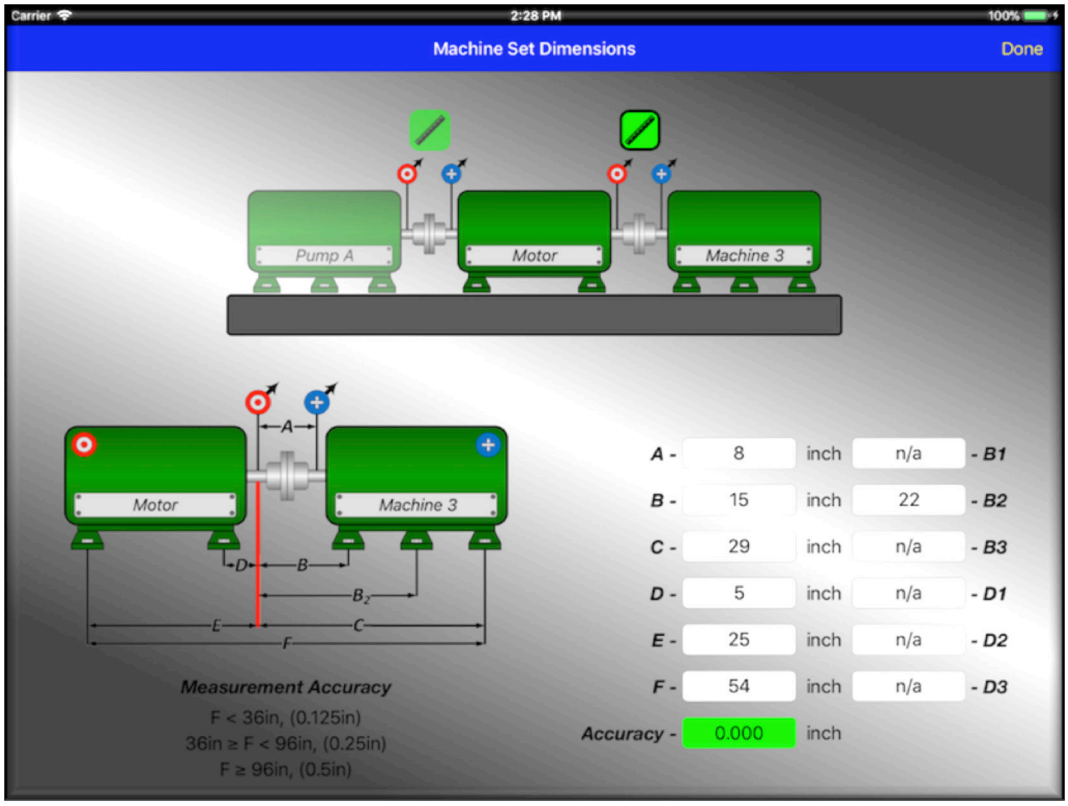
A -	8”	E -	25”
B -	15”	D2 -	15”
C -	30”	F -	55”
D -	5”		

Step 3 – Enter Machine Set Dimensions (continued)



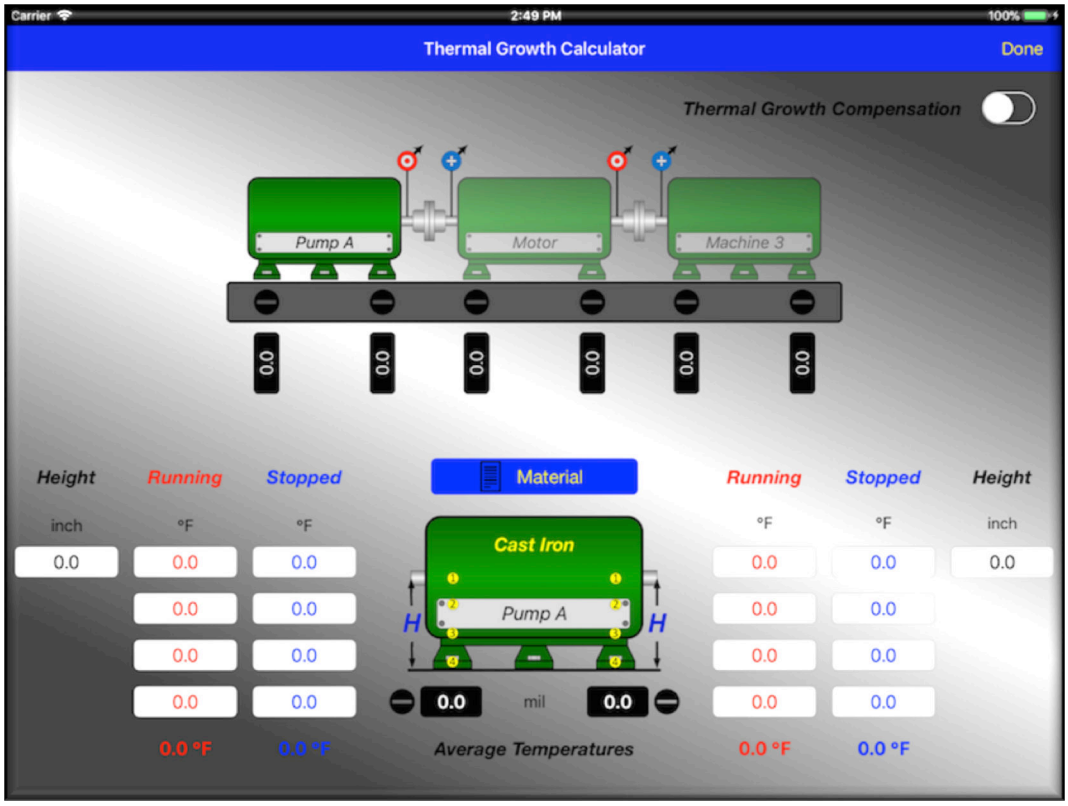
- After entering or changing the "D" dimension value, a question box will appear.
- The "D" dimension should be the total distance from the DriveN (Pump A) dial indicator to the DriveN (Motor) drive side foot no matter which side of the dial indicator the foot is actually located.
- However, RD-Align Pro must know where the foot is located. The foot will be located outside the dial indicators or between them. Touch NO for this example.
- Continue to enter the dimensions in the remaining boxes.
- 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 the RULER button above the dial indicators. The buttons correspond to the subset of machines that make up the entire machine set.

Step 3 – Enter Machine Set Dimensions (continued)



- Touch the second RULER button to enter dimensions for the Motor and Pump B.
- Enter the dimensions as shown in the illustration above.
- Touch DONE to return to the Machine Set Details screen

Step 4 – Thermal Growth



- Touching the THERMAL GROWTH button on the Machine Set Details screen will present this screen.

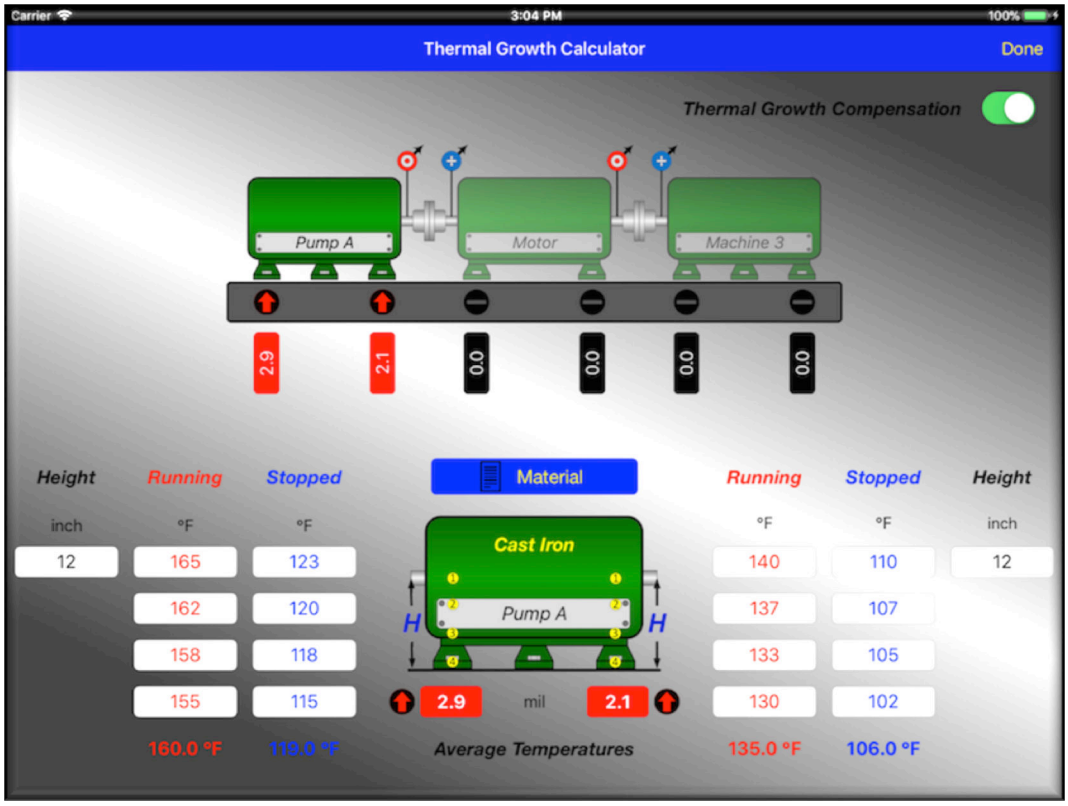
- Thermal growth alignment compensation is not required. However, machine performance and longevity is greatly increased when it is included. By compensating for thermal growth, the machine will actually be misaligned in a controlled manner. As the machine warms up (or cools down for refrigeration),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

- The machine set is illustrated on the top of the screen. Touch each machine to enter the shaft height, running temperature, and stopped temperature. The temperatures should be measured at 4 equally spaced intervals from the shaft centerline to the feet. Only the feet at the extreme ends of the machine should be used for measurement.

- The Thermal Growth Compensation switch can be used to select between compensating for thermal growth or not. For this example, touch the switch ON. The switch will move to the right.

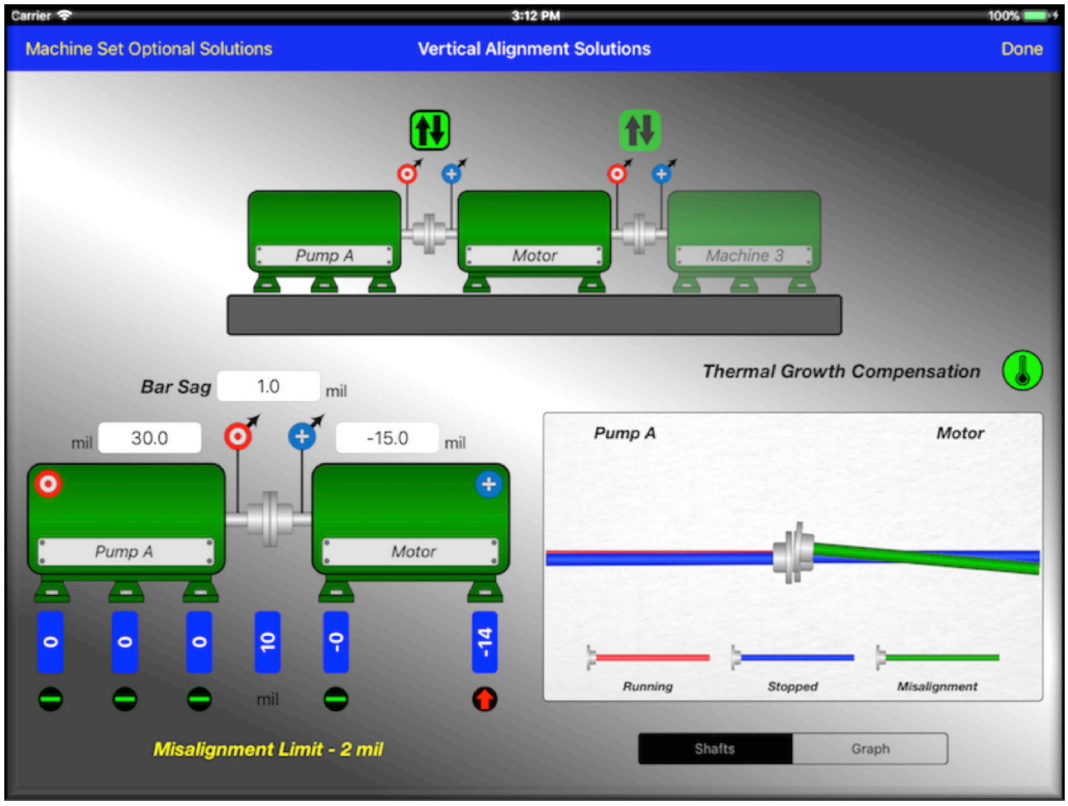
- For this example, we will only enter information for Pump A. Touch Pump A in the machine set at the top of the screen.

Step 4 – Thermal Growth (continued)



- Enter the shaft height, running temperature, and stopped temperatures as illustrated in the image above.
- Based on this information, Pump A will grow 2.9mil at the ODS foot and 2.1mil at the DS foot.
- Touch the MATERIAL button to select the corresponding material for the machine case.
- Touch DONE to return to the Thermal Growth Calculator screen.

Step 5 – Vertical Alignment



- Touch the VERTICAL ALIGNMENT button on the Machine Set 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.

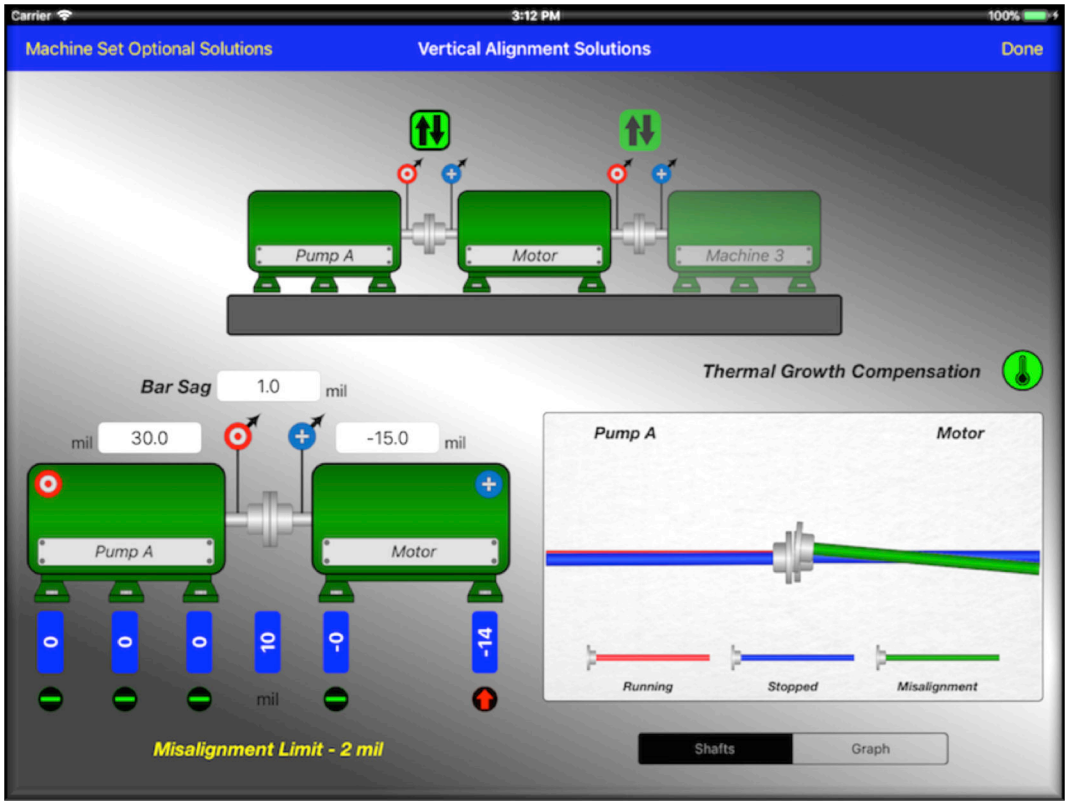
- Install the reverse dial alignment jig on the machine. Set both dial indicators to the measured bar sag at the top or 0° position. Rotate the alignment jig 180°. Carefully read the values on the indicators.

- Touch the DriveN (Pump A) 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 (Motor) machine.

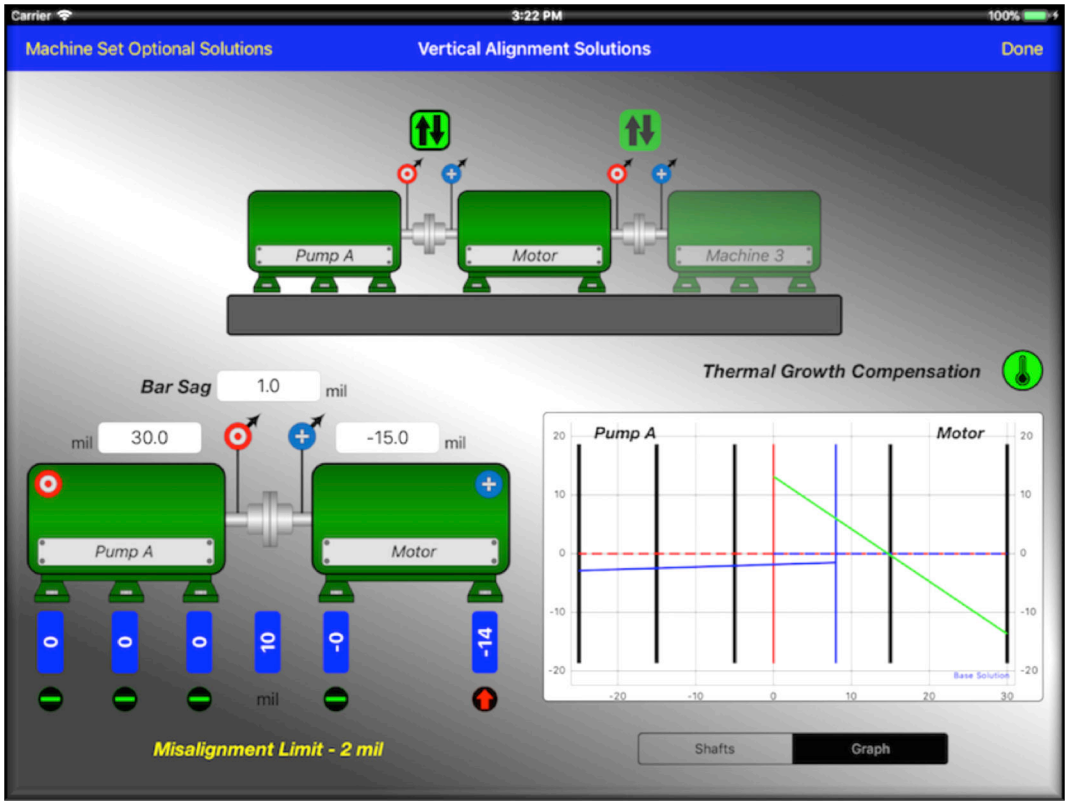
- Shaft positions will be updated in the image on the right.

Step 5 – Vertical Alignment (continued)



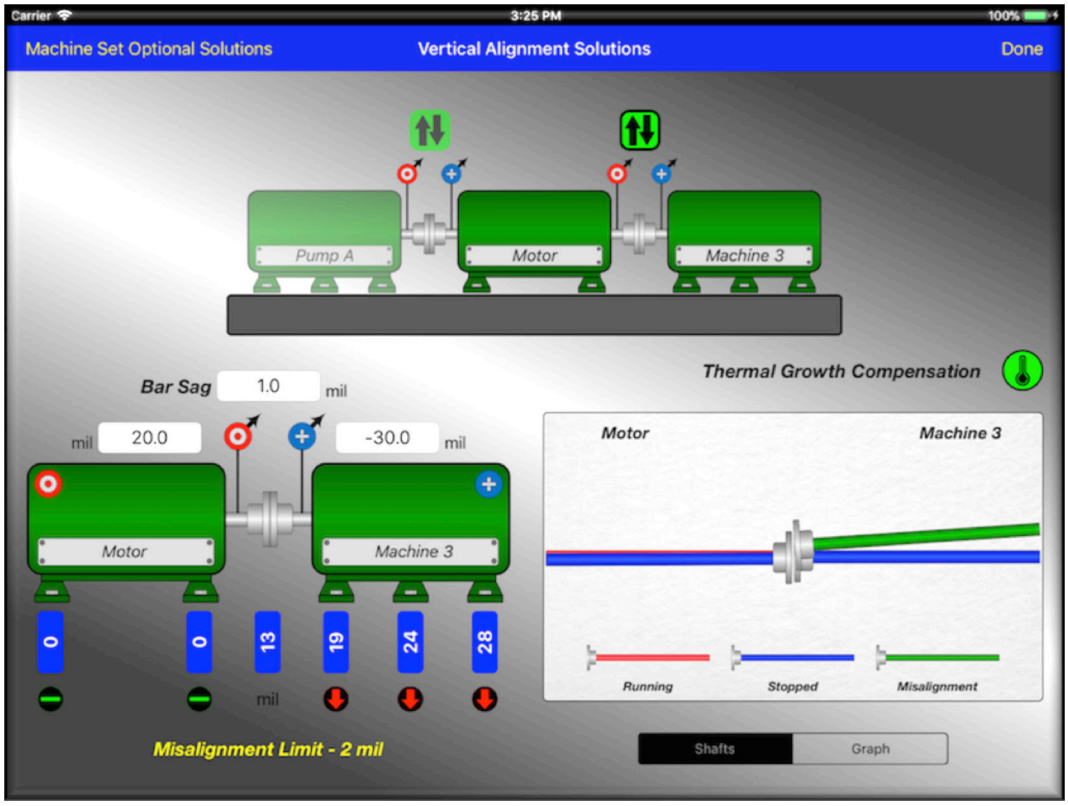
- If the alignment solution is within the allowable tolerance, the move indicators under the feet will be GREEN and show a horizontal bar. No move will be needed.
- For this example, the machine set is not aligned within tolerance. RD-Align Pro calculated a solution to raise the ODS Motor feet 14 mils.
- To see a visualization of the shaft positions, touch SHAFT under the image area in the lower right corner of the 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.

Step 5 – Vertical Alignment (continued)



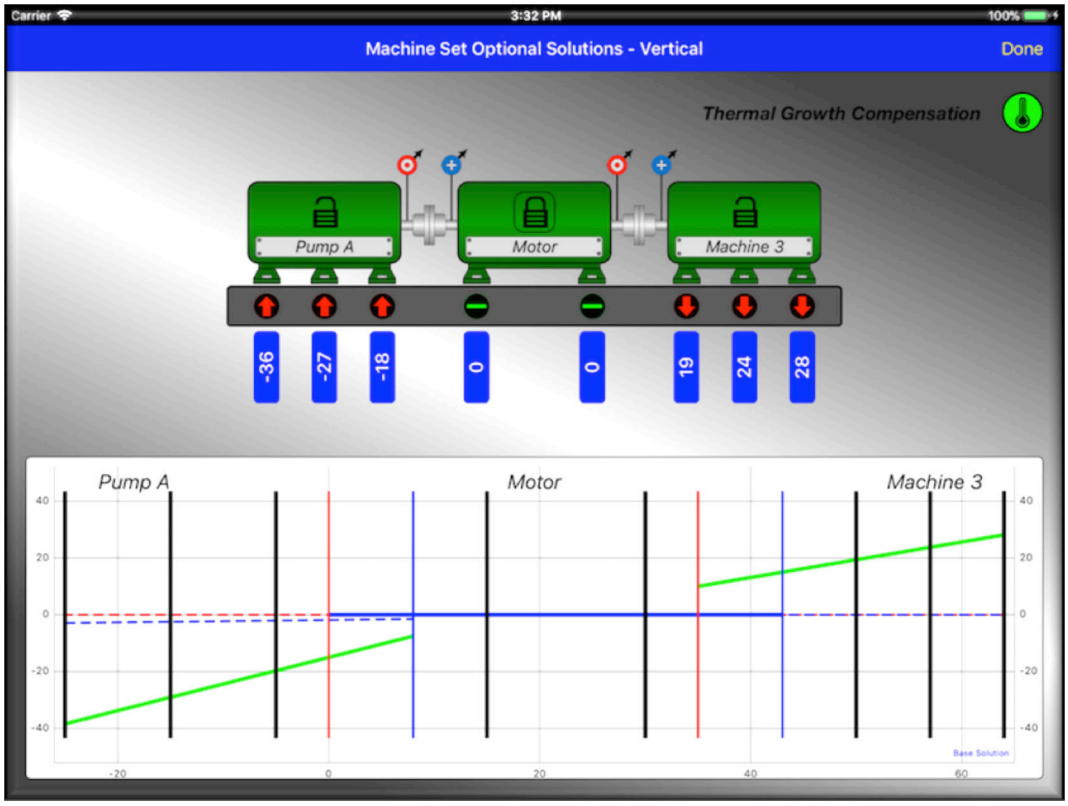
- Touch GRAPH to see the graphical solution of the machine set alignment.
- "Pinch" the image to zoom in or zoom out.
- The solution can be used to correct this machine set (Pump A and the Motor). However, this machine set has an additional pump. Determine the position of the second machine set prior to making any corrections.
- Touch the second vertical arrows button above the couplings in the total machine set image to make the second machine the working machine set.

Step 5 – Vertical Alignment (continued)



- Enter the second set of dial indicator readings from the second machine set in the corresponding entry boxes.
- The shaft image will update with the new indicator readings and the calculated moves at each pair of feet will also be updated.
- Touch GRAPH to see the graphical solution.
- Often times, the difficulty in aligning multiple machine connected into one machine set is adjusting the alignment on one set only to be unable to make the required adjustments at the second set. This will require the first set to be adjusted to allow adequate room for the second set. This can be frustrating and time consuming.
- However, RD-Align Pro provides multiple optional solutions.
- Touch MACHINE SET OPTIONAL SOLUTIONS.

Step 6 – Vertical Alignment Optional Solutions



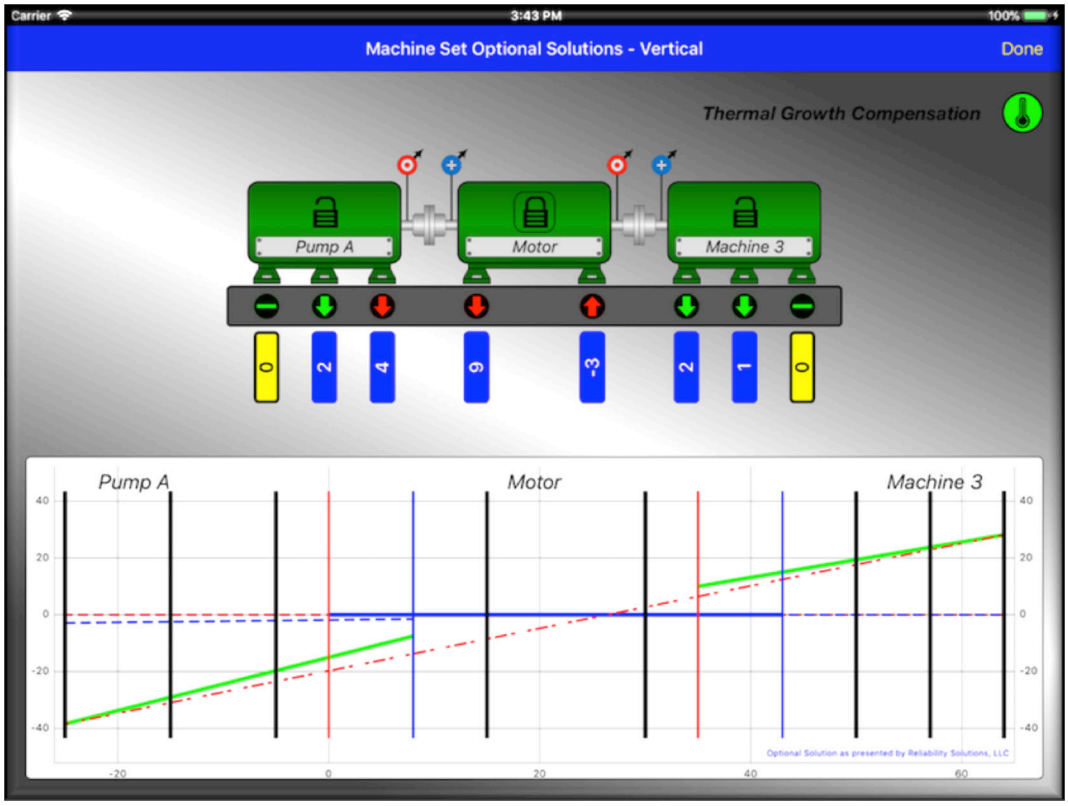
- Touching MACHINE SET OPTIONAL SOLUTIONS from the Vertical Alignment Solution screen will reveal this screen.

- The total machine set is illustrated at the top of the screen with corresponding move indicators and quantities under each machine foot.

- A lock indicator is also shown in each machine. Selecting each machine will lock the selected machine. Locking a machine will update the graphical solution with the selected machine as the reference machine. The reference machine is always shown as a horizontal line in the graphical solution.

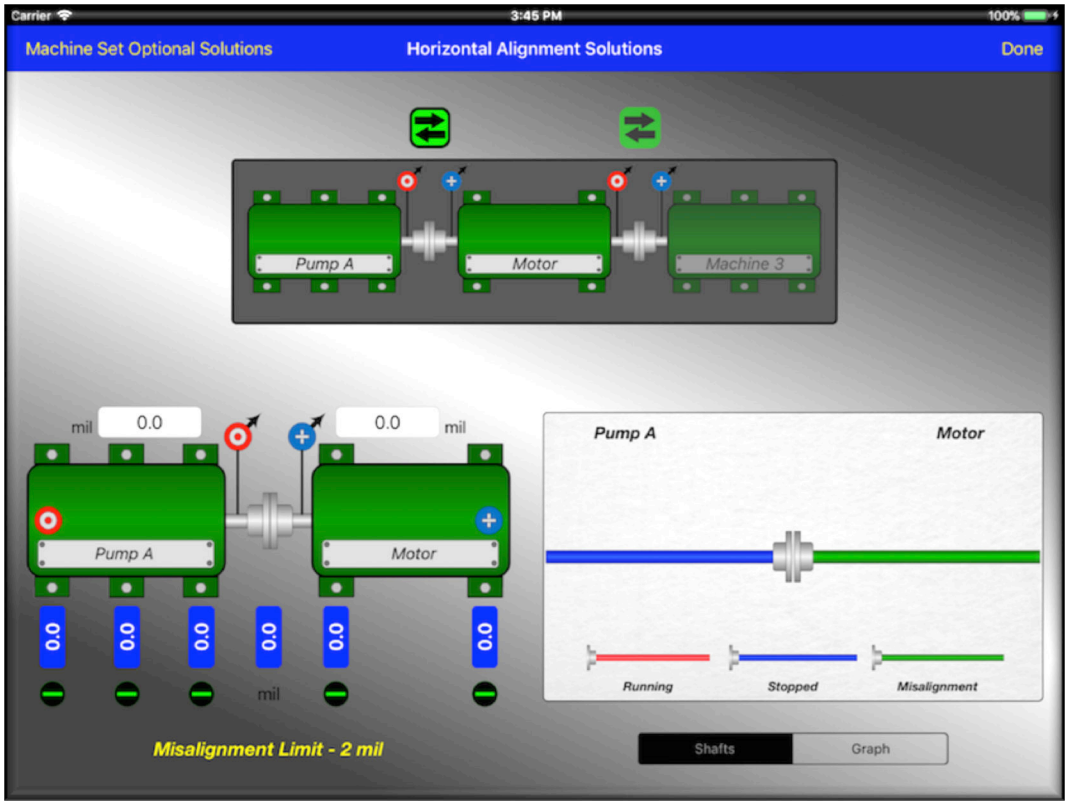
- The graphical alignment solution will be shown at the bottom of the screen.

Step 6 – Vertical Alignment Optional Solutions (continued)



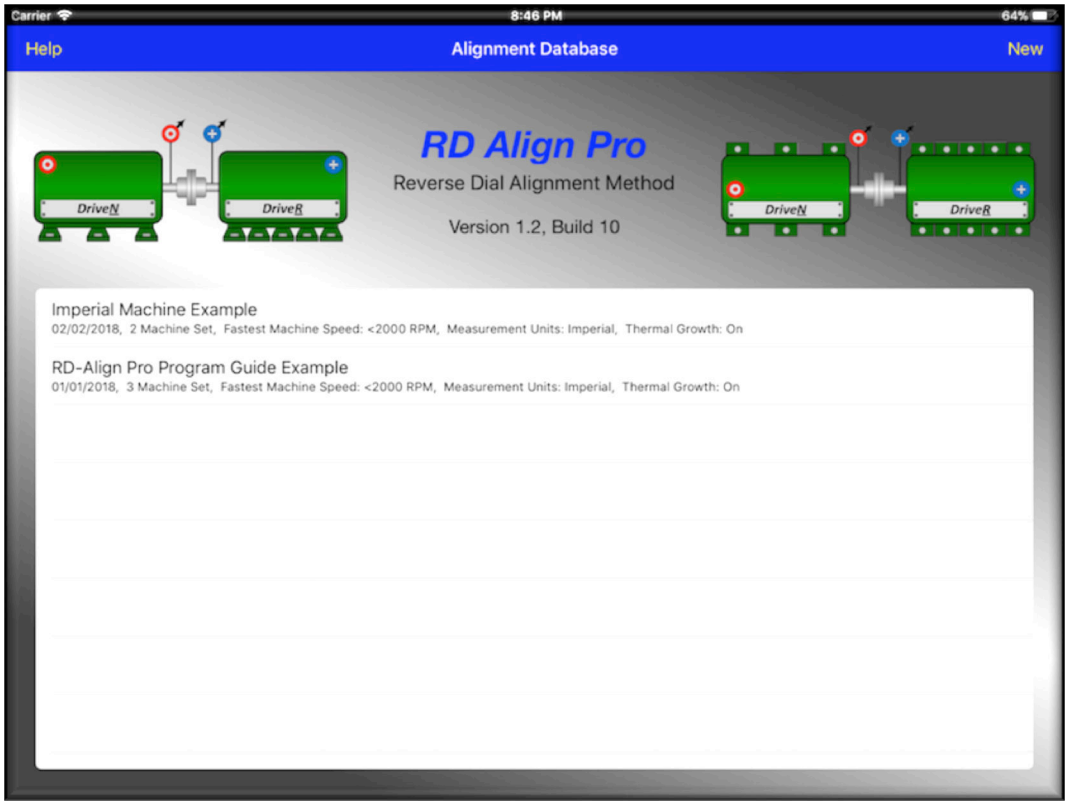
- Touching any 2-machine feet will provide an optional solution.
- Touching a foot will change the foot color to yellow. When the second foot is selected, it will turn yellow as well.
- After the second foot is selected, the move indicators will update with the direction of move and quantity of move.
- The graphical solution will update with the optional solution line in red dashed line.
- Various combinations may be explored to determine the best, easiest, or achievable moves.
- Touch DONE to return to the Vertical Alignments Solution screen.

Step 7 – Horizontal Alignment



- Touch the HORIZONTAL ALIGNMENT button on the Machine Set 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 Pro 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.