Application Note

Power Generation

System Recommendations

Turbines	**L-706 Turbine Alignment System**
Split-Joint Flatness	**L-740 Leveling Laser System**
Rotating Equipment	**S-680 5-Axis Shaft Alignment System**

How the Alignment System Works – L-706 Laser

The L-706 Bore Alignment Lasers is designed to perform alignment of gas and steam turbine bores. The system uses a laser, reference target, measuring target, inside micrometer sweep device, and fixtures to hold the laser and targets. Since the laser beam is concentric to the OD of the L-706 housing to within .0005 in. (0.013 mm), it can serve as one reference target. This saves a lot of time during setup.

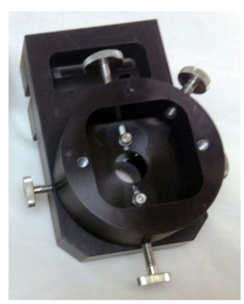
On most turbine alignments, the rotor bearing bores are used as the references. This means that fixtures that hold the laser and reference target must be placed precisely in these bores to the set points determined by the manufacturer of the turbine.

The fixtures are hung in the bores using angle iron and special magnetic bases. Depending upon the size of the bore, either the A-501 Large Bore Sweep Fixture or the A-501A Small Bore Sweep Fixture is used to position the A-502L Laser or A-502A Target fixture so that the center is exactly on the reference points provided. The sweep unit is an inside micrometer that allows the fixture to be placed to any points desired to an accuracy of .001 in. (0.025 mm).

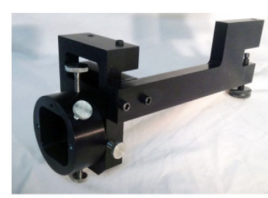
Once both fixtures are swept in, the L-706 Bore Laser is placed in the A-502L Laser Fixture and a T-218T Target is placed in the second A-502A Target Fixture. The L-706 laser is designed so that the laser beam is concentric (centered to) to the housing's OD to within .0003 in. (0.0075 mm). With the fixture "swept in," the laser is inserted into the fixture and is thus centered to the reference points.

All that is needed now is to adjust the angle of the laser beam, using the two micrometers on the back of the L-706. These micrometers are adjusted until the reference target reads zero, both vertically and horizontally. The laser is now set up and ready for measurements.

A-501A Turbine Bore Sweep Indicator Unit



A-502A Turbine Target Fixture



A-502L Turbine Laser Fixture

How the Alignment System Works – Targets and Readouts

For measuring an individual component, such as a diaphragm, there are two target choices.

The T-218T Target

The first is the T-218T Turbine Target. The T-218T works much the same as the reference targets. The target fixture (A-502A) is swept into the center of the bore using the A-501(A) sweep unit, then the target is placed in the fixture and the reading is taken. A positive vertical reading means the diaphragm is higher than the reference bores. A positive horizontal reading means the diaphragm is to the right of the reference bores. Since the data is live, the diaphragm can be adjusted until the reading is zero (or to an offset determined by the engineers).

T-218T Turbine Target

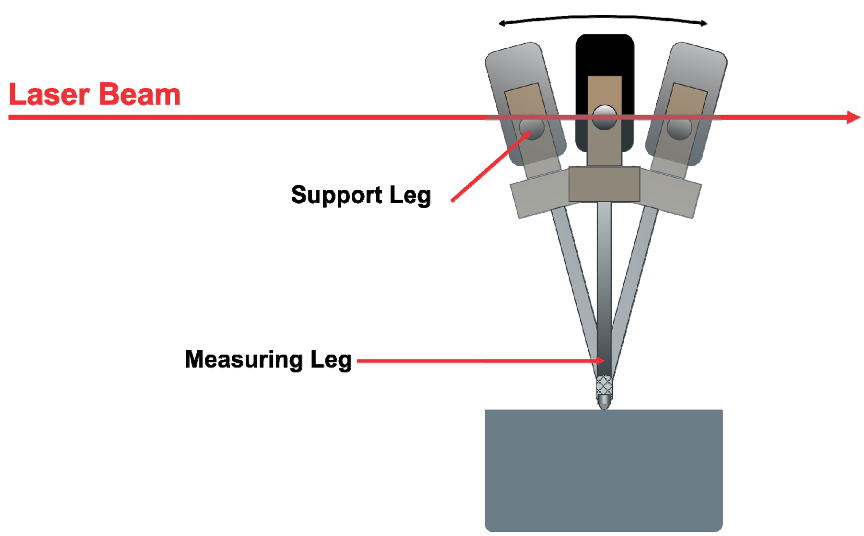
The A-1511 Wand Bore Target

The second measuring target that can be used is the A-1511 Wand Bore Target Fixture with our A-1519-2.4ZB Wireless Target. Instead of using a fixture to "hang" a target in the center of the bore, the A-1511 uses fixed-length legs that are approximately equal to the radius of the bore. Two legs are used, each 90 degrees from the other. One leg has a measuring tip on it and the other is used for support. The A-1511 has replaceable legs and can be used on bores with a 12 in. (304 mm) to 6 feet (2M) diameter.

To take readings, the measuring leg and tip are placed horizontally on the left side of the bore and zeroed out using the Sweeping-Through-the-Arc method (typically used in tight-wire alignment) where the target is slowly swept through an arc, in the same direction of the laser beam, and the highest reading value is recorded. Next, the tip is placed on the bottom of the bore and the vertical measurement is recorded. The target measuring tip is then placed on the right side of the bore and the horizontal measurement is recorded.

L-1511 Wand Bore Target w/A-1519 Target

Once all the measurements are recorded, they can then be entered into a spreadsheet to determine the component moves. After the moves have been determined, either the A-1511 or the T-218T can be used to align the individual components to their calculated locations. Again, the laser and reference targets do not have to be repeatedly setup and taken down when moving or replacing turbine components.



Good Repeatability Depends Greatly on Component Surface Condition

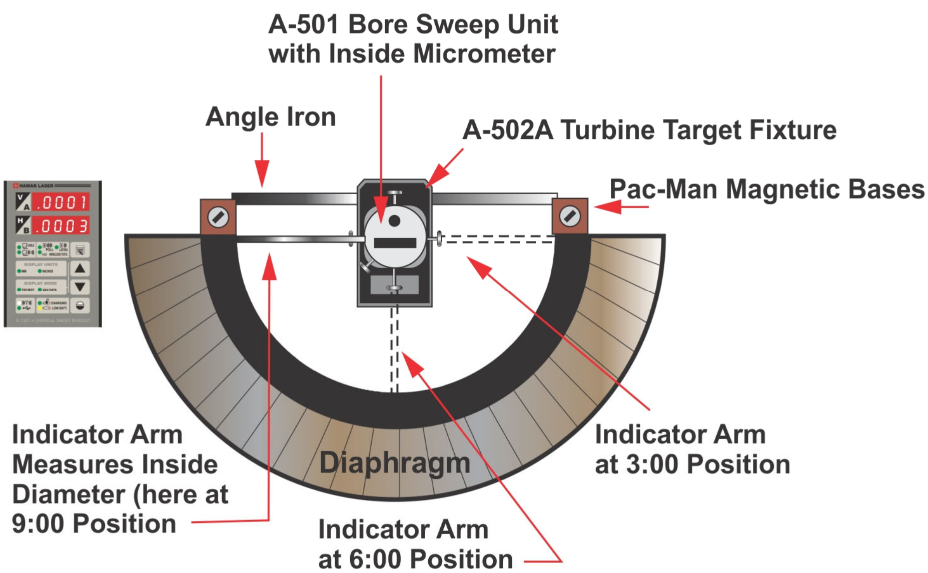
Both the A-1511 and T-218T measuring targets are very repeatable. However, in our experience, the A-1511 is much faster at taking the measurements. To get the best repeatability, some mechanism should be employed to ensure that each point on the diaphragm or other component is marked and the measuring tip is placed exactly on the same point. Given that the surfaces inside a turbine are usually pitted and rough, a radius tip should be used. For new turbine installations, repeatability of .001 in. (0.025 mm) or better is easily achievable. However, for older turbines, it becomes increasing more difficult to hold .001 in. repeatability because of the high level of pitting and corrosion.

R-1307 2-Axis Readout with Wireless Transmission

The R-1307B-2.4ZB 2-Axis Readout connects to the target via a short cable to display the values. The data from one R-1307 Readout can be transmitted to a second R-1307 Readout via the 2.4 GHz radio up to 150 feet (45 m) away. This is very helpful when the far reference target, the T-218T is over 20 feet away from the laser. The operator needs to adjust the horizontal and vertical angular axes on the laser to do the final "buck-in" setup. The R-1307 can show inches or mm and has a resolution of .0001 in. or 0.001 mm.

Turbine Alignment Procedure using A-1511 Wand Bore Target

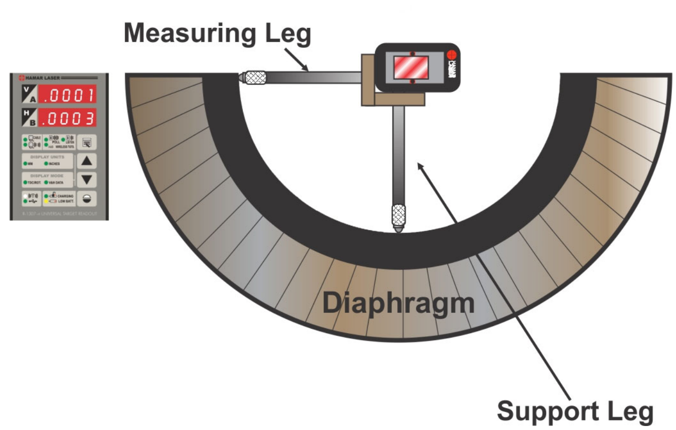
1. Place "Pac-Man" magnets (included with the A-502A and A-502L fixtures) at the edge of the first reference half-bore and place angle iron in them.
2. Attach the A-502 Bore Target Fixture to the angle iron and roughly center using a tape measure.
3. Place A-501 Bore Sweep Unit in the A-502.
4. The indicator is usually zeroed on either the left or right side. For now, assume it is zeroed in the 9 o'clock position (left position).
5. Move the indicator arm to the 6 o'clock position and measure vertical axis ID offset. If it is not zero, turn the adjustments in the A-502 until the value is half the value originally measured value.



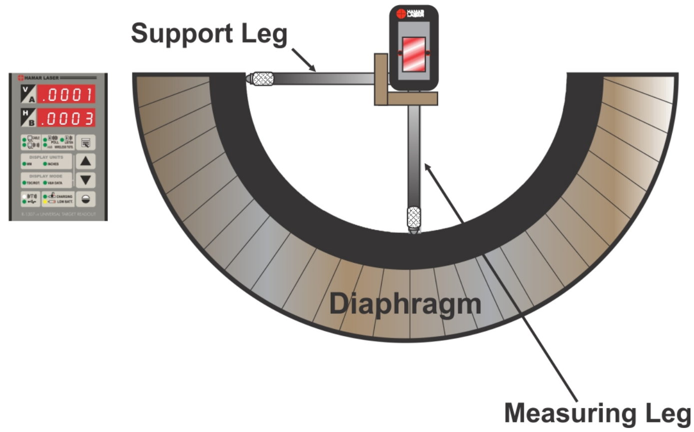
Steps 3-5

A-502 Turbine Fixture with A-501 Bore Sweep Unit

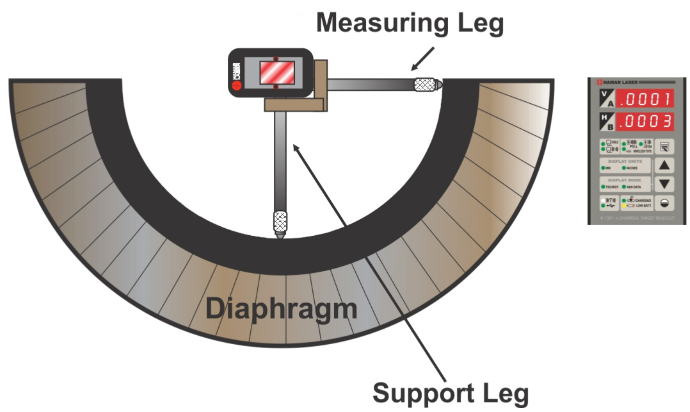
6. Rezero the indicator at 9 o'clock.
7. Move the indicator arm to the 3 o'clock position and measure the horizontal axis. If it is not zero, then turn the adjustments until the value is half of the originally measured value.
8. Double check the 6 o'clock value to ensure it is still within tolerance.
9. Once the A-502 fixture is in the correct position on the centerline (or in turbine alignment, to "setpoints") remove the A-501 and replace with the L-706 laser. Since the laser beam is concentric to the housing OD within 0.01 mm, the laser beam is now on the centerline of the bore.
10. Place a second fixture in the second reference half-bore and repeat Steps 4-8, placing the T-218T Turbine Bore Alignment Target in the A-502A.
11. Turn the L-706 angular adjustments until the laser beam hits the center (zero) of the target. The laser is now concentric with the centerline of the two reference half-bores.
12. Use either the same combination (A-502 and T-218T and Pac Man magnets) or the A-1511 Wand Bore Target to measure the other half-bores in between the 2 reference bores. Measuring each bore works the same as described in the diagram, but the target would be set up as described above.
13. To use the A-1511/A-1519-2.4ZB Wand Bore Fixture/Target, adjust the legs to fit the bore radius.
14. Connect to the R-1307-2.4ZB Readout.



15. Place the measuring foot on the left side of the bore and use the Top Dead Center (TDC) method to find the high point. Zero the A-1519-2.4ZB Target by pressing the ZERO button.
16. Move the measuring foot to the bottom of the bore. Use the TDC method to find the high point and record that point.



17. Move the measuring foot to the right side of the bore. Use the TDC method to find the high point and record that point.

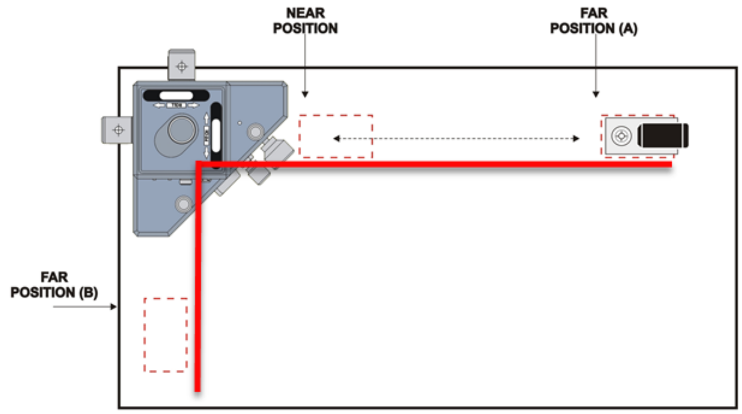


Step 14

18. Either enter the values obtained into a spreadsheet or do the calculation to determine the H & V alignment values.
19. Repeat for each bore, periodically checking the T-218T Reference Target data to make sure the laser did not drift (a common problem with all lasers). If the laser drifted, adjust the L-706 micrometers to steer the laser back to zero.

How the Alignment System Works – L-740 Laser

Checking Flatness using 3 Reference Points



1. Place the L-740 laser either on the split joint or and instrument stand. Level both level vials.
2. The goal is to align or "buck-in" the laser to 3 reference points on the split joint, usually arranged in an "L" pattern (see the image to right).
3. Place one A-1519-2.4ZB Single-Axis Target on the split joint as close to the laser as possible. Zero the display on the R-1356-2.4ZB PDA Readout. The target has now been set to zero on the first reference point.
4. Move the target along the "pitch" axis to the farthest point from the laser (this is the second reference point). Adjust the laser pitch adjustment until the R-1356 display is zero. Bring the target back to the first reference point. If the display does not read zero, re-zero the display. Repeat this process until the target in both reference points reads zero.
5. Place the target on the farthest point along the "roll" axis and adjust the roll adjustment until it reads zero. The laser is now parallel to 3 reference points.
6. Move the target to the desired measurement points along the split joint and any deviation from zero is a measure of the flatness of the split joint. If the display shows a plus (+), the measurement point is higher than the reference point. A minus (-) indicates that the point is lower than the reference point. If the measurement point has an adjustment pad under it, use the target and readout as a live digital indicator and adjust until the display shows zero. The measurement point is then in the same level plane as the reference point.

Checking Flatness using 1-Arc-Second Levels Instead of Reference Points

To level a surface, put the laser on an instrument stand or stable mounting surface and level in two axes. Next, place the A-1519-2.4ZB Single-Axis Target on 1 reference point and zero it (this is done electronically by pressing a button on the target or readout).

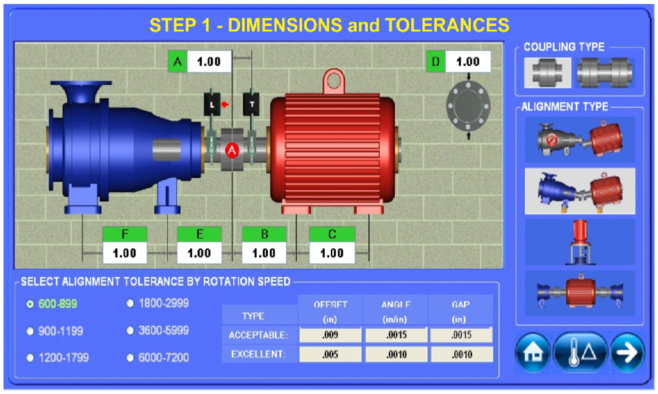
Move the target to a measurement point on the split joint. If the value is not zero, then this is the deviation of that point from the reference point relative to an *earth-level* laser plane. If the display shows a plus (+), the measurement point is higher than the reference point. A minus (-) indicates that the point is lower than the reference point. If the measurement point has an adjustment pad under it, use the target and readout as a live digital indicator and adjust until the display shows zero. The measurement point is then in the same level plane as the reference point.

The levels can be calibrated in the field using an easy 15-minute procedure and usually hold calibration for several months.

Note – it is quite likely that the split-joint is not level to earth, so we recommend using the 3-point Buck-In Method.

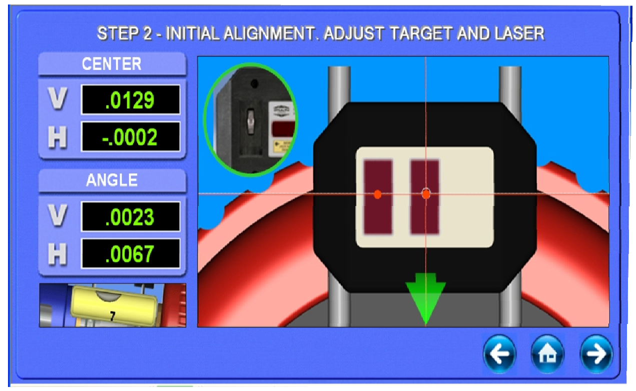
Using Plane5 Flatness Software

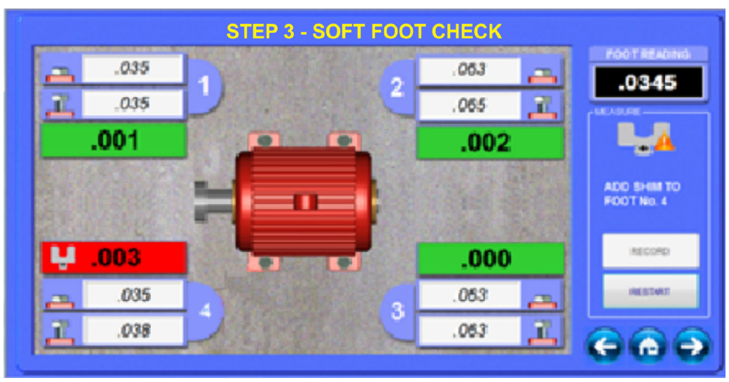
Our Plane 5 software can be used with the L-740 to quickly download flatness data for analysis and reporting. When simply taking data, Plane5 employs a least-squares, best-fit algorithm to eliminate any slope errors in the data from the laser not being parallel to the surface. What this means is that the laser does not have to be bucked-in to reference points to check flatness, which saves about 10 minutes of setup time.



Step 1: In the MOTOR SETUP SCREEN, the motor's foot dimensions, machine description and desired alignment tolerances are entered. Thermal grown offsets (the amount the motor grows from a cold start to operating temperature) are also entered at this stage.

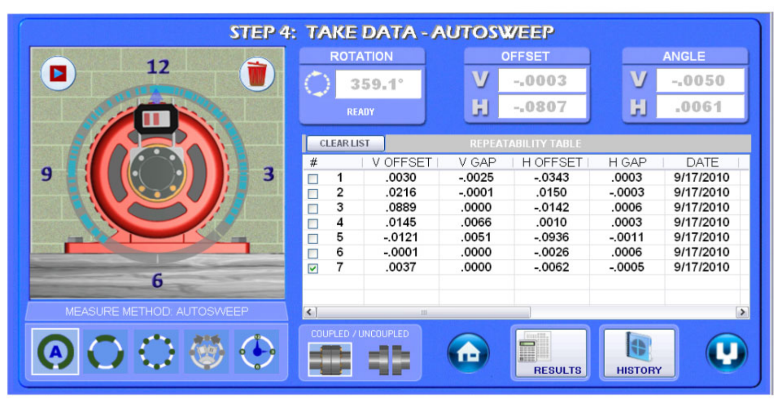
Step 2: The LASER SETUP SCREEN displays and the laser and target are placed on the brackets and adjusted until the readings are within ±.030 in. (0.8 mm) of zero. Adjustments to the vertical center are made by moving the laser up or down on the brackets. Adjustments in the horizontal center are made by an adjustment knob on top of the laser. For new motor installations, this screen is used to "rough in" the motor's large angular misalignment.

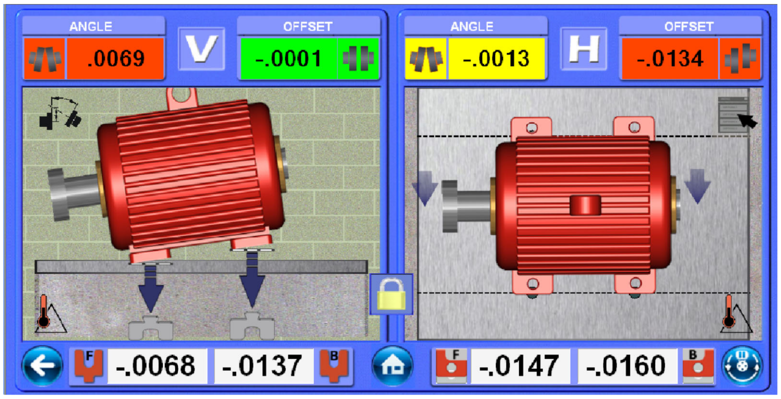




Step 3: After the laser and target setup and the motor rough-in, the SOFT FOOT SCREEN displays an easy-to-follow routine that finds potential soft-foot problems and recommends corrective action. The soft-foot routine is best used with the motor uncoupled to the driven unit. This is because a large pump and rigid coupling can prevent the laser from finding soft-foot problems. The laser measures shaft deflections caused by a soft foot, and if the shaft is rigidly coupled to a driven unit, it may not move much at all.

Step 4: Once the soft foot routine is completed, the DATA TAKING SCREEN displays. The laser and target are rotated for data collection and analysis of mounting errors. The S-680 system automatically senses when the laser and target are being rotated and when they stop. When rotation stops, the software automatically calculated the mounting errors and subtracts them from the misalignment readings. A coupled or uncoupled routine may be selected.





Step 5: The MISALIGNMENT SCREEN displays a graphic of the misalignment, including center and slope readings corrected for mounting errors and shim values in all 4 axes. The readings and motor graphics automatically update when moves are made or shims added. The data-updating speed (averaging) can be adjusted to smooth out fluctuations in the readings due to air turbulence or vibration. Shim value displays are replaced by IN TOLER when the alignment comes into tolerance. The DATA TAKING and MISALIGNMENT screens also show a light meter that warms the user if bright light, such as the sun, is affecting the readings.

For motors with large misalignment, Steps 4 and 5 may need to be repeated. In general, however, one set of shims and moves is all that is needed to perform the alignment.