

Application Note 2

Machine Tool Alignment

Boring Mills, Gantry, Machining Centers, VTLs

System Recommendations

L-743 Machine Tool Alignment System

How the Alignment System Works

The following section describes how the laser is used to measure straightness, flatness, squareness, levelness and parallelism on a 6-axis horizontal floor mill. Note that if a machine is going to be aligned, rather than just measured, it is important to put the laser on an instrument stand. If the laser is on the machine bed or table, adjustments will likely move the laser and affect the setup.

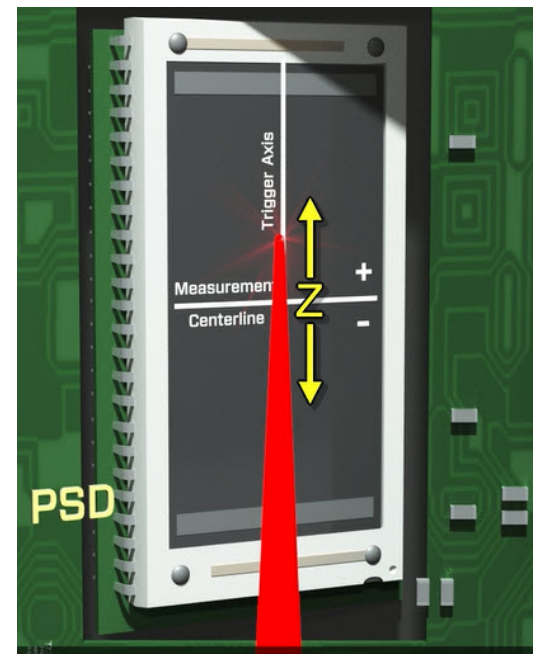
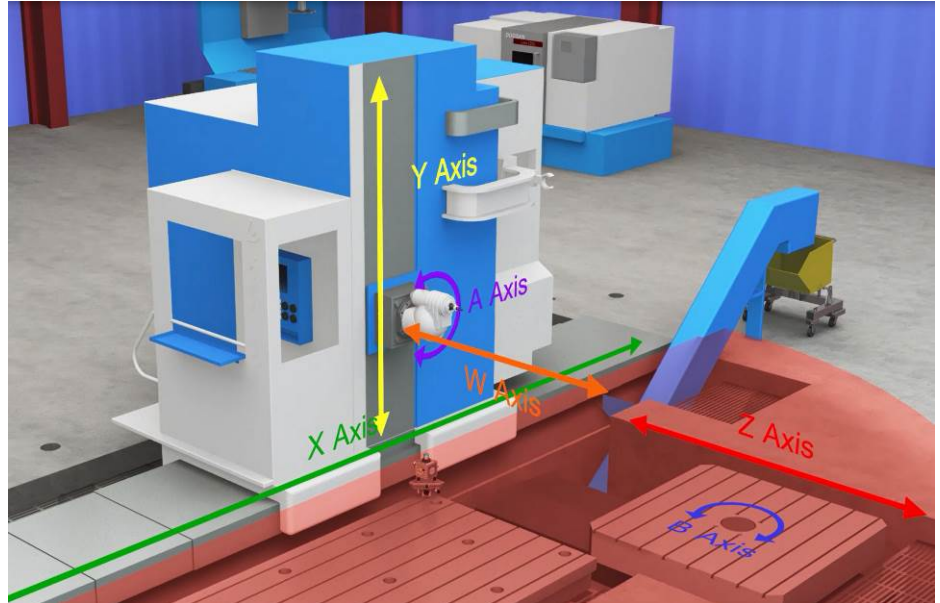
Setting Up (Bucking-in) the Laser

When setting up the laser to measure either straightness or flatness, you must first position the laser plane(s) so that they are parallel to the reference points on the machine. This process is called "bucking in" the laser. To speed up the setup process, the use of 3 reference targets is highly recommended.

- For measuring straightness, 2 reference points are needed.
- For measuring flatness, 3 reference points are needed.
- For measuring the flatness, straightness and squareness of a machining center, 5 reference points are needed.

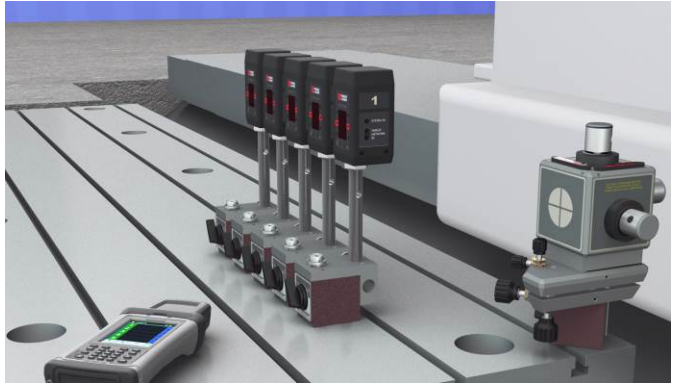
In this procedure, we'll use 3 targets for the initial 3-point setup and one target for the 2-point setup.

Once the laser has been set up to its reference points, the targets can be repositioned to measure the various surfaces or lines of motion for deviation from the references. A plus (+) reading indicates a target is higher than the reference points, and a minus (-) reading indicates it is lower.

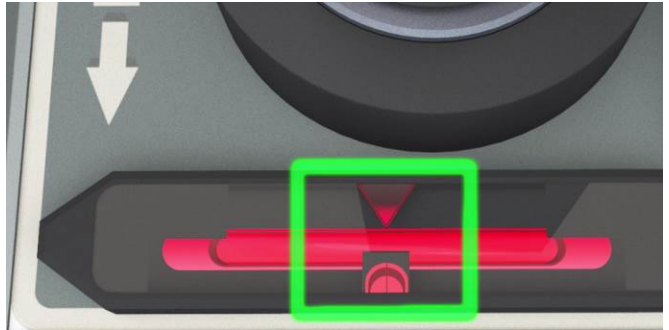


Procedure

1. Place the laser on the table at a spot that provides the ability to measure all the axes from the same setup.



2. Level the Pitch-Axis level via by using the coarse and fine adjustments to line up the edges of the bubble. Repeat the process with the Roll-Axis level vial. Now the red laser plane is level to earth



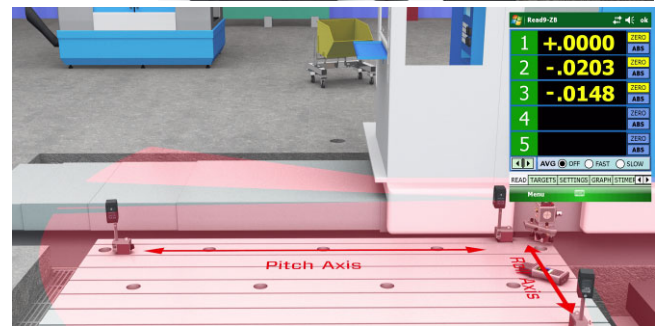
3. Place Target #1 at a location next to the laser and mark the outline of the magnetic base for good repeatability. Point the laser at the target window and adjust the target height until the laser beam is centered.



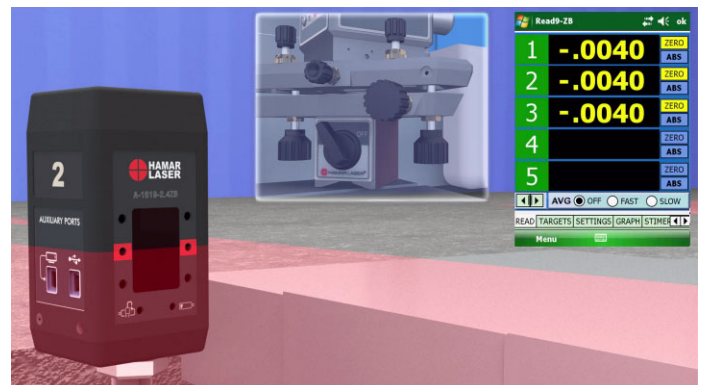
4. Turn on the laser rotation (which also turns on the targets). Target #1 data displays in the Read9 software on the PDA. Zero the display. Remove Target #1 and replace it with Target #2. Zero the Read9 display for Target #2. Repeat the process for Target #3.



5. Spread out the targets on the table on three reference points, two along the Pitch Axis and one on the Roll Axis.

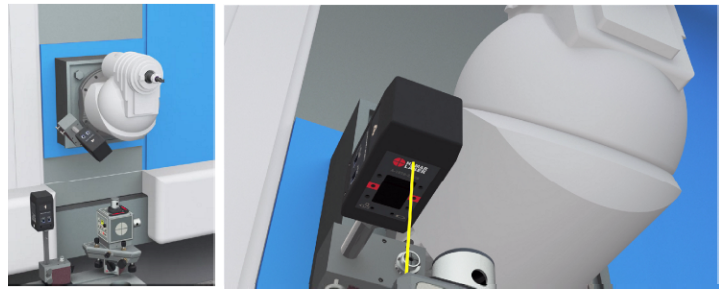


6. Looking at the data for Targets #1 and #2, adjust the Pitch-Axis knobs on the laser until the two values are equal. Switch to Targets #1 and #3 and adjust the Roll-Axis knobs on the laser until those two values are equal. Now the target values for all three targets are equal and the laser plane is aligned to the table.

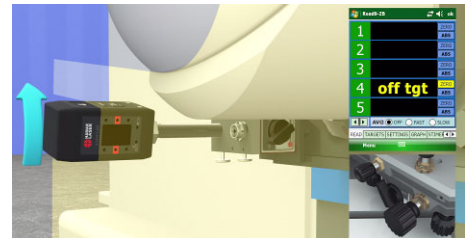


Aligning the Laser to the X-Axis Travel

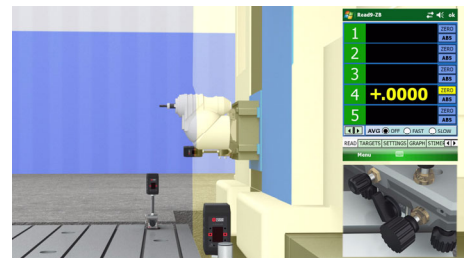
1. Mount Target #4 on the ram, move the spindle and adjust the target height.



2. Power on the laser and zero the target in the Read9 PDA. Move the column down to the end of the X-Axis travel and rotate the target head to point towards the laser.



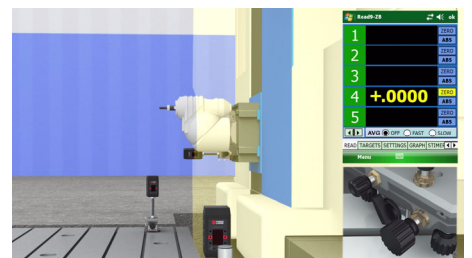
3. Turn the Yaw-Axis adjustment knob to center the laser to zero on the target.



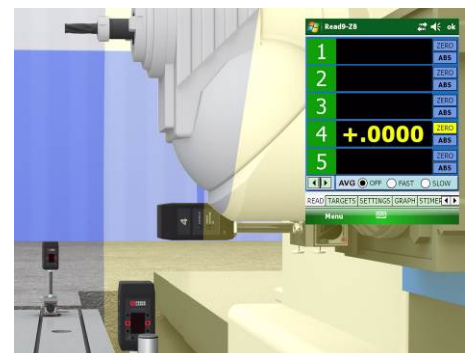
4. Return the column to its starting position and rotate the target toward the laser. Zero the target.



5. Send the column back to the far end of travel and tweak the Yaw-Axis adjustment knob to zero the laser.



6. When the target reads zero at both ends, the laser is aligned to the X-Axis.



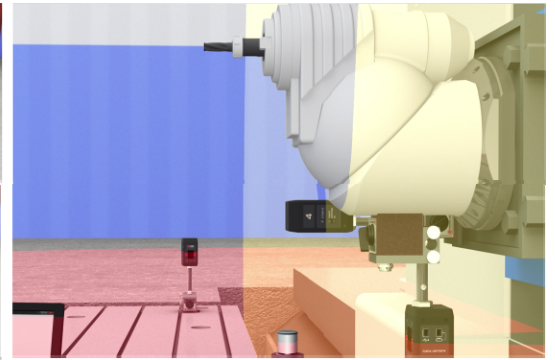
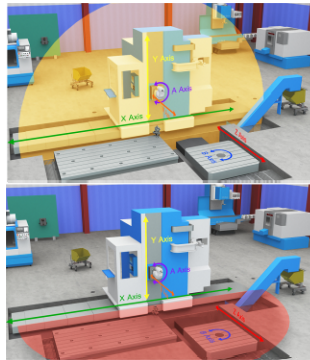
Measuring X-Axis Straightness and Flatness Simultaneously

The straightness and flatness for X can be measured simultaneously by adding a second measuring target to the bottom of the spindle ram. The targets come with a 3-piece post set, so a shorter post may be used to adjust the target height to pick up the red laser.

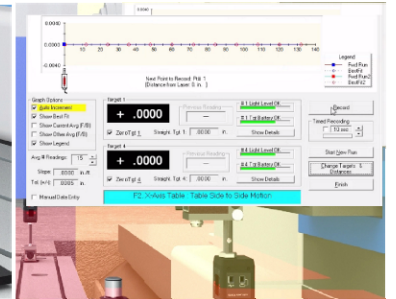
1. Attach a second measuring target to the bottom of the spindle ram with a short post. Adjust the target height to pick up the red laser.



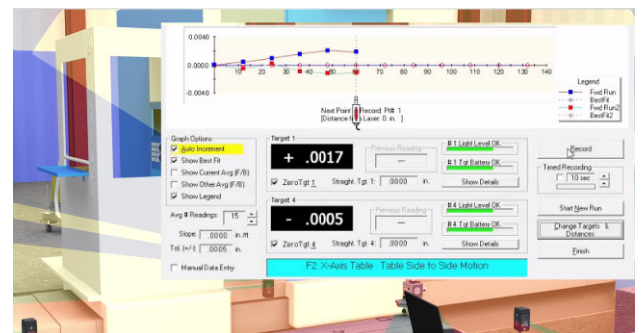
2. Turn on the rotation for both laser planes. The Gold Laser (top left) measures X-Axis Straightness and the Red Laser (bottom left) measures Flatness.



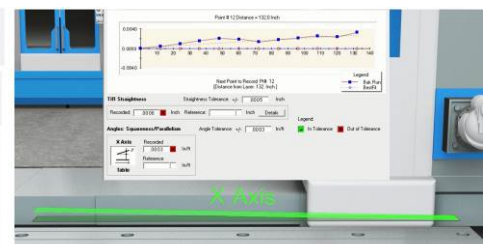
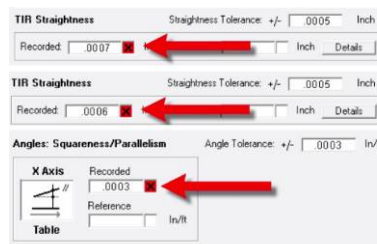
3. The target readings are sent wirelessly to a laptop computer, where our Machine Tool Geometry software records them. Select the axis, enter the length of travel and number of points, and ensure the targets are pointed at the laser. Hit the **RECORD** button and the Machine Tool Geometry software records both targets' data simultaneously and plots out straightness.



4. Continue to move the column to each point and hit Record. After the data has been taken, return the column to the home position.

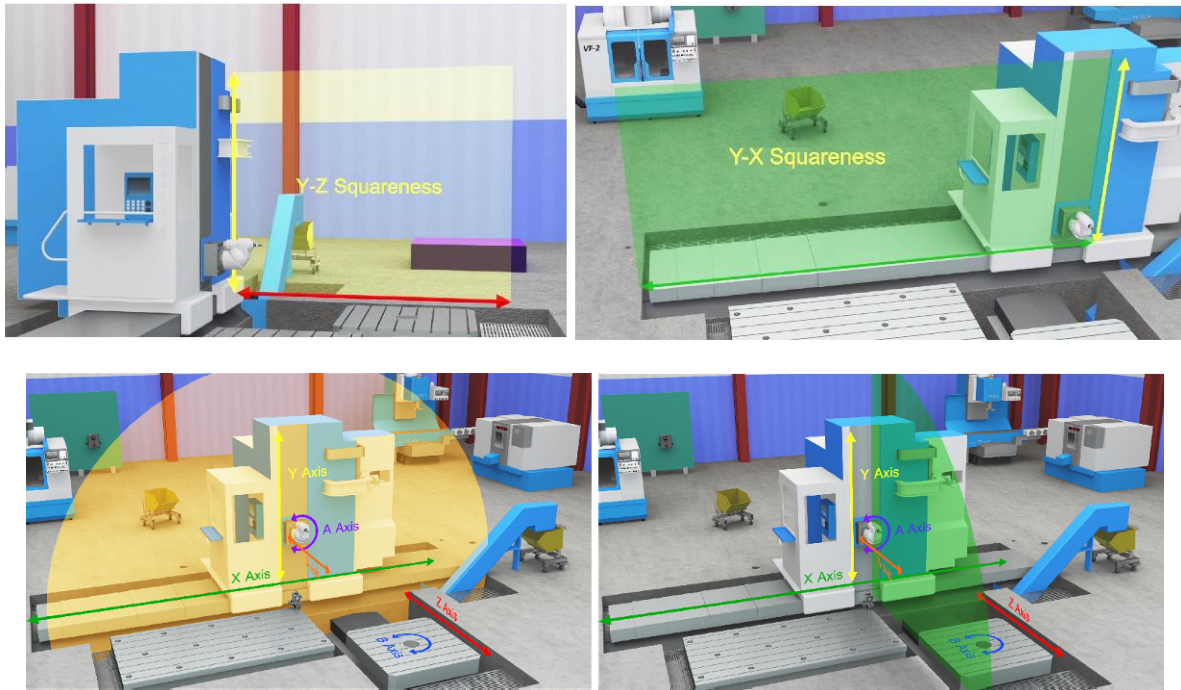


5. The X-Axis results show a Straightness error of .0007" TIR and a Flatness error of .0006" TIR. The slope of the Best Fit line is .0003 in/ft, which means the X-Axis is sloping UP relative to the table.

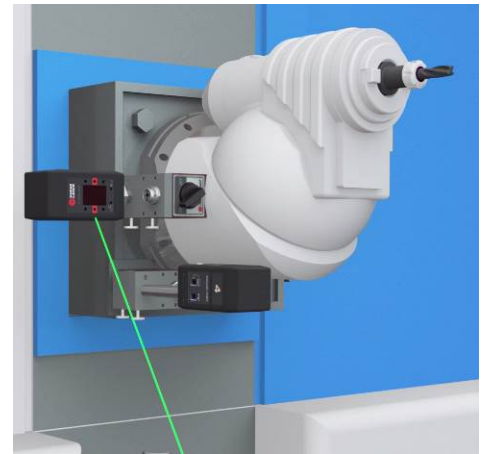


Y-Axis Flatness and Straightness and Y-Z / Y-X Squareness

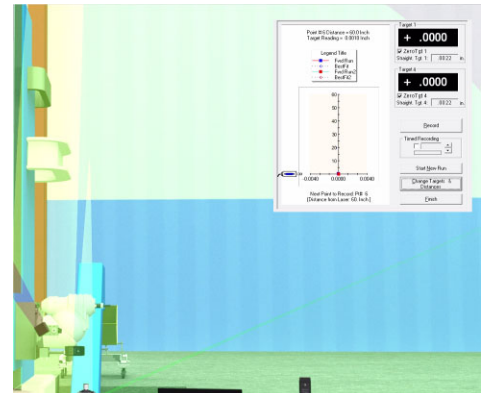
After measuring the Y-Axis flatness and straightness, the Machine Geometry software calculates the Y-Z and Y-X Squareness. The Gold Plane (bottom left) measures Y Flatness and the Green Plane (bottom right) measures Y Straightness.



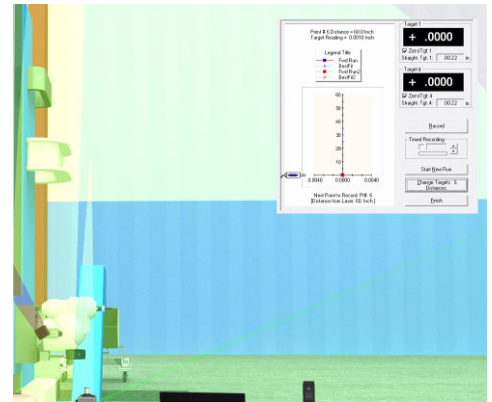
1. To measure the Y-Axis, move the second target to the side of the spindle and adjust the column and target height to center the laser in the window.



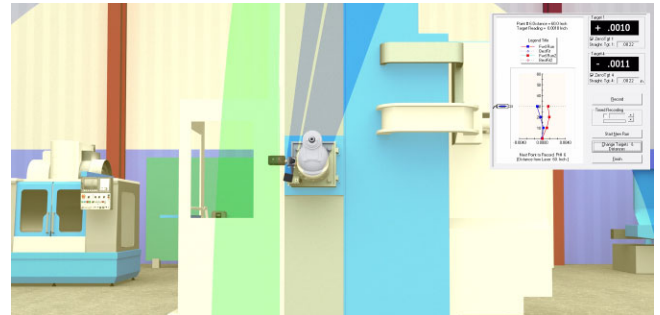
2. Turn on the laser rotation and zero the targets.



3. Move the column, pause a few seconds, and click **Record**. Repeat for each point.



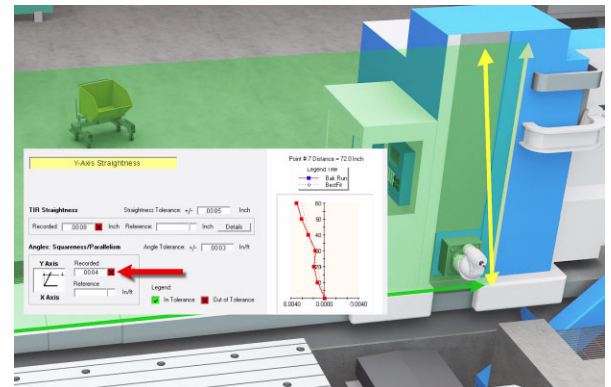
4. The Gold Plane measures the squareness of the Y-Axis to Z and the Green Plane measures Y to X squareness.



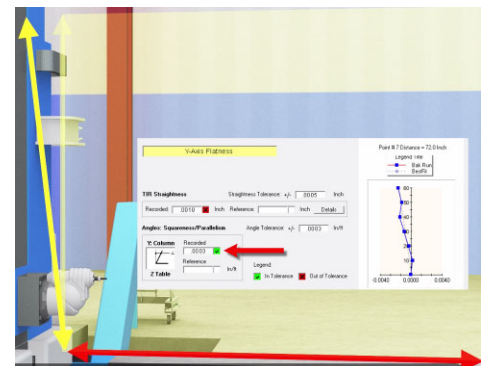
5. As before, the Machine Tool Geometry software does the straightness and squareness calculations. The results show .0010" TIR for flatness and .0008" TIR for straightness.



The X-Y Squareness is .0004 in/ft, meaning the column is leaning to the left.

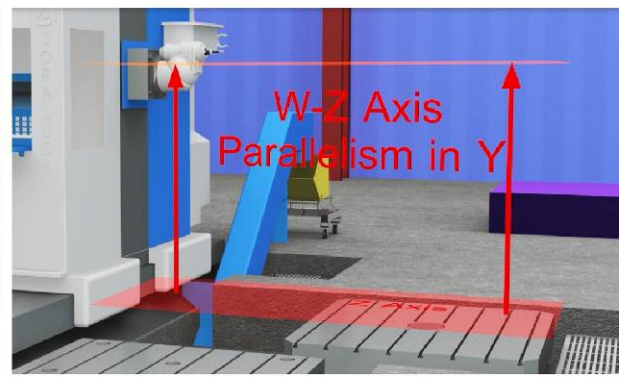
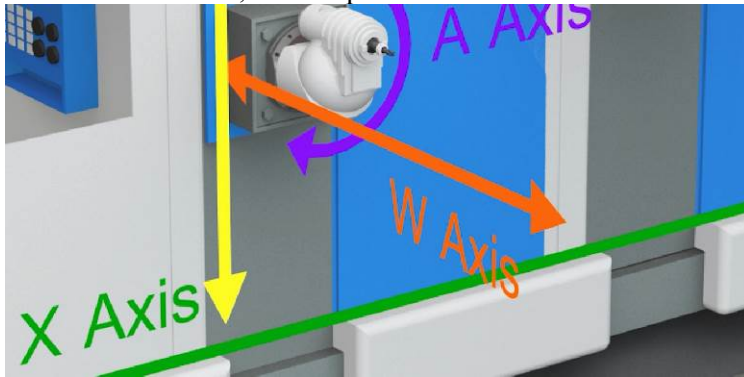


7. The squareness of Y to the tables is .0003 in/ft, meaning the column is leaning back.



W-Axis Flatness and Straightness, W-Z (in X) Parallelism, W-Z (in Y) Parallelism

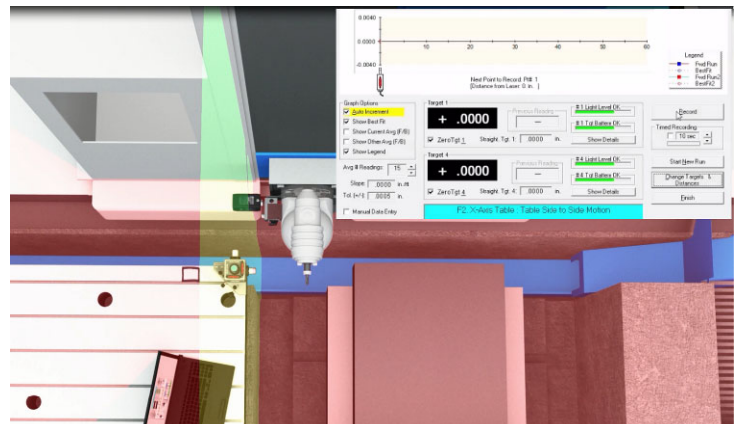
Without changing the L-743 setup, the W-Axis can be measured for flatness and straightness and parallelism to the Z-Axis in the Y direction, and the parallelism to the Z-Axis in the X direction.



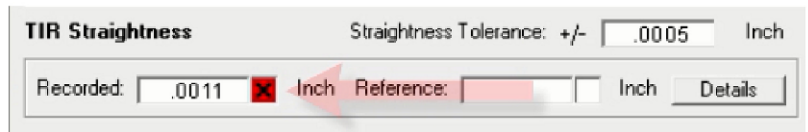
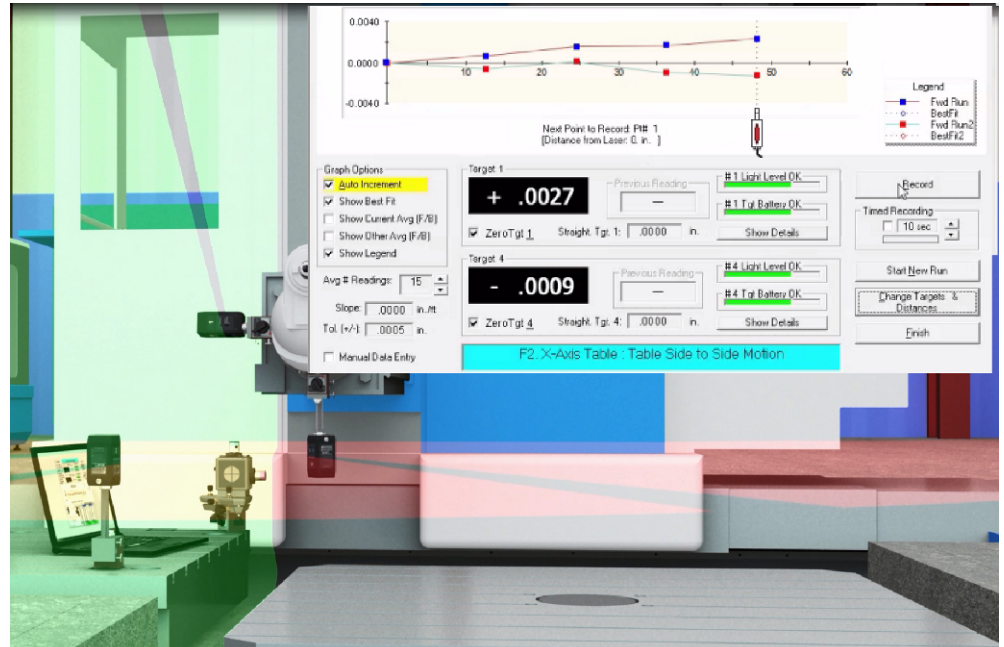
1. To set up for W, change the target position, turn on the laser rotation and adjust the spindle to center the laser.



2. Zero Targets #1 and #4. The green plane measures the straightness of W, W-X squareness and parallelism to Z (in X).

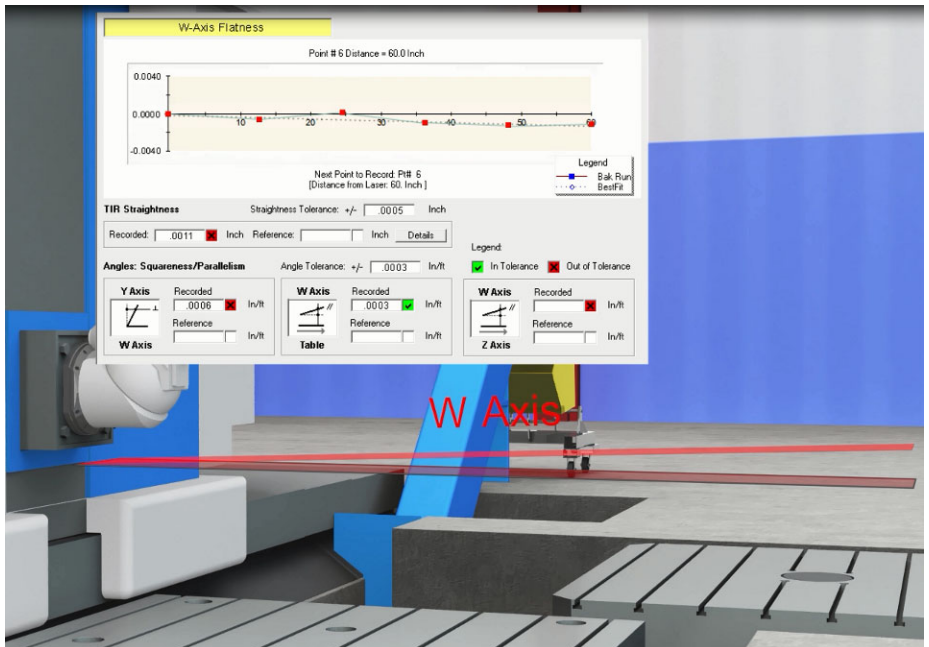


- The red plane measures the flatness of W, W-Y squareness and parallelism to Z (in Y). The software records the straightness of W and calculates the squareness and parallelism to the other axes. The results show .0003" for straightness and .0011" for flatness.



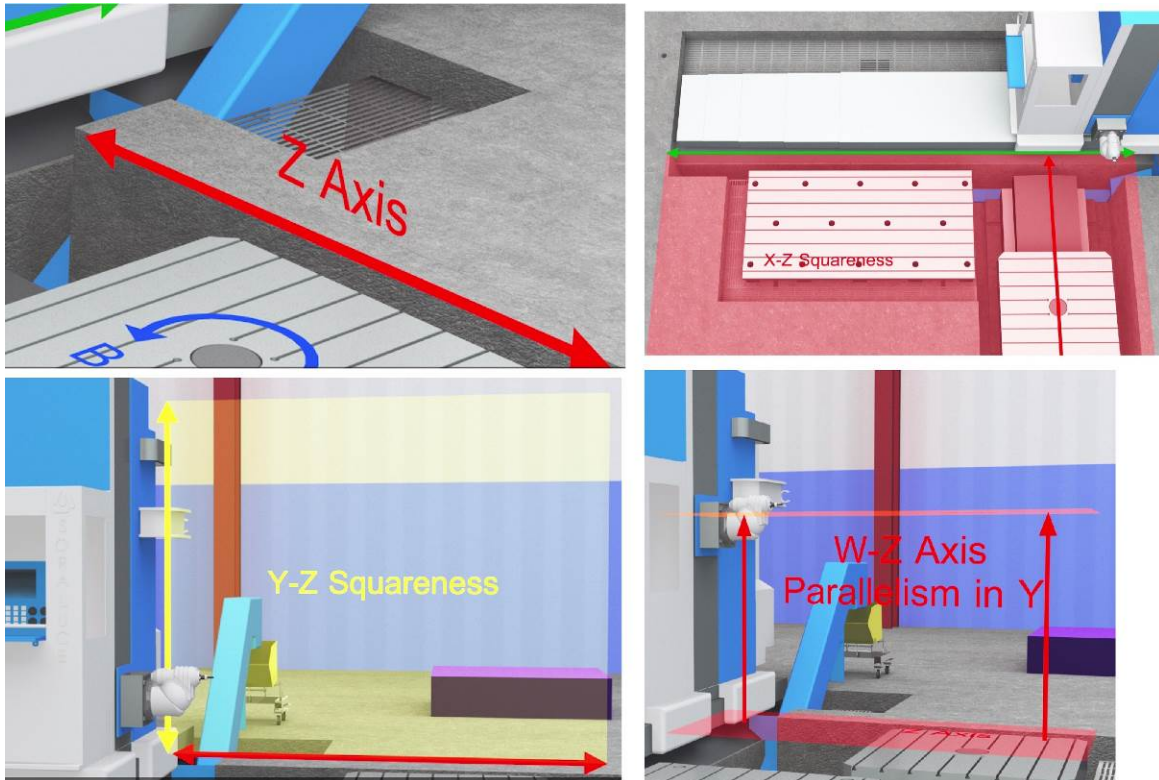
- The slope of the vertical Best-Fit line is .0003 in/ft, meaning the W-Axis is sloping up from left to right relative to the table.

For Z-W parallelism, Z must be measured first.

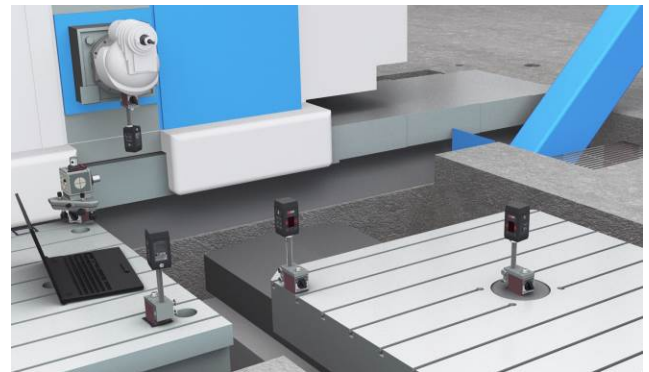


Z-Axis Flatness and Straightness, Z-X and Z-Y Squareness, Z-W (in X) Parallelism, Z-W (in Y) Parallelism

The final axis check is Z-Axis flatness and straightness, which provides the squareness to the X-Axis and the squareness to the Y-Axis. In addition, the parallelism for Z-W (in Y) and Z-W (in X) can be determined.

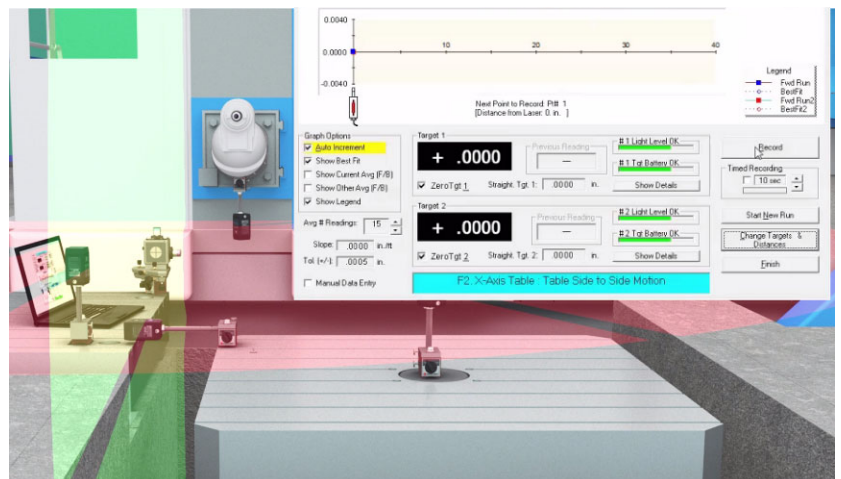


1. Leave the laser in position and re-position the targets. To measure Z-Axis flatness, use the red laser plane with Target #1 on the table.



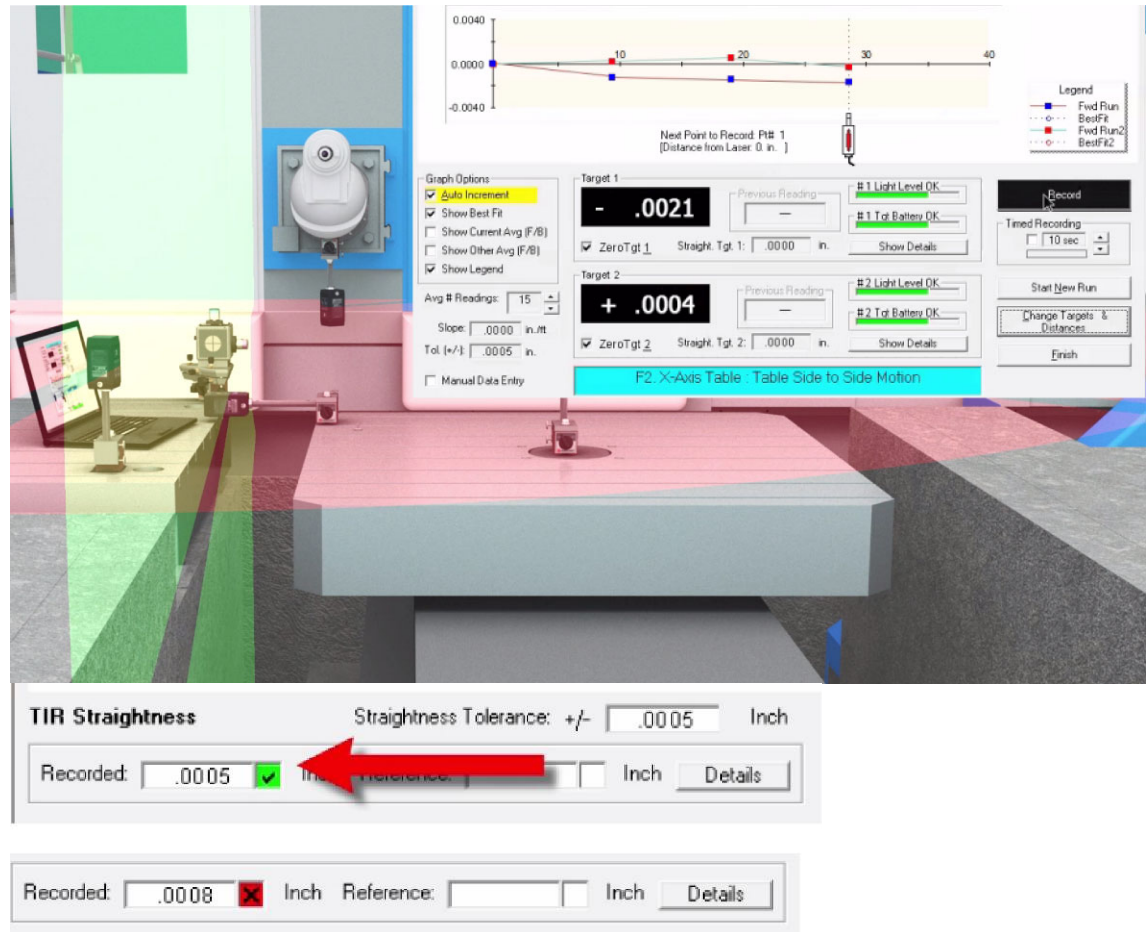
2. For straightness, mount Target #2's post into the side hole in the magnetic base to pick up the green laser plane. Adjust the pole length for Target #2, turn on the green laser and zero the display.

Repeat for Target #1 and the red laser plane. Now you're ready to measure.

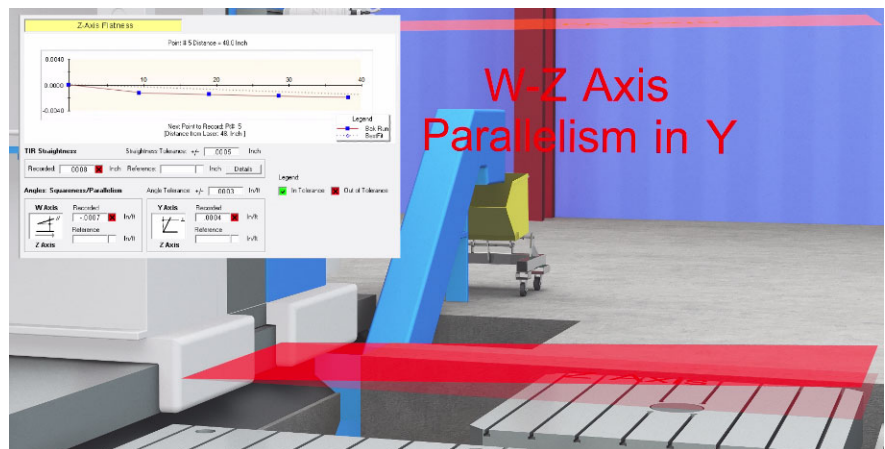


- Record the data in the Machine Tool Geometry program and the parallelism and squareness are automatically calculated.

The Z-Axis results show errors of .0005" for straightness and .0008" for flatness.



- The slope of the vertical Best-Fit line is -.0007 in/ft, which means the Z-Axis is sloping up toward Y relative to W.



- The horizontal Best-Fit slope is -.0003 in/ft, which means Z is sloping toward X relative to W.



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- The screenshot displays the SolidWorks CAD software interface with the 'Z-Axis Straightness' feature highlighted. The feature's tolerance is set to ± 0.0005 inch. The 'W Axis' and 'X Axis' are also shown with their respective tolerances. A red arrow points to the 'X-Z Squariness' feature, which is currently out of tolerance.

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- The screenshot displays two measurement results from a 3D printing software interface. The top section, titled "Z-Axis Flatness", shows a graph of "Point # 5 Distance = 48.0 Inch" with a tolerance of ± 0.0005 inch. The graph plots "Ball Run" (solid line with blue squares) and "Ball Pa" (dashed line with blue circles) against distance. The "Ball Run" data points are approximately: (0, 0.0000), (10, -0.0001), (20, -0.0002), (30, -0.0003), and (40, -0.0004). Below the graph, the "TIR Straightness" section shows a recorded value of 0.008 inch, which is out of tolerance (red X), with a reference of 0.0035 inch. The "Angles: Squareness/Parallelism" section shows the "W Axis" recorded at -0.007 in/ft (out of tolerance, red X) and the "Y Axis" recorded at 0.004 in/ft (out of tolerance, red X). The bottom section, titled "Y-Z Squareness", shows a 3D model of a part with a yellow arrow pointing to a vertical surface and a red arrow pointing to a horizontal surface, indicating the measurement locations.

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- A 3D schematic diagram of the experimental setup. It shows a grey rectangular block with a circular hole in the center. A red double-headed arrow labeled "Z Axis" points along the vertical direction. A blue circular arrow labeled "B Axis" indicates rotation around the central hole.

