Lathe10 Alignment Software

for Aligning Lathes and Turning Centers

Operations Manual

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HAMAR LASER
ALIGN WITH THE BEST

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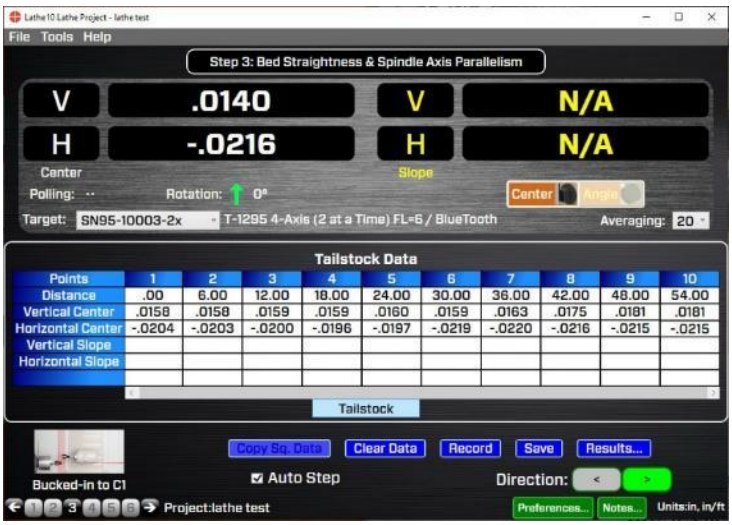
Lathe10 Lathe and Turning Center Alignment Software



Lathe10 is used with the L-700 and L-703S Spindle Alignment Laser Systems to align lathes and turning centers. A 6-step process guides the user through the alignment in 2 phases:

1. Checking the headstock rotation axis for alignment (parallelism) to the tailstock guideways, the saddle (or turret) guideways, or both.
2. If the headstock is parallel to the guideways, then a 4-axis check of the alignment of the tailstock or subspindle axis to the headstock spindle axis is performed.

The L-700/L-703S Laser is mounted in the headstock spindle chuck or collet, and the T-1295/1296 or T-261 4-Axis Target is mounted in the tailstock chuck (or fixture) or subspindle. The laser is aligned to the headstock axis of rotation (AOR) and the alignment checks are performed using either of the targets.

The T-1295/1296 Target is connected to a computer using a Bluetooth radio and running the Lathe10 software, which provides a real-time graphic display of the alignment process. The T-261 Target is connected to Lathe10 via the R-358 Computer Interface through the USB port. Lathe10 software is offered as a standalone program and runs on any Windows 7/8/10 PC or tablet.

System Components

The L-700 Spindle Alignment System - includes the following components:

- Model L-700 Visible Light Laser
- Model T-261 4-Axis Simultaneous Target
- R-358 Computer Interface with USB connection
- Lathe10 Software
- Calibration Factors (supplied with the system)
- Laptop or tablet with Microsoft® Windows 10 (optional with system purchase).

The L-703S Spindle Alignment System - includes the following components:

- Model L-703S Spindle Laser
- Model T-1295/T-1296 4-Axis Wireless Target
- Lathe10 Software
- Laptop or tablet with Microsoft® Windows 10 (optional with system purchase).

Computer System Requirements

- Physical memory (RAM): 8 GB recommended.
- Processor: Intel Pentium5 or later version or AMD equivalent, 1.3 GHz minimum speed.
- Available Hard Drive space: 6 GB minimum, 10 GB or better for more adequate file storage space.
- Video Resolution: 1024 x 600 minimum (32-bit color) with hardware acceleration and dedicated video memory.
- Windows 7/8/10/11 Professional editions.
- USB Driver file, which is provided with Lathe9 or Lathe10 software.

System Features

- **Complete Lathe Spindle Alignment System**
  The spindle alignment system includes the laser, target, computer interface and software, and a storage case.
- **Step-by-Step Checklist**
  The Lathe10 software uses an easy-to-follow, 6-step checklist, with illustrations and step-by-step instructions prompting the user for information to complete each stage of lathe alignment.
- **User-Definable Tolerances**
  Alignment tolerances can be as tight or relaxed as the user requires for accuracy or speed. Accuracy assures precision and longer tool life; speed allows less downtime for repairs.
- **Real-Time Alignment Display and Shim Calculator**
  The real-time display moves, showing changes in alignment as they are made. Shim calculations are also available when the alignment is out of tolerance and the components need to be re-aligned.
- **Comprehensive Reporting Function**
  Generate and save reports that include collected data and graphical views of the alignment. Reports can be modified and printed to a printer or to a .pdf file for emailing.

Lathe10 Hardware Overview
The L-703S Spindle Laser System

This section describes the equipment and procedures for aligning lathes and turning centers using Hamar Laser's L-703S Spindle Laser System. The system includes targets, fixtures, readouts and software.

Figure 1 - L-703S Spindle Laser

L-703S Laser - Features and Setup

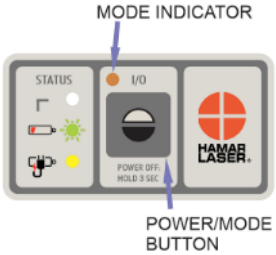
- Operating range of 50 ft. (15 m).
- Pitch and yaw angular adjustments.
- A .4995 in. (12.69 mm) mounting stud with the laser beam concentric to < .0005 in. (0.013 mm).
- Under good environmental conditions, it is accurate to .0015 in. (0.075 mm) in 50 ft. (15 m).
- By carefully following the NORMIN procedure described below, accuracies of .0002 in. (0.005 mm) in 10 feet (3 m) can also be achieved.
- Rechargeable Li-ion battery with 11 hours of battery life.

The L-703S is mounted directly in the spindle's chuck or a collet, and, using Lathe10's Step 2 Laser Setup, is aligned to the rotation axis of the spindle. This provides a straight reference line for checking the spindle's rotation axis parallelism to the machine bed or to a sub-spindle or tailstock.

Applications include:
- Lathes
- OD/ID grinders
- Rotary-dial machines
- Transfer-line spindles
- Turning centers

Laser Control Panel and Functions

The I/O and Status LEDs
- *Battery Status LED* – green – normally it is off.
  - Blinks when the battery is low.
  - Solid green when the battery is charging. Turns off when the battery is fully charged.
- *I/O LED* – indicates the laser is turned on. This is also the mode indicator for the laser mode (see Laser Modes below).



The On/Off Button
Press the **I/O** button once to turn it on and press and *hold* for 3 seconds to turn it off. The I/O LED will illuminate when the power turns on.

Laser Modes

There are 2 laser modes:

1. **Double-Blink Mode** (default) – this is used for the T-1295/T-1296 Targets only. The I/O LED will blink twice and pause, blink twice and pause, and will do this continuously.
2. **Fixed (Continuous) Beam mode** – the laser beam is turned on continuously and does not blink. This is used for legacy targets using the R-358 Computer Interface or R-307/R-307V Readouts. The I/O LED will be continuously on (no blinking).

To change the mode, press the **I/O** power button once – do <u>not</u> press and hold, just press one time.

The chart below indicates the operational modes for Readouts/Computer Interfaces that operate with the bore and spindle lasers.

Mode	Lasers	Targets	Readouts	Computer Interfaces
Blink (Pulse) supported by:	L-702SP, L-703, L-703B, L-705, L-706 and L-708	A-220, A-221, A-510, A-512, T-212, T-218, T-219, T-271	R-1307B-2.4ZB, R-1307BC, R-1307C, R-1307-900/2.4, R-1307-2.4ZB, R-1307+R	A-910-900/2.4 (when used with R-1307-900 or R-1307-2.4) A-910-2.4ZB
Double-Blink supported by:	L-702SP, L-703 and L-703S	T-1295, T-1296	R-1357-2.4ZB	Bluetooth + MultiTurn10 or Read16 Software
CONTinuous supported by:	L-700, L-702SP, L-703 L-703S, L-703B, L-705, L-706 and L-708	A-220, A-221, A-510, A-512, T-212, T-218, T-219 T-261, T-271	R-1307, R-1307B (R-307, R-307V – discontinued)	R-358 (R-355 – discontinued)

Notes:

1. *The T-261A+R-358 does not support the Single or Dual Pulsed-Beam Mode and the system purchased is factory-configured to operate in CONTinuous mode when using these targets.*
2. *When using the L-700 Laser with the R-1307 and a 2-Axis Target, the system is factory-configured to operate in CONTinuous mode.*

A/C Connector

The L-703S comes with a rechargeable battery. The connector is shown in Figure 2. To connect it, line up the red dot on the A/C adapter plug with the red line on the connector.

Figure 2 - The L-703S - Laser A/C Adapter Connector

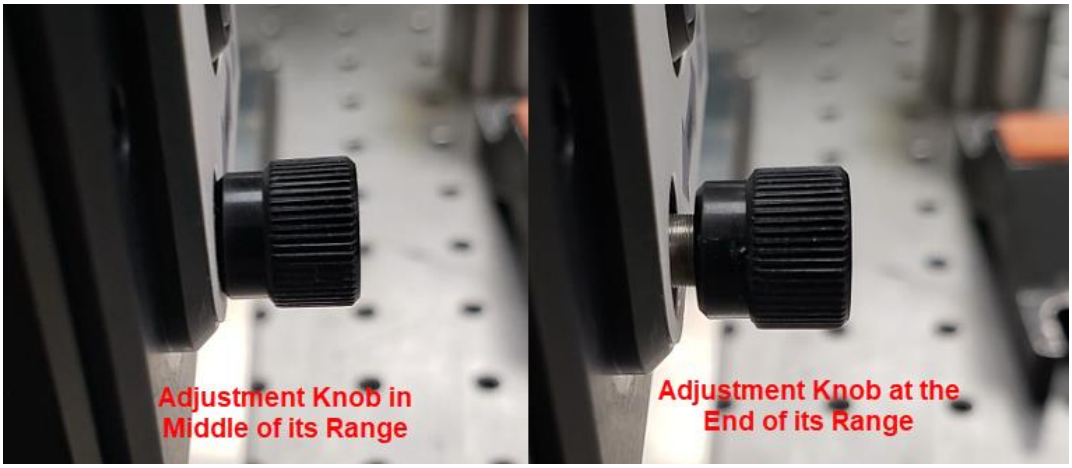
L-703S Angular Adjustments

The L-703S comes with pitch (vertical) and yaw (horizontal) angular adjustments to adjust (tilt) the laser to align it to reference points or a rotation axis. The angular adjustments have a resolution of .00001 in/ft (0.000833 mm/m) and an adjustment range of ±0.36° (±.075 in/ft or ±6.26 mm/m)

Figure 3 - L-703S Laser showing Pitch & Yaw Adjustments

L-703S Angular Adjustments – Returning Adjustments to the Center of their Range

To start an alignment, it is best to return the L-703S's angular adjustments to the middle of their range. The middle of the range is when the knob is flush with the overlay (see below). If the knob is unscrewed all the way, then the knob will come out but this will not harm the mechanism, so just screw it back in. If the knob is screwed in, then it will also go into the face plate about .25 in. (10 mm).



L-703S Level Vials

When using the L-703S, we typically will do measurements with the laser at the NORMal position (12:00) and then rotate the spindle 180 degrees to the INverted position (6:00). There are level vials on the *side* of the laser to help you know if the laser is directly at 12:00 or 6:00.

To use the level, rotate the laser 90 degrees so that the control panel is on the side (i.e. at 3:00 or 9:00). Then, slowly rotate the spindle until the bubble is centered in the circle. This indicates the laser is ready to be aligned to the rotation axis.

Lathe10 Hardware Overview
The T-1295/T-1296 5-Axis Wireless Spindle & Scan Targets

Hamar Laser's T-1295/T-1296 5-Axis Targets are designed to work with our L-703S Lathe & Spindle Laser and L-702SP Spindle/Machine Tool Laser. With Bluetooth communication and multiple measuring axes, the T-1295/T-1296 targets are multi-purpose targets that can be used for many different applications.

Figure 4 - T-1295/T-1296 5-Axis Wireless Spindle & Scan Target

- Offers 3 measurement modes:
  - *Center Mode* - 2-axis center measurement for use with the L-702SP's through-beam.
  - *Angular Mode* - 2-axis angular measurement for use with the L-702SP's through-beam.
  - *Flatness (Scan) Mode* - single-axis flatness measurement for use with the L-702SP's auto-rotating laser plane in Scan Mode.
- PSD (Position Sensing Detector) Size:
  - T-1295: 1.3 x .51 in. (33x13 mm) PSD
  - T-1296: .39 x .39 in. (10x10 mm) PSD
- Resolution:
  - *Center* (2 axis & 1 axis):
    - T-1295: .00002 in. (0.0005 mm)
    - T-1296: .00001 in. (0.00025 mm)
  - *Angular* (2 axis) – Standard 3 in. Lens:
    - T-1295: .00008 in/ft. (0.007 mm/m)
    - T-1296: .00004 in/ft. (0.0035 mm/m)
  - *Angular* (2 axis) – High-Res 6 in. Lens:
    - T-1295: .00004 in/ft. (0.0035 mm/m)
    - T-1296: .00002 in/ft. (0.0018 mm/m)
- Wireless communication via Bluetooth Class 1 radio with 100 ft. (30 m) of communication range.
- Accuracy is < 0.25% of the measurement for center and <0.5% for angle.
- PSD concentric to the mounting stud to < .0005 in. (0.012 mm).
- The T-1295/T-1296 are designed so the measuring plane of the target is at the face plate of the mounting stud, giving better accuracy on spindle alignments.
- Accelerometer rotation axis (6th axis) helps to orient the PSD sensor axes to the alignment axes of the spindle.
- Lithium polymer rechargeable battery with 14 hours of battery life.

How to use the T-1295/T-1296 Targets

The T-1295/T-1296 Targets are designed for use with the L-702SP in Double-Blink Mode (center/angular measurements) or Scanning Beam Mode (flatness measurements using the L-702SP's rotating scan plane). The targets have a .4995 in. (12.69 mm) mounting stud for mounting spindles and fixtures. The center of the target PSD sensor is aligned to the mounting stud to <.0005 in. (0.012 mm).

Center Mode

This is the default mode when the target is turned on. It is recommended to use the light/dust shield while using the target in center mode, which is held in place with magnets. While in this mode, the values shown in the MultiTurn10 Software displays show the center (offset) values of the target relative to the laser beam. It follows the same sign convention as shown **Page 41**, *Interpreting the + and – Signs in the Live Displays.*

Figure 5 - Figure 5- T-1295/T-1296 Target with light shield installed

Angular Mode

To use the T-1295/T-1296 Targets in Angular Mode, insert the T-1295-AO-3 Lens or the A-1295-AO-6 Lens, making sure to line up the red or yellow dots at 12:00 when you insert it (see **Figure 6**). Then click on the **Angle** button in Step 2 or 5 (see below) and the values will switch to the angular display. Using the lens, converts the display readings in MultiTurn10 to angular values with the following raw-value resolution:

Figure 6 - T-1295/T-1296 Target with T-1295-AO-3 Lens installed correctly

T-1295-AO-3: in/3 in. (mm/76.2 mm), which is converted in the software displays to: in/ft or mm/m when you click on the Angle Button (see figure below).
T-1295-AO-6*:* in/ 6 in. (mm/152.4 mm), which is converted in the software displays to: in/ft (mm/m) when you click on the Angle Button.

Note that if the displays are left in Center Mode, then the values shown in the displays are *raw* values and will be in the units shown above.

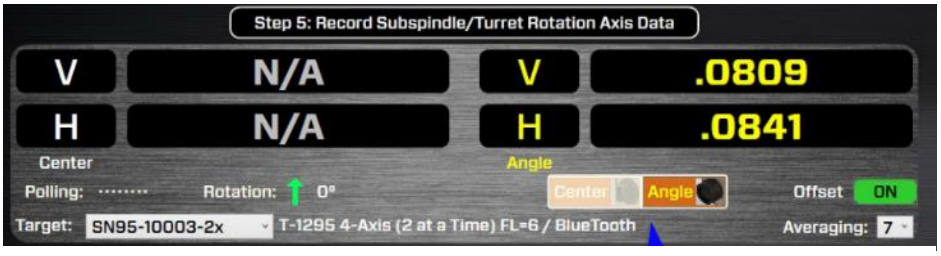


Figure 7 - MultiTurn10 Step 5 – showing Angle Mode turned on

Scanning Laser Mode

The T-1295/T-1296 Targets can be converted to scanning targets to be used with the L-702SP laser in **Scanning Mode**, which creates a laser plane. To change, the T-1295/1296 target into Scanning Mode, make sure the L-702SP is *turned off* or the laser beam is blocked. Then press and hold the Power Button. The **ON-TGT** LED will blink instead of being continuously on, as it is when it's in **2-Axis Center Mode**. See page 4 on how to put the L-702SP into Scan Mode. To return the T-1295/1296 to ***2-Axis Center Mode,*** power down the target and turn it back on.

Figure 8 - T-1295/1296 Control Panel

***Note**: You must also put MultiTurn10 into Scan Mode using the dropdown list in Step 3.*

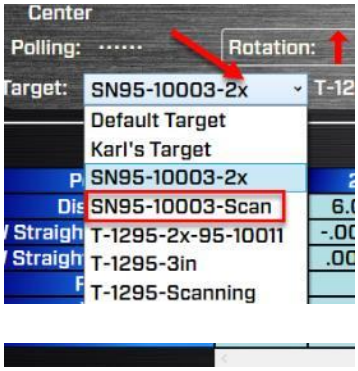


Figure 9 - Target Scan Mode Selection Step 3

T-1295/T-1296 ON-TGT LED

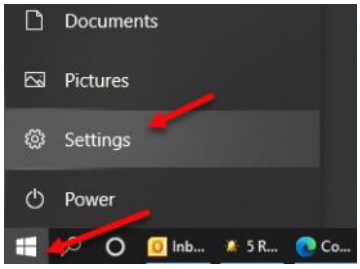
The **ON-TGT** LED has several colors and actions to indicate certain functions:

Continuous Green – means the target is detecting the laser beam properly.
Continuous Red – means the target is not detecting the laser beam.
Blinking Green – means the target is detecting the laser scan plane (Scan Mode) properly.
Blinking Red – means the target is not detecting the laser scan plane (Scan Mode).

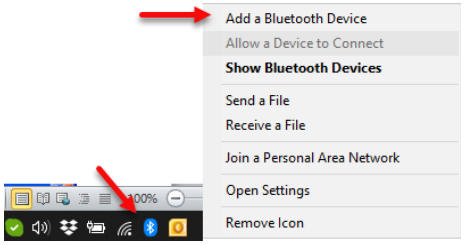
How to Pair the T-1295/T-1296 Target's Bluetooth to a PC

For your computer to see the Bluetooth device, you need to turn it on.

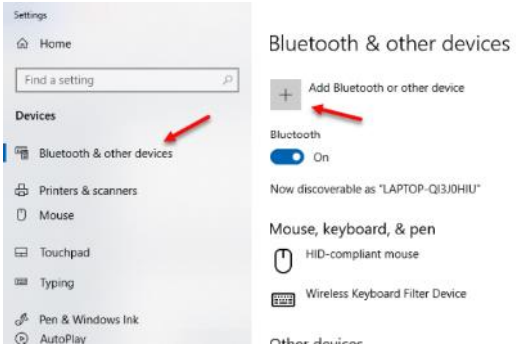
1. Tap on **Start** (the Microsoft Logo) > **Settings**.
2. Navigate to **Devices** and go to **Bluetooth**



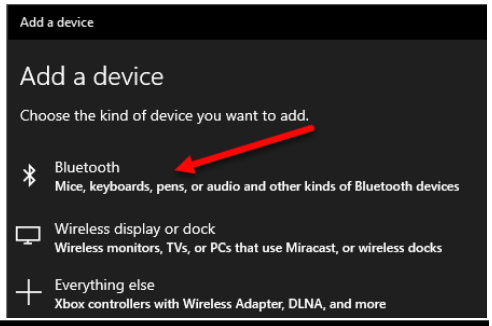
Or click on the **Bluetooth** icon in the system tray and click on Add a **Bluetooth Device**.

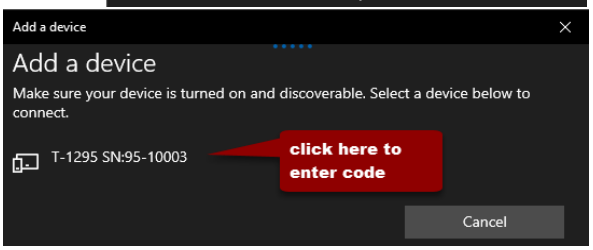


3. Make sure the Bluetooth toggle is in the **On** position. (You'll know it is working because you'll notice the message that reads "Your PC is searching for and can be discovered by Bluetooth devices.")
4. Click on **Add Bluetooth or other device**

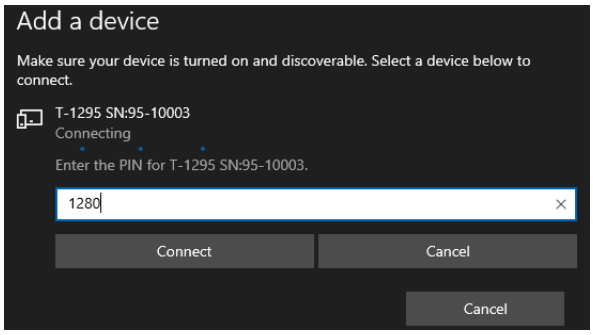


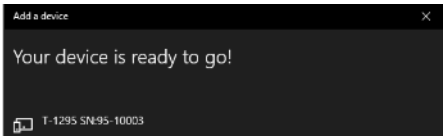
5. Select the device type you want to connect (usually you will select **Bluetooth**). You will see the devices listed under **Add a Device.**





6. Enter **1280** for the passcode, if prompted, and hit **Connect**. Your Target is now paired and ready to be used. Exit Settings window





Lathe10 Hardware Overview
L-702SP Spindle & Scan Laser

The Model L-702SP Lasers have a low-power, Class II visible-light laser designed to mount in the spindle of a machine tool to project its axis of rotation during alignment. Vertical and horizontal angular controls allow the user to fine-adjust the laser angle to the spindle's precise axis of rotation. The L-702SP is designed for applications where the distance between target and laser is approximately 100 ft. (30 m).

In addition to the spindle laser, the L-702SP features an automatically rotating turret that sweeps a laser scan plane perpendicular to the laser beam for checking cross-slide/turret axis squareness and multi-turn milling axes.

Built-in levels on the sides provide easy indexing when inverting for error correction readings. A .4995 in. (12.7 mm) mounting stud simplifies fixturing and can be removed to adapt the unit to custom fixtures or other alignment applications.

The L-702SP features a built-in, rechargeable, lithium-ion battery that provides operation for up to 8 hours of battery life.

The L-702SP works with any Hamar Laser target, readout, or interface and can be used for many types of alignment jobs, including spindle and bore alignment, and measuring and correcting the alignment of a workpiece on the machine.

Applications include:
- Horizontal Boring Mill Indexing Checks for Deep-Bore Applications
- Lathe/Turning applications (cylindrical, OD/ID grinders, lathes)
- Horizontal and Vertical Machining Centers
- Multi-Turn Machining Centers

Figure 10 -- L-702SP Spindle Laser and Scan Plane

Warning - Do not stare into the beam.

Laser Control Panel and Functions

The Status LEDs

- Status LED – red – indicates the laser is powered on.
- Low Battery LED – red - blinks if the battery is low and needs charging.
- Charging LED – yellow – lights when the rechargeable battery is charging (see Figure 3).

The On/Off Button

Press the **I/O** button once to turn it on and press and *hold* to turn it off. The I/O LED will illuminate when the power turns on.

Laser Modes – Beam Laser

There are 3 laser modes (see **Figure 11**):

3. **Beam mode** – the laser beam is continuous. This is used for Scan Mode and for legacy targets using the R-358 Computer Interface and Scan Mode. The STATUS LED will be continuously on (no blinking).
4. **Blink Mode** – this is used for 2-axis cabled targets using the R-1307 Readouts in Pulsed Mode. The STATUS LED will blink continuously.
5. **Double-Blink Mode** – this is used for the T-1295/T-1296 Targets. The STATUS LED will blink twice and pause (continuously).

Figure 11 - L-702SP Control Panel

To change the mode, press the **I/O** power button once. You can keep pressing the button to toggle to the next mode.

Switching L-702SP Turret to Scan Mode

To create the L-702SP perpendicular laser scan plane, a flip mechanism is used to move a pentaprism into the laser beam that bends the beam 90 degrees. This creates a perpendicular laser beam that emits from the side of the spindle, which is then rotated to create the scanning laser plane.

To switch the L-702SP to *Scan Mode* (laser plane), you must first put the laser into *Beam (continuous) Mode*. Then the pentaprism optic in the turret needs to be rotated into place to create the scan plane by turning the set screw (see **Figure 12** - L-702SP Flip Mechanism for Scan Mode). Then press the **SCAN** button to turn on the turret laser rotation and create a scan plane. Press the **SCAN** button again to turn it off.

The pentaprism flip mechanism is controlled by a "flip" screw in the top of the spindle (see **Figure 12**). Use a standard screwdriver to lightly turn the screw until you feel a "click", which is created by a small magnet that holds the prism in place. You can confirm that the mechanism is properly in place by noting if the laser beam emits from the hole in the side of the turret.

Warning – do not over-turn or attempt to tighten the "flip" screw. This could damage the mechanism.

Figure 12 - L-702SP Flip Mechanism for Scan Mode

A/C Connector

The L-702SP comes with a rechargeable battery. The connector is shown here.

L-702 A/C Adapter Connector

Pitch/Roll Adjustment Knob
The adjustment knobs use *differential* micrometers, allowing both coarse and fine functions (see **Figure 13)**.

- *Coarse* Adjustment – loosen the set screw to enable the coarse adjustment.
- *Fine* Adjustment – tighten the set screw to disable the coarse adjustment and enable the fine adjustment (it rotates within the coarse adjustment), which is 12 times finer adjustment resolution.

Figure 13 - L-702SP Pitch and Roll Adjustments & Differential Micrometer

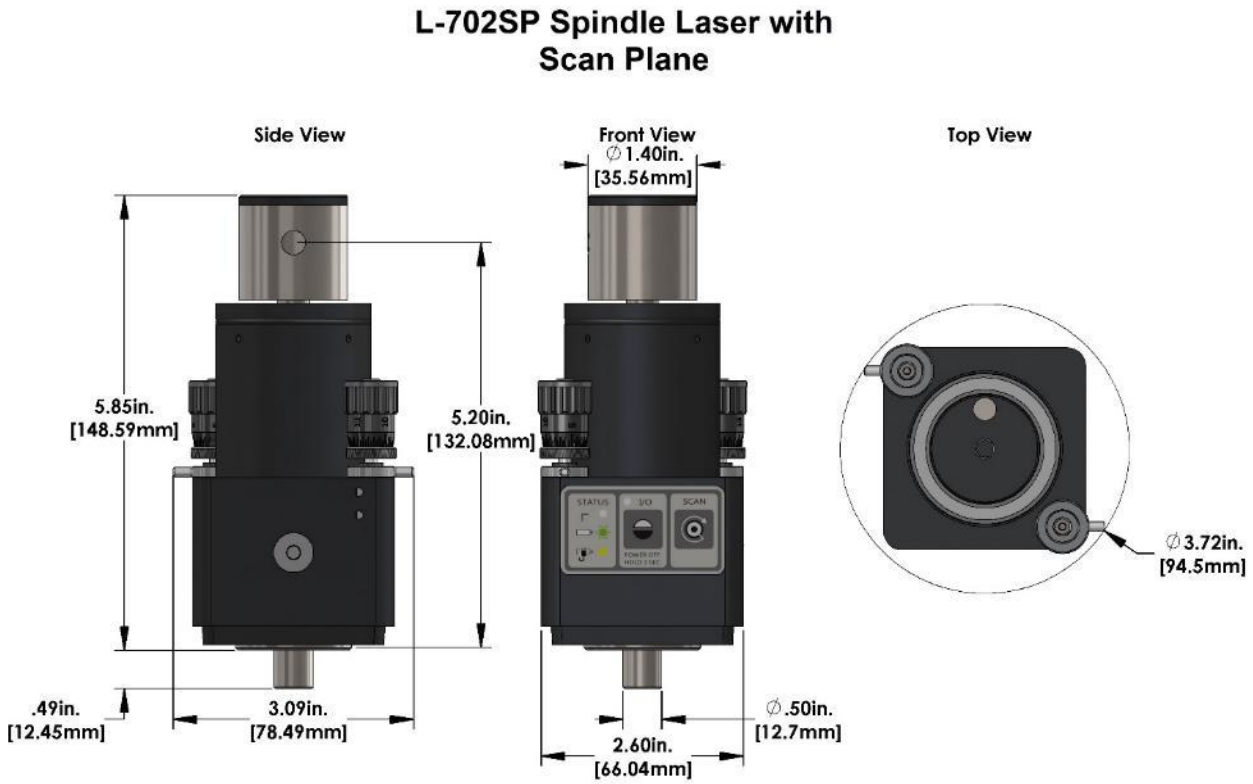
Re-Centering the L-702SP Laser's Angular Adjustments

All Hamar Laser's L-702SP Lasers are factory-qualified (pre-aligned) to the mounting stud. To obtain accurate spindle alignment results, it is important to adjust the laser beam so that it is aligned (bucked-in) to the spindle axis of rotation (AOR) to remove any mounting errors, which are always present. After the alignment, it is always a good idea to put the angular adjustments back in the center of their adjustment range.

To return the angular adjustments to the middle of their adjustment range, adjust the *Pitch* and *Roll* coarse adjustment axes so that the bottom of the L-702SP base cover is aligned to the white line on the mounting base (see **Figure 14**).

Figure 14 - Returning the L-702SP Pitch/Roll Adjustments to the middle of their range

L-702SP Laser Dimensions



Lathe10 Hardware Overview
L-702SP Mounting Accessories

A series of mounting fixtures for the L-702SP Laser and T-1295 5-Axis Universal Geometry Measuring Target to aid in measuring hard-to-measure axes on enclosed machining centers, boring mills and multiturn machines.

L-702MB Laser Mounting Mag Base
Used to mount the L-702SP on flat surfaces for (see **Figure 15**):

- Flatness measurements of surfaces.
- Flatness, straightness & squareness measurements of machine tool axes.

To hold the laser in place, use the thumb screw to tighten the mounting stud. Make sure to tighten it very tight to ensure a rigid mount and avoid laser drift issues.

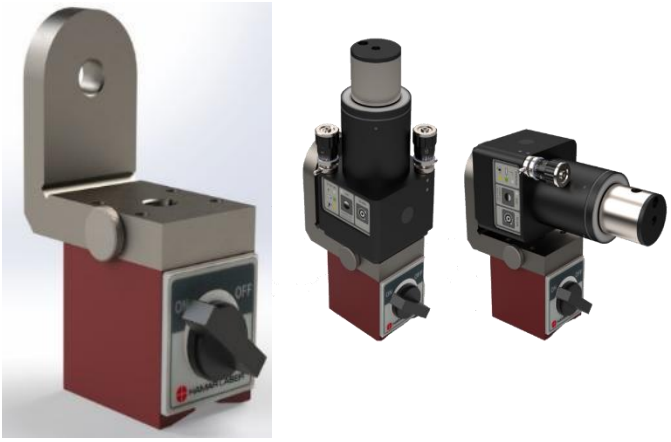


Figure 15 - L-702MB laser mounting mag base

L-702RA – Right Angle Spindle Mounting Fixture
Used to mount the L-702SP Laser and T-1295 Target at right angles to the spindle axis for use on (see **Figure 16**)

- Boring mills.
- Horizontal and Vertical Machining Centers to measure other axes with the L-702SP mounted in the spindle.
- Multi-turn machines to measure X & Y axes

To hold the laser in place, use the thumb screw to tighten the mounting stud. Make sure to tighten it very tight to ensure a rigid mount and avoid laser drift issues.

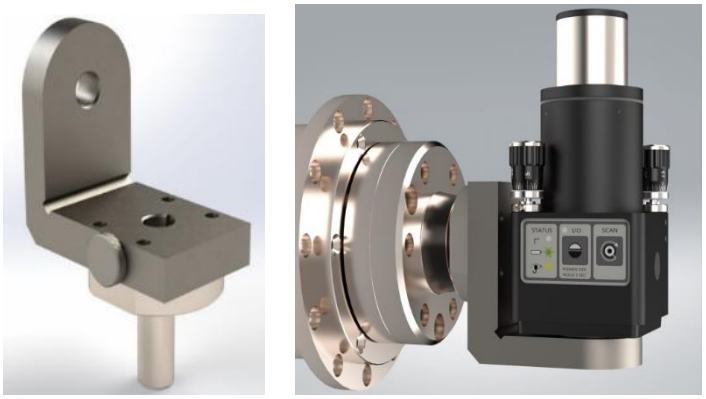


Figure 16 - L-702RA right angle spindle mounting fixture

T-242 Target Straightness Measuring Base
Used to hold the T-1295 5-Axis Target to measure the vertical and horizontal straightness of machine tool axes and surfaces. Comes with X-Y micrometers to center the target to the laser beam in X (H) & Y (V) and a mag base and set of posts (see **Figure 17**).

T-243 Target Flatness Measuring Base
Used to hold the T-1295 5-Axis Target to measure the flatness of machine tool axes and surfaces. The target rotates 360° on a very flat surface built into the T-243 fixture to ensure the target can always be pointed at the laser. The flatness of target rotation is ± .0001 in. (0.0025 mm) (see **Figure 18)**.

Figure 18 - T-243 Target Flatness Measuring Base

Figure 17 - T-242 Target Straightness Measuring Base

Preparing for an Alignment

There are several preparations that need to be made before beginning a measurement or alignment process. Ensure that accurate records are kept for all procedures.

Lathe9 and MultiTurn10 are designed to measure and align the spindle axis of rotation (AOR) to the tailstock, saddle or turret guideways. It is also used to check the 4-axis alignment of the tailstock or sub-spindle to the headstock AOR. The software fully compensates for mounting errors of both the laser and target with highly accurate results.

In lathe alignment, the L-702SP is mounted in the headstock spindle and aligned to the AOR. The T-261 Target is then mounted in the tailstock chuck or in a fixture on the saddle, and then the straightness and flatness of the guideways is measured relative to the L-702SP laser. The least-squares, best-fit algorithm is used to calculate the slope of the "best-fit" line for the straightness data. This slope is a measure of the headstock alignment (parallelism) to the lathe guideways.

If the headstock rotation axis (AOR) is parallel (aligned) to the guideways, only then can the tailstock center or a sub-spindle AOR be checked for alignment to the headstock AOR. The T-1295, T-1296, and T-261 offer a real-time, 4-axis display of the tailstock, sub-spindle or turret centers or AOR relative to the laser beam (headstock AOR).

The same process is followed in MultiTurn10, but with the addition of the X, Y and Z axes of the machine head. MT10 also allows for measurements of these axes and also calculates the squareness or parallelism between them.

Hardware Mounting

The L-702SP Laser, T-1295/T-1296 and T-261 Targets all have a standardized .4995 in. (12.69 mm) mounting stud (see **Figure 19**) that simplifies fixturing and can be removed to adapt the unit to custom fixtures or other alignment applications. A .500 in. (12.7 mm) reamed hole that is square to a face is all that is required to mount the laser/target mounting stud. The mounting stud also has a ¼-20 threaded hole in the end of it.

Typically, the laser is mounted in the headstock chuck or collet. For large lathes, this may involve creating a fixture to hold the laser in place. The T-1295/T-1296 or T-261 is mounted in the tailstock chuck, sub-spindle chuck or the turret center.

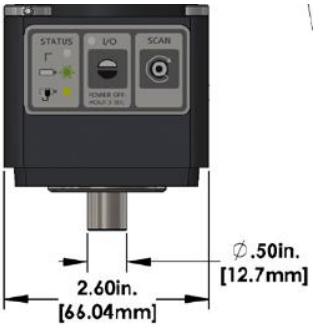


Figure 19 - L-702SP Mounting Stud

Maintenance and Cleaning

The spindle to be aligned should be checked thoroughly to ensure that it is clean and working properly. The windows on the T-1295/T-1296 and T-261 should be clean and free from dirt, thumbprints and other smudges. The same applies to the L-702SP pentaprism.

Tools and Equipment

Determine all the necessary tools and equipment (other than what Hamar Laser supplies) that will be needed for performing an alignment, such as torque wrenches, shims, and equipment manuals.

Other Considerations

- Measure the travel distance of the tailstock, sub-spindle or turret. This information is necessary for the software setup. Use only the distance that the unit realistically travels during use, not the full distance of which it is capable.
- Keep records of all procedures. Log all data file names and keep record copies of all reports and printed data.

Target Calibration

The T-1295/T-1296 and T-261 Targets must also be calibrated. When purchased as part of a system, target calibration factors are provided, usually on a USB thumb drive located in the shipping case. If the target is purchased separately, it should be calibrated before use. This can be done at the factory or on site using the A-807 Calibration Fixture and Read8, available for purchase from Hamar Laser. The procedure is included in Appendix C, *Target Calibration*, beginning on **Page 83**.

Hamar targets are designed to give accurate readings, despite small mounting errors, with no field adjustment. Attempts by the user to re-adjust the target to fix centering or angular errors are strongly discouraged, as this can lead to damage or inaccurate alignment and will void the warranty.

Warning!!
Attempts by the user to adjust the internal mechanism of the laser and/or target can cause damage and void the warranty.

Lathe10 Hardware Overview
The L-700 Spindle Laser System

The Model L-700 Laser is a low-power, Class II visible light laser designed to mount in the spindle of a machine tool to project its axis of rotation (AOR) during alignment. There are 4 axes of adjustment on the front of the laser that allow the user to fine-adjust the laser *angle* and *center* to the spindle's precise axis of rotation. A shutter on the front closes off the beam for safety.

The L-700 is designed for applications where the distance between target and laser is approximately 50 ft. (15 m).

Built-in levels on the top and bottom provide easy indexing when inverting for error correction readings. Other features include a shutter to protect the optics and an LED to indicate when the beam is on. Power is provided to the laser by a standard 9V battery for up to eight hours of operation. A .500 in. (12.7 mm) mounting stud simplifies fixturing and can be removed to adapt the unit to custom fixtures or other alignment applications.

Figure 20 - L-700 Spindle Laser

The L-700 works with any Hamar Laser target, readout, or interface. They can be used for many types of alignment jobs, including spindle and bore alignment, and measuring and correcting the alignment of a workpiece on the machine.

Applications include:

- Transfer-line spindles
- Rotary-dial machines
- Turning applications (cylindrical, OD/ID grinders, lathes)

Laser Controls

The On/Off Switch

The laser has a small ON/OFF switch, located on the bottom of the laser housing behind the lower bubble level (**see** Figure 21). When the laser beam is turned on, the red LED on the faceplate lights up to safely indicate that the unit is powered on.

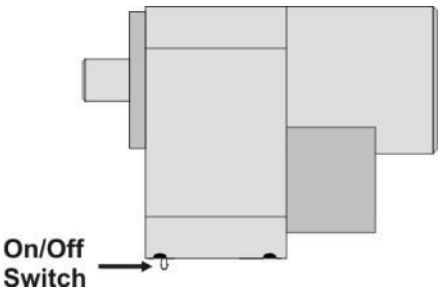


Figure 21 - On/Off Switch

The Shutter Control

The shutter control closes off the laser beam to protect the user from accidental eye contact with the beam. It also protects the laser's lens from dust or damage. The shutter control is a simple slotted screw head on the lower left side of the faceplate (**see Figure 22**). Use a straight-edge screwdriver to open or close the shutter.

Centering and Angular Adjustments

The laser also has centering and angular adjustments on the faceplate. The beam is emitted from the large hole in the center.
shows the location of the various adjustment screws.

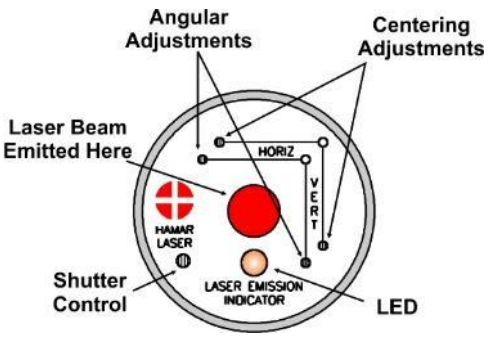


Figure 22 - Shutter Control and Adjustments

Replacing the Battery

The L-700 Lasers use a standard, replaceable 9-volt battery for up to 8 hours of continuous use. For best results, use alkaline or rechargeable nickel-cadmium (NiCad) batteries.

To install or replace the battery:

1. **Remove the battery cover.**
   Using the 3/32 in. hex key included with the laser, loosen the two hex screws on either side of the bubble level. The screws do not need to be removed.
2. **Slide the cover out.**
   Pull the cover straight out of the laser to access the battery.
3. **Replace the battery.**
   Remove the battery (rock it gently from side to side to disconnect it) and replace it with a new 9-volt battery. Make sure the battery is seated in the clips. If the battery won't snap in, check to see if the clips are bent or distorted.
4. **Slide the cover on and tighten the screws.**

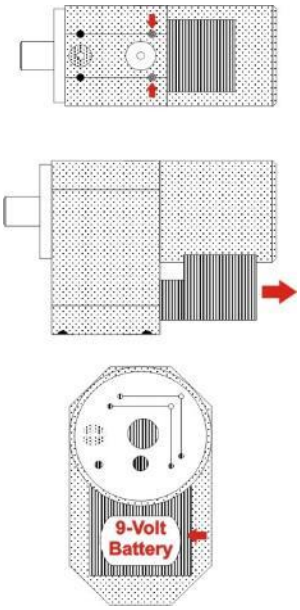


Figure 23 - Replacing the L-700 Laser battery

The T-261A 4-Axis Target

The T-261 4-Axis Target reads both center and angle (pitch and yaw) simultaneously, allowing a real-time display of the alignment data. The resolution is .00001 in/ft (0.00083 mm/m) in angle and .00001 in. (0.00025 mm) for center when used with the R-358 Computer Interface. Two bubble levels on the top and bottom make it easy to position when inverting for NORMIN readings (see Appendix A – *The NORMIN Procedure*, beginning on Page 77).

When the target is purchased as part of a system, it is calibrated at the factory before shipping. If the target is purchased separately, Hamar provides calibration factors that must be entered into Lathe10. A calibration fixture and software are also available from Hamar Laser and can be used for in-house calibration. The procedure is outlined in Appendix C–*Target Calibration*, beginning on **Page 83**.

Figure 24 - T-261A Four-Axis Target

The R-358 Computerized Interface

The R-358 computer interface provides high accuracy (.00001 in. or 0.00025 mm resolution) for downloading live target data into a computer. It attaches to the computer with a USB cable, is powered by a lithium ion battery for long life and usage. The R-358 automatically turns on when the target starts taking measurements. An AC adapter/charger is provided, and the unit features Charging and Power LED indicators.

Hamar Laser's Alignment Software

Hamar Laser provides alignment software as standalone programs. The latest software is Lathe10. Older programs include Lathe9, Spindle8 and Read8.

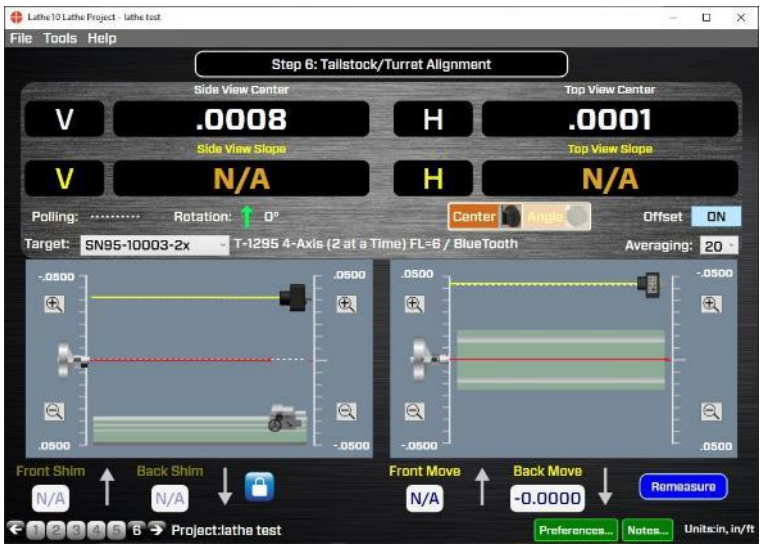


Figure 25 - Lathe10, Step 6 – Tailstock/Turret Alignment

Preparing for an Alignment

There are several preparations that need to be made before beginning a measurement or alignment process. Ensure that accurate records are kept for all procedures.

Hardware Configuration

Lathe10 is designed to measure and align the headstock spindle axis (AOR) to the tailstock, saddle or turret guideways. It is also used to check the 4-axis alignment of the tailstock or subspindle to the headstock AOR. The software fully compensates for mounting errors of both the laser and target with extremely accurate results.

The L-703S has 2-axis adjustment to align the laser beam to the spindle's AOR in:

- Vertical *Angle*
- Horizontal *Angle*

In lathe alignment, it is best to check the tailstock or saddle guideways' alignment to the headstock spindle axis. To do this, the L-700/L-703S is mounted in the headstock spindle and aligned to the axis of rotation (AOR). The T-1295/T-1296 Target or T-261 Target is then mounted in the tailstock chuck or in a fixture on the saddle, and then the straightness and flatness of the guideways are measured relative to the laser. The least-squares, best-fit algorithm is used to calculate the slope of the "best-fit" line for the straightness data. This slope is a measure of the headstock alignment (parallelism) to the lathe guideways.

If the headstock AOR is parallel (aligned) to the guideways, only then can the tailstock center or a subspindle AOR be checked for alignment to the headstock AOR. The T-1295, T-1296, and T-261 offer a real-time 4-axis display of the tailstock, subspindle or turret centers or AOR relative to the laser beam (headstock AOR).

Hardware Mounting

Mount the laser in the headstock chuck or collet. For large lathes, this may involve creating a fixture to hold the laser in place. Mount the T-261 in the tailstock chuck, subspindle chuck or the turret center.

Both the target and laser have a standardized .4995 in. (12.69 mm) mounting stud that simplifies fixturing and that can be removed to adapt the unit to custom fixtures or other alignment applications. A .500 in. reamed hole that is square to a face is all that is required to mount the laser/target mounting stud.

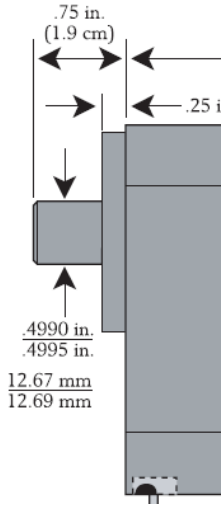


Figure 26 - Target & Laser Mounting Stud

Tools and Equipment

Determine all the necessary tools and equipment (other than what Hamar Laser supplies) that will be needed for performing an alignment, such as torque wrenches, shims, and equipment manuals.

Other Considerations

- Measure the travel distance of the tailstock, subspindle or turret. This information is necessary for the software setup. Use only the distance that the axis realistically travels during use, not the full distance, since this might negatively affect the alignment results.
- Keep records of all procedures. Log all data file names and keep record copies of all reports and printed data.

Qualifying and Calibrating Lasers and Targets

L-703S Laser

The laser needs to be set so it's in the center of its adjustment range. See *L-703S Angular Adjustments* **Page 5** for details.

L-700 Laser

The L-700 should be "qualified" or aligned to its mounting stud before use. This is done using the A-801 Laser Alignment Fixture and Lathe10 **Step 2: Qualify Laser.** This is fairly important since it maximizes the L-700 adjustment range for each of the four alignment axes (**see** *Appendix B – Qualifying the Laser,* beginning on **Page 78**).

The T-1295/T-1296 and T-261 Targets must also be calibrated. When purchased as part of a system, target calibration factors are provided. If the target is purchased separately, Hamar normally provides the calibration factors that need to be entered in Lathe10. Field or in-house calibration is possible using our A-807 Calibration Fixture and Read8, available for purchase from Hamar Laser. The procedure is included in *Appendix C -- Target Calibration*, beginning on **Page 83**.

Hamar targets are designed to give accurate readings, despite small mounting errors, with no field adjustment. Attempts by the user to re-adjust the target to fix centering or angular errors are strongly discouraged, as this can lead to damage or inaccurate alignment and will void the warranty.

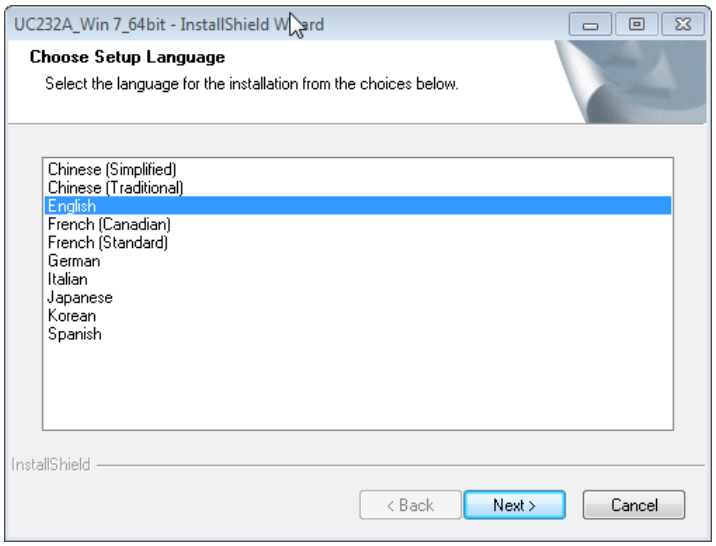
Warning!!
Attempts by the user to adjust the internal mechanism of the laser and/or target can cause damage and void the warranty.

Installing the (RS-232) USB to Serial Port Driver for R-358 Computer Interface

This driver is required for the R-358 Computer Interface to communicate with targets via the RS-RS-232/USB converter cable and the computer USB port. The driver creates a virtual COM Port that is recognized by the applications as a standard serial port.

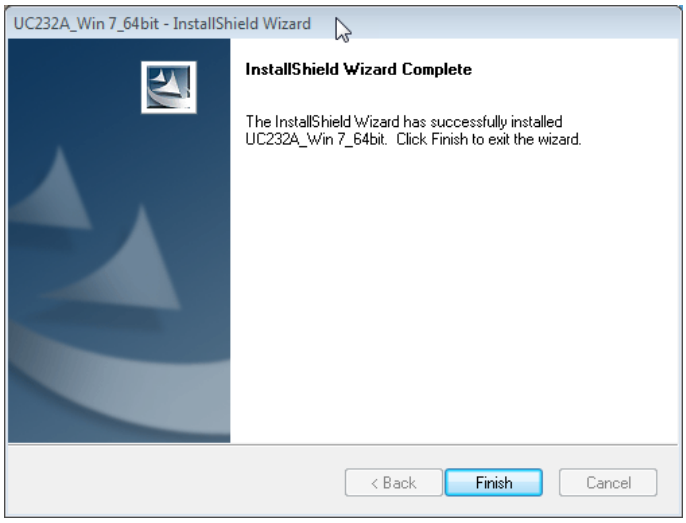
Note 1: *You must install this driver* ***prior*** *to connecting the device(s) to the computer through the USB port.*

Note 2*: This is not required for the T-1294/1295/1296 Targets.*



Installing the Driver

1. Insert the Flash drive in an available USB port.
2. Select **My Computer**, locate the **REMOVABLE DISK** icon and click to open it.
3. Select the USB Drivers folder.
4. Open the **GUC232A_Win8** folder and double-click **GUC232A_Windows_8_Setup.exe** to initiate the installation process. The **Install Driver** dialog box displays.
5. Select the language for the installation and click **Next** to continue.
6. Once the installation is complete, the **Installation Successful** message displays. Click **Finish** to exit.



Connecting to the R-358 Computer Interface

Hamar Laser's R-358 Computer Interface works with a portable computer to automatically upload the target data into the software to perform calculations, display live laser beam-to-target position information, and plot results. The R-358 attaches to the computer with a USB/RS-232 converter cable and is powered by a lithium-ion battery or an AC adapter. The resolution of the measurement is .00001 in. (0.00025 mm).

IMPORTANT NOTE – you must install the software driver for the USB cable <u>BEFORE</u> plugging in the USB cable into your computer. The driver is located on the same thumb drive as Lathe10 software. Please see Page 235 (above) for details on installing the driver.

Before using the R-358 Computer Interface, ensure that the battery is fully charged or that the AC charger/adapter is plugged in.

1. **Connect the T-261 target to the INPUT connector on the FRONT of the R-358 Interface.**
   The interface can support one 4-axis target. It can also support two 2-axis targets with the use of an optional splitter cable. Make sure to screw in the flat-head screws to securely hold the connector in place.

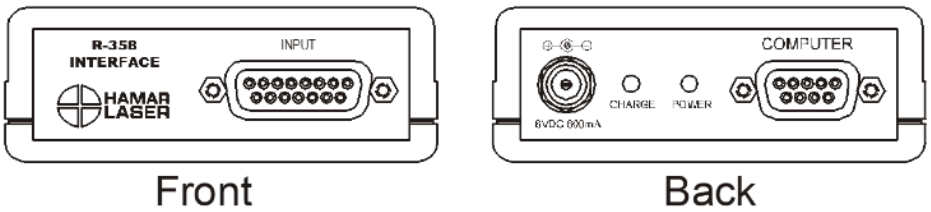


Figure 27 - R-358 Interface Connections

Note: *The R-358 is powered on by the software. When you click any of the Lathe10 steps that have live data displays, the R-358 automatically turns on and lights the green "Power" LED.*

2. **Connect the R-358 Interface to the computer.**
   Connect the RS-232 extension cable provided to the BACK of the R-358 (labeled COMPUTER) and screw in the plastic thumb screws. Then plug the USB/RS-232 Converter cable into the RS-232 extension cable and then into the computer USB port. The connector for the cable is located on the BACK of the unit.
3. **Power on the computer.**

Lathe10 Alignment Software System Requirements

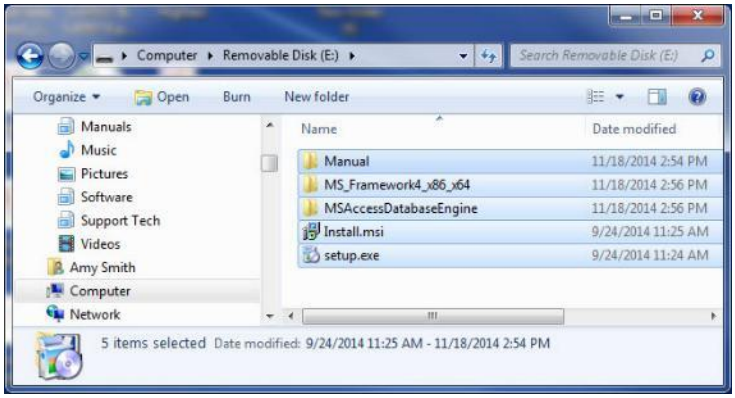
- Physical memory (RAM): 16 GB recommended
- Processor: Intel i5 or later version or AMD equivalent, 1.3 GHz minimum speed
- Available Hard Drive space: 10 GB minimum
- Video Resolution: 1366 x 768 minimum (32-bit color) with hardware acceleration and dedicated video memory.
- Windows 10/11 professional editions.

Before installing Lathe10, ensure that your computer has the latest Windows Service Pack and critical updates. To find security updates, visit **www.windowsupdates.com** .

In addition, software for reading .pdf files, such as Adobe Acrobat, is necessary to access the program documentation and read alignment files saved in this format.

Installing Lathe10

1. Insert the USB flash drive provided into the USB port on the laptop or tablet PC.
2. If your system is configured to do so, the AutoPlay window displays. Click **Open folder to view files**.
3. If the AutoPlay window does not display, click **Start>Run**. Click **Browse>My Computer** and select the USB flash drive.
   Note: *.NET 4.0 framework must be installed– see Page 25 if you are unsure if this has been installed.*
4. Click **setup.exe** to begin the Lathe10 installation.



Hamar Product Registration

In order to protect against software piracy, we have implemented a simple product registration procedure. After a Hamar product is installed and when the program is run for the first time, the user is prompted to enter the Product Registration Code (see **Figure 28**). To obtain the Product Registration Code, send the PC ID Code (automatically generated) displayed on the screen to Hamar Laser Support (Support@hamarlaser.com). A Hamar representative will issue a Product Registration Code via email to complete the registration process **(see Figure 29**).

Enter the Product Registration Code and click ***Register Product***. The product is now registered.

Figure 28 - Product Registration Screen

To begin using Lathe10, double-click the Lathe10 icon on your desktop or select the program from the Windows Start Menu. The initialization screen displays, providing the number of the current software version.

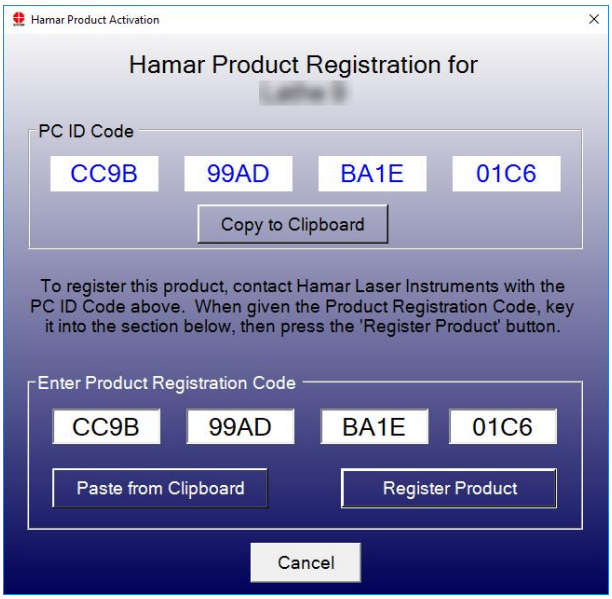


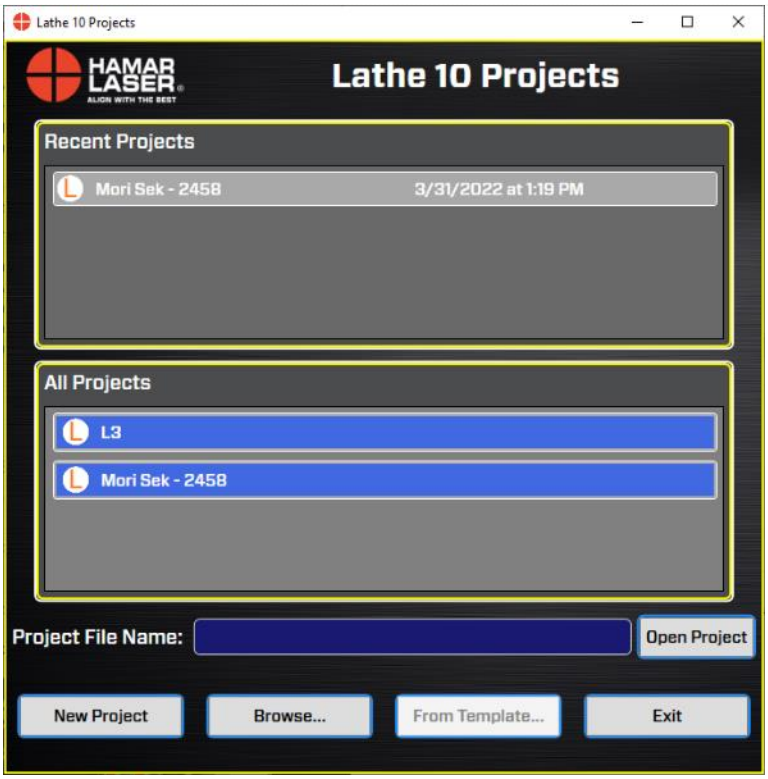
Figure 29 - Enter Product Registration Code

Creating a New Project File or Opening an Existing Project File

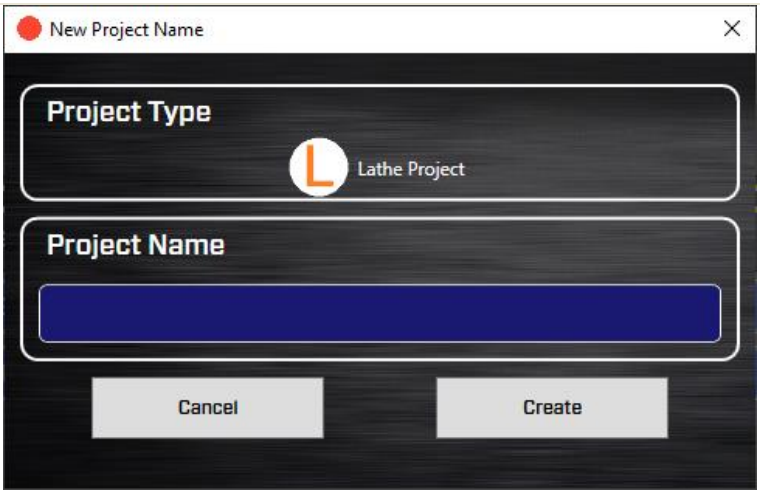
When Lathe10 opens, the **Project Selection** screen displays. Here you can:

- ***Open Project*** – select one of the recently saved projects and click ***Open Project*** to open the project. You can also double-click the filename to open it.
- ***New Project*** – click here to enter a filename and create a new project.
- ***Browse*** – Click here to open the Windows File Open dialog box and browse for a saved file, either from another folder or from a USB drive.
- ***Exit Lathe10*** – this closes Lathe10.

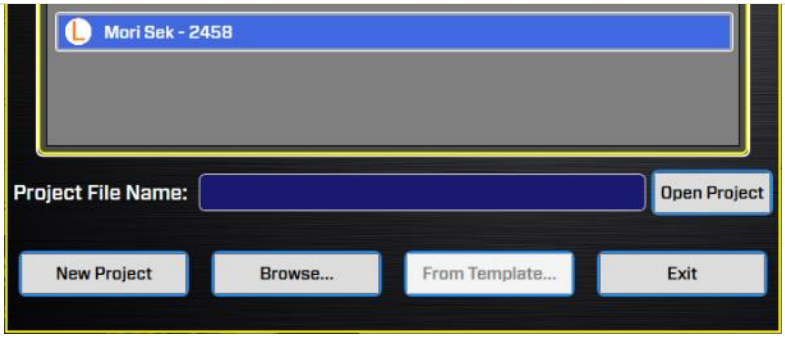
Note: *This screen can also be accessed by clicking* ***Open Project*** *from the* ***File*** *menu.*



To create a new project, click **New Project** and enter a project name.



To open a saved project file from another folder or USB drive, click **Browse** from the **Projects** pop-up, browse to the desired folder and double-click the project folder.

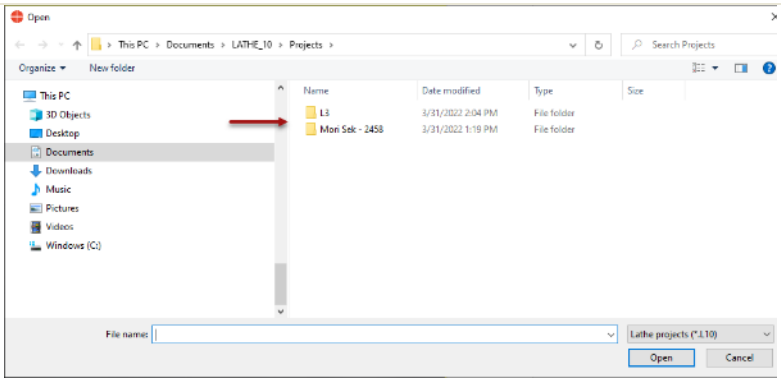


Saving Projects and Data

File Location

Files are saved in the *Documents/Lathe_10/projects* folder.

Each project is saved into a dedicated folder in the Projects folder that you specified in the New File dialog box.



File Structure

In each Lathe10 folder, there are several data files.

- The ***.*L10* file contains all the data taken during the session.
- The ***.L10.backup* are backup files recorded during each session you save data.

The data format for these files is XML. The file can be opened in Notepad and viewed there. All data is recorded in microns. Divide all values by 1000 to get millimeters.

Warning! Do not delete or modify the L10 files in these folders as Lathe10 will be unable to open the project.

Name	Date modified	Type	Size
Mori Sek - 2458.L10	3/31/2022 1:19 PM	L10 File	17 KB
Mori Sek - 2458.L10.backup1	3/30/2022 6:08 PM	BACKUP1 File	16 KB
Mori Sek - 2458.L10.backup2	3/29/2022 6:09 PM	BACKUP2 File	12 KB
Mori Sek - 2458.L10.backup3	3/29/2022 5:47 PM	BACKUP3 File	12 KB

Restoring File Backups

To restore older version backup:

1) Rename original file to something else, or delete it
2) Rename backup by removing the ".backupn" part. In the example, change *L3.L10.backup1* to *L3.L10*

Name	Date modified	Type	Size
L3.L10	9/19/2022 3:38 PM	L10 File	16 KB
L3.L10.backup1	4/8/2022 8:35 AM	BACKUP1 File	16 KB
L3.L10.backup2	4/5/2022 2:47 PM	BACKUP2 File	15 KB
L3.L10.backup3	4/5/2022 2:33 PM	BACKUP3 File	15 KB
L3.L10.backup4	3/31/2022 9:54 AM	BACKUP4 File	14 KB
L3.L10.backup5	3/23/2022 2:15 PM	BACKUP5 File	13 KB

Converting Raw Data Values in CSV files to Inches or Millimeters

- To get inches for dimensions and center values: inches = (micron value/1000) / 25.4
- To get in/ft for angular values: in/ft = mm/mm value *12.
- To get mm's for dimensions and center values: mm=micron value/1000
- To get mm/m for angular value: mm/m = mm/mm value*1000

Lathe10 Main Screen Summary

Figure 30 - Lathe10 - Step 1 Dimensions & Tolerances

Step 1: Set Up Lathe10- Enter the headstock and tailstock dimensions, choose the number of points to be recorded for the lathe and saddle guideway and enter the alignment tolerances. The dimensions are used to calculate shims when aligning the headstock, tailstock and/or turrets. The alignment tolerances are automatically applied to graphs.

Step 2: Qualify Laser Spindle Axis - Align the laser to the headstock spindle axis by following the NORMIN procedure. Display offsets are automatically calculated and applied, so the user adjusts to zero the angular or center adjustments to make them parallel and coincident with the spindle axis of rotation (AOR).

Step 3: Bed Straightness, Pitch/Yaw & Spindle-Axis Parallelism - After qualifying the laser, straightness data is recorded for tailstock bed ways, the turret (saddle) bed ways or both, using the number of points selected in **Step 1**. Lathe10 records up to 4 axes of data (V-center, H-center, V-angle (pitch), H-angle (yaw)) at each location along both sets of bed ways. This is especially helpful where the tailstock and turret (saddle) ride on separate machine ways. To take the data, the target is mounted in the tailstock or turret (saddle) and moved along the bed to each point. Press the spacebar to record the values. When finished, click **Results** to view the alignment data.

Step 3: Alignment Data Results - After taking data, click **Results** to view alignment results for:

- Tailstock guide-way straightness
- Saddle (turret) guide-way straightness
- Headstock spindle-axis parallelism to the tailstock guideways and/or turret guideways or the parallelism between both sets of bed ways.

Step 3: Headstock Spindle-Axis Live Move Screen - In this screen, the headstock parallelism can be aligned to the tailstock, turret (saddle) bed ways or an average of both. Shim values are calculated to align the headstock, and a real-time angular display shows whether the alignment is in or out of tolerance.

Step 4: Lathe-Bed Straightness Results and Graph -After recording data in **Step 3**, **Step 4** displays a summary of the alignment results and a graph of the straightness for the tailstock guideways, saddle (turret) guideways or both.

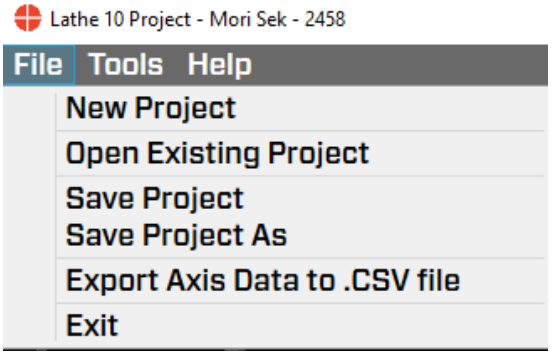
Step 5: Record Tailstock/Subspindle Axis Data
After the headstock AOR has been aligned to the lathe bed ways, use **Step 5** to take data for the alignment of either the tailstock center or a subspindle AOR to the headstock spindle AOR. Three or six data points are taken to measure the mounting errors and calculate the alignment results, which are compared to the tolerances, and a graphic display illustrates the alignment

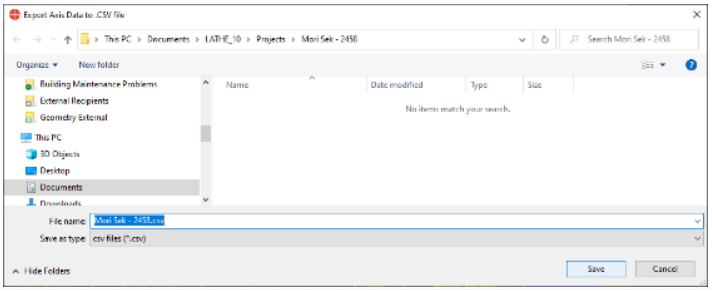
Step 6: Tailstock/Turret Alignment Live Move Screen - If the data recorded in **Step 5** is out of tolerance, the misalignment can be fixed in **Step 6**. Lathe10 automatically applies display offsets, so the data displays show the actual alignment results, which update in real time. It also calculates the shims necessary to align the tailstock or turret. Live spindle graphics automatically update with each move, showing how the alignment is progressing.

Lathe10 File Menus

The File Menu

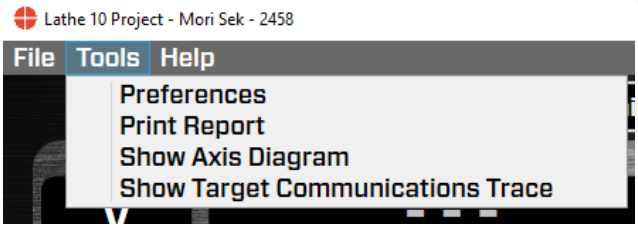
New Project	Opens a pop-up to enter a filename for a new project.
Open Project	Browse folders to open a saved project.
Save Project	Saves the current project.
Save Project As	Allows you to change the filename and start a new project based on the current file's data.
Export Axis Data to CSV	Exports data to a CSV file type, which can then be opened in Excel. Opens a Save File Window to enter the filename.
Exit	Stores all current settings, prompts the user to save any unsaved data, and exits Lathe10.

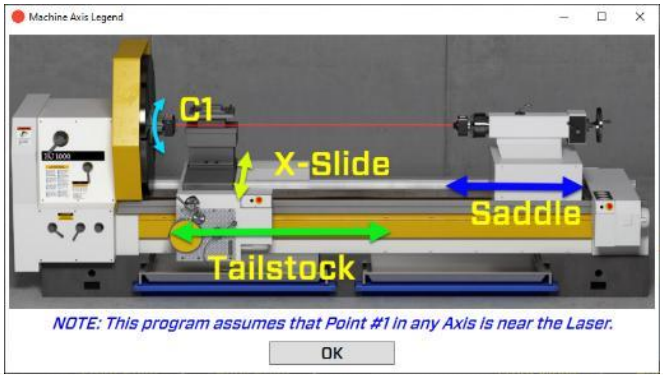




The Tools Menu

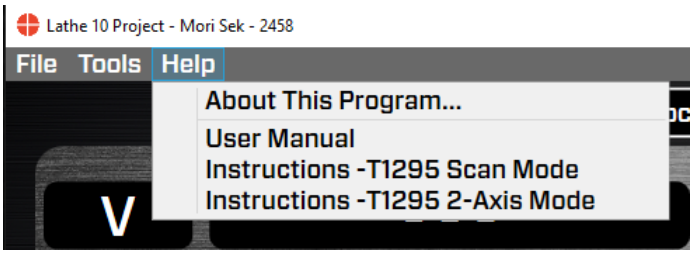
Preferences	Opens the Preferences window to change units, decimals, target type, etc.
Print Report	Prints a report of data and graphs.
Show Axis Diagram	Opens a drawing legend of the machine and identifies the axes.
Show Target Communications Trace	Opens a dialog box showing the incoming target data packets, usually only used for troubleshooting purposes.





The Help Menu

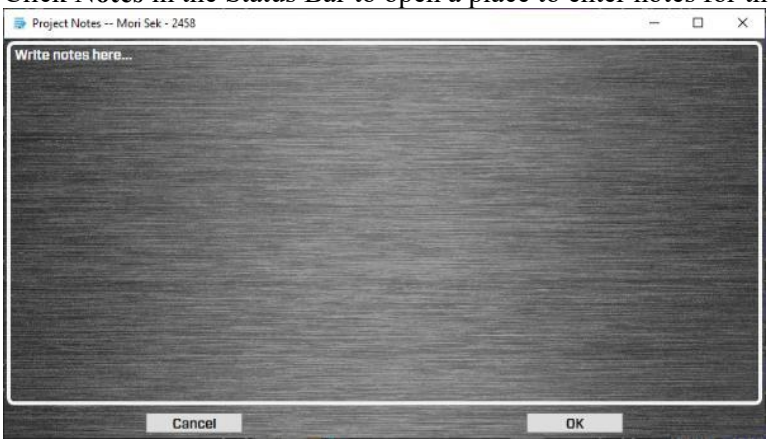
About This Program:	Usual info about the program.
User Manual	Opens a PDF of the manual.
Instructions – *T-1295 Scan Mode:*	Instructions on how to change T-1295/1296 Targets into Scan Mode when using the L-702SP Scan Laser.
Instructions – *T-1295 2-Axis Mode:*	Instructions on how to change T-1295/1296 Targets into 2-Axis Mode when using the L-702SP Beam Laser



Navigating Lathe10 with the Status Bar

Software Steps
The *right* blue arrow and *left* blue arrow will take you to the next screen, or click any step number on the Status Bar to navigate to that step in the software.

Notes
Click **Notes** in the Status Bar to open a place to enter notes for the alignment. This information is printed in the report.



Units
Displays the measurement units selected in **Preferences** (see **Page 33**).

Lathe 10 Screens - Preferences

Click **Preferences** to open a pop-up to change Lathe10 settings.

Note: *If you are installing the software yourself, you will need to go to* ***Enter Target Info*** *(see* ***Page 34****) and follow the procedure to enter the target serial number and calibration factors. You can use the T-261 without calibration factors but the accuracy will suffer. However, the closer the values are to zero, the less the errors become, so even an uncalibrated target will produce accurate results if the axes are aligned to zero or close to zero.*

Project Information

Enter a project description, company contact information and notes that will be displayed in the reports here. If you click **Include Logo in Reports** and then click **Browse**, you can import a company logo to display on the report.

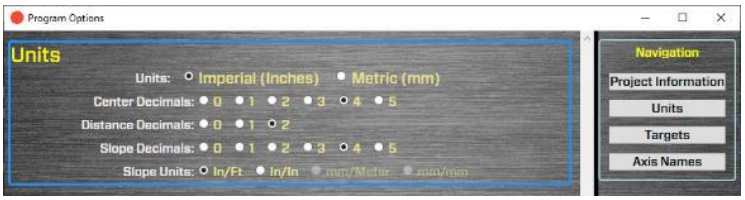
You can also access the **Notes** popup here (see **Page 32**) to enter notes. The information will be stored in the Notes Popup and be accessible from the *Status Bar* in all steps of Lathe10.

Units - Digits

Select **Imperial** (in.) or **Metric** (mm) and units for any slope calculations. For slopes, there are 2 formats:

- Inches/foot or inches/inch
- mm/m or mm/100 mm

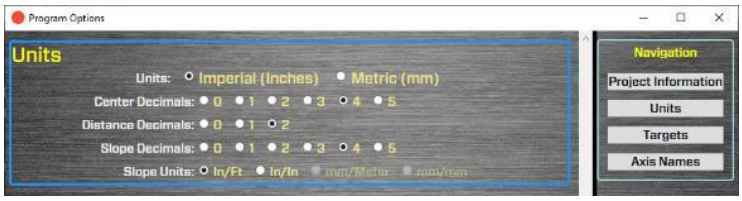
Note: *The raw data coming from the T-261 is expressed in units of in/ft. The T-1295/1296 Target raw angular unit is expressed in in/3 in. for the 3 in. Lens and in/6 in. for the 6 in. lens. Lathe10, however, will automatically adjust the angular data displays to show the correct angular units chosen here when you click on the* ***Angle*** *button in the real-time display area. If you don't click on* ***Angle*** *(you will see the numbers in the left display) but install the lens, then the values will be in units as described above.*



Units - Decimal Display

Select the desired number of decimal points to be used for the alignment data displays.

For inches, we recommend 4 decimal points for center and angular values. For mm, we recommend 3 for center and 2 for angular values.
Note: *If choosing a higher resolution than noted above, we recommend changing the data averaging to 20 or higher to help reduce measurement noise for the last digit. This will, however, cause the update rate to slow down and any position movements in the target or laser to slow down considerably.*

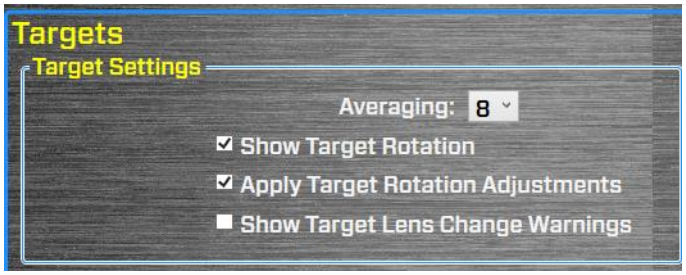


Target Settings

Show Target Rotation – This will show or hide the target Rotation angle (in degrees) in the display screens in Steps 2, 3, 5 and 6.

Apply Target Rotation Adjustments – This will apply a trigonometric correction factor for the display values in Steps 2, 3, 5 and 6. This adjusts the display reading back to TDC (Top Dead Center) when the target rotation value is not 0 or 180. The default setting is "checked."

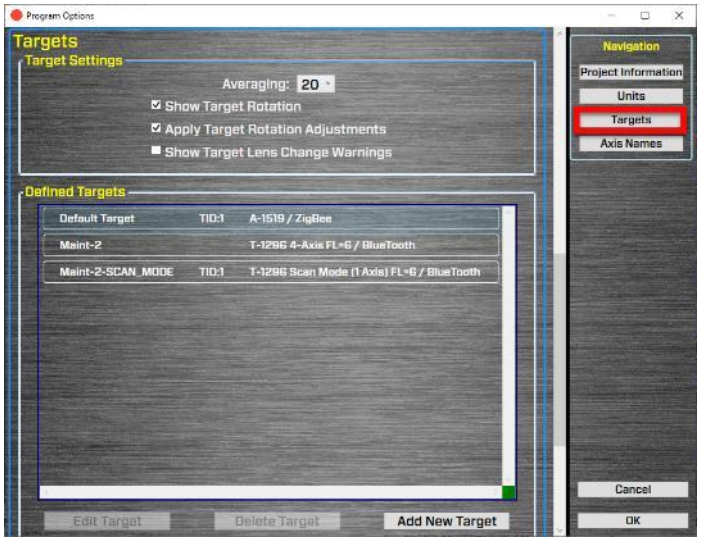
Show Target Lens Change Warnings – if you click on Angle in the displays in Steps 2, 4 and 5, you will get a warning message to insert the lens. This toggles this message on/off for those who prefer not to be warned.



Targets - Setup Procedure

When you buy a new system and laptop from HLI, target setup and calibration factors are already pre-configured into Lathe10. However, if you are installing Lathe10 on your laptop, then you must follow this procedure to set up the target and enter calibration factors.

1. Click the **Target** button.



2. Click **Add New Target** to specify and set up a target type and computer interface if needed. There will be a dropdown list of target types supported by Lathe10. Pick the target type by clicking on it.

   You will then be prompted to supply calibration factors for the targets, which vary by target type. You will need to supply the:

   - Serial Number
   - Calibration Date
   - Calibration Factors

3. **Enter Target Info - *T-261 Target*** –

If you choose the T-261 Target, then Lathe10 will automatically select the R-358HR Computer Interface since they work as a set.

a. **Target Name** – enter the target "nickname". This name will show up in the Target area on the data displays. The target part number and focal length are automatically displayed by Lathe10.

b. **Serial Number & Calibration Date**– enter the target serial number and date that comes with the T-261

c. **Calibration Factors**. You will need to input the 8 target calibration factors that are supplied with the target.

Note: *the calibration values vary from .85 to 1.2.*

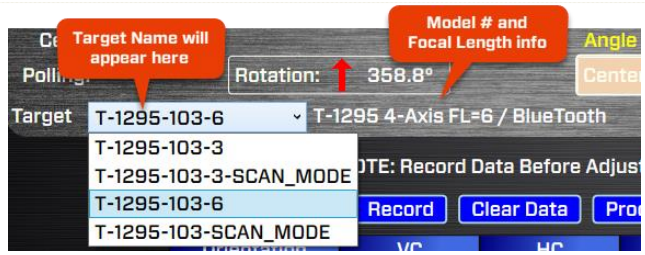
Note 2: *All R-358 Computer Interfaces come in HR Mode. However, if you have our discontinued R-355 Interface, you will need to upgrade to the R-358 to use Lathe10.*

4. **Enter Target Info – *T-1294/T-1295/ T-1296/T-1297 Targets 2-Axis Mode***

Click on **Target Type/Interface** to choose the T-1294, T-1295, T-1296 or T-1297 targets, select the target number with "*2 Axis Mode*".

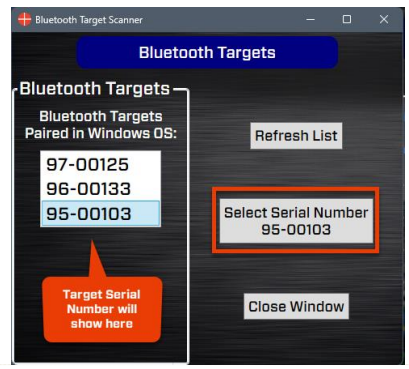
Note - *Scan Mode will automatically be added as a target type for each T-1294/T-1295/T-1296/T-1297 selected. Scan Mode is needed with the L-702SP Laser but is typically not used with Lathe10.*

a. Target Name. Enter a "nickname" for the target. This name will show up in the Target drop-down list on the data displays. We suggest using the target part number, serial number and lens focal length in the nickname. The target part number and focal length descriptions are also displayed by Lathe10.

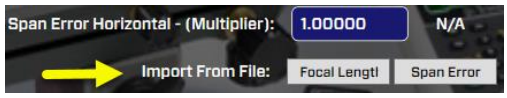


b. Serial Number and **Calibration Date** – Enter the serial number and calibration date (supplied with the system), or you can load it from the Bluetooth list, by clicking on **Scan for Bluetooth Targets.**

You will first need to pair the target with the laptop (**see Page 9** *How to Pair the T-1295/T-1296 Target's Bluetooth to a PC*). Once paired, you can click on **Scan for Bluetooth Targets** to see if your target is being recognized by Windows OS. If you see your target serial number, click on it and then click on the **Select Serial Number** button to select it.



c. **Calibration Factors**
Hamar Laser supplies several calibration factors that need to be entered into the software. You can enter the values is the entry boxes (either in microns or as a multiplier), or load them from 2 *XML files* that are on the USB drive supplied with the system by clicking on **Import From File.**



The files are:

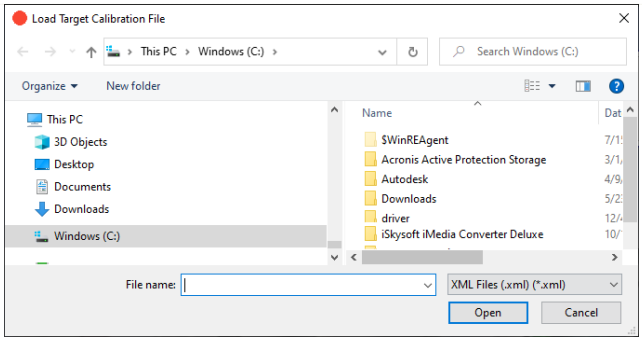
1. Focal Length (Serial number (FL=X).xml),
2. Span Error (Cal Factors.xml)

96-00133(FL=3).xml
96-00133 Cal Factors.xml

- **Vertical/Horizontal Slope Offset** – This is a calibration factor to ensure the squareness to the mounting stud. This is an offset that is subtracted from the raw value. There are separate

factors for the V & H axes of the target.

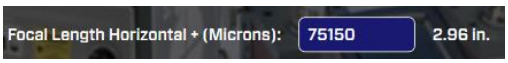
- **Vertical/Horizontal Focal Length –** This is a calibration factor to correct the error in the focal length of the lens. This is the actual focal length, which Lathe10 uses instead of the nominal value. There is a separate factor for the "+" and "–" values of each of the V & H axes, for a total of 4 factors.



- **Vertical/Horizontal Span Error –** This is a calibration factor to correct for an error when moving the target by a known and calibrated amount, usually .05000 in. (1.270 mm). This is a multiplier that is multiplied by the raw value. These values vary from 0.8 to 1.2. There is a separate factor for the "+" and "–" values of each of the V & H axes, for a total of 4 factors.

WARNING – clicking on Lens Type (3-Inch or 6-Inch) will insert the nominal values into the Focal Length entry boxes, overwriting any previously entered calibration factors. If this happens, you can either hit Cancel or hit the Focal Length button to reload the factors.

***Note**: 3 in. = 76,200 microns and 6 in. = 152,400 microns. These are the nominal values and can be used if the actual cal factor is not available. After entering the value, when you click on OK or another box, it will update the white number to the inch equivalent.*



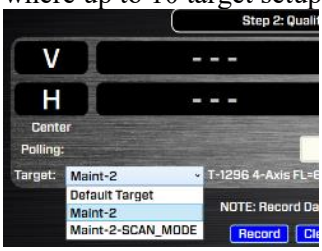
d. **Ambient Light Frequency** – The T-1295/1296 Targets utilize an ambient light correction feature that improves accuracy. It is important to make sure that the electrical frequency selected here matches the frequency at the plant.

Note – *the target must be turned on and the Bluetooth be paired with the PC to change the frequency. Normally, this is set at the factory to match the country it is being shipped to.*

e. Defined Targets

You can set up multiple targets if desired. The target names and modes will appear in the **Defined Targets** area.

To select a target, go to **Steps 2, 4, 5 or 6**, choose from the ***Target*** dropdown list where up to 10 target setups may be stored.



Note *– Lathe10 saves the last target you used in a Preferences XML file and it also saves the target you used in a saved data file. When opening Lathe10, if you select a New File, it will automatically select the last target used (from the Preferences XML file) when going to Step 2. However, if you select a saved file, then Lathe10 will select the target that was used to take the data when you go to Step 2.*

Lathe 10 Screens - Step 1: Dimensions and Tolerances

After entering a new project name, enter some parameters for the alignment in **Step 1: Setup**. Enter the number of points to take, the distance between points, the headstock and tailstock bolt dimensions and the alignment tolerances.

Data Points

Bed Data-Point Spacing

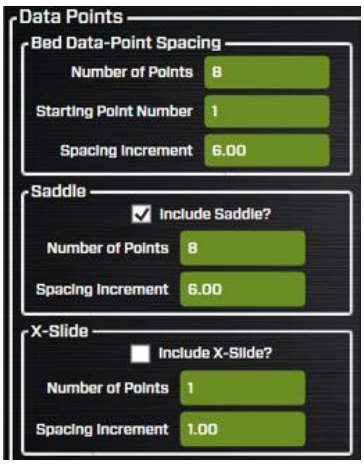
Pick the number of points to record and the dimensional spacing between the points to be used in **Step 3: Bed Straightness & Spindle Axis Parallelism**. The first set of points is for the main lathe-bed guideways.

Saddle

Select the check box for **Saddle** if there are separate guideways for the saddle axis that you want to record separately.

X-Slide

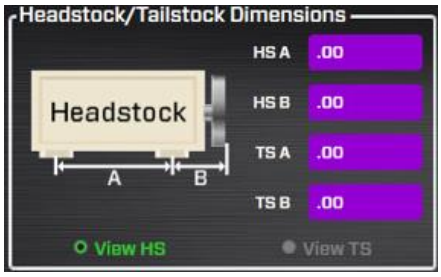
Select the check box for **X-Slide** if there is a cross-slide axis that needs to be measured (requires the L-702SP Laser). By selecting the check boxes, a data-taking tab will appear in Step 3 to record the data.



Headstock/Tailstock Dimensions

Enter the dimensions between the bolt holes in the headstock and the tailstock or subspindle, using the graphic image to ID where to take the measurements. These dimensions will be used in **Step 3: Move Screen** to calculate shim values to re-align the headstock to the tailstock or saddle guideways. The dimensions will also be used to calculate shim values to re-align the tailstock or subspindle in **Step 6: Tailstock/Turret Alignment**.

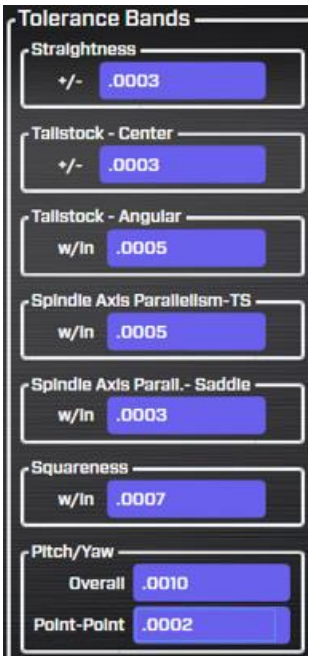
Note: *The dimensions should be taken to an accuracy of ± 1/8, if possible, to ensure the accuracy of the shim calculations.*



Tolerance Bands

Enter alignment tolerances for the following:

- **Straightness** – this is the overall straightness of the lathe bed data for either the tailstock or saddle set of data.
- **Tailstock (Subspindle) Center** – this is the *center* (H&V) tolerance for the alignment of the tailstock's axis of rotation (AOR) *center*s (H&V) relative to the headstock's AOR's centers.
- **Tailstock (Subspindle) – Angular** – this is the *angular* tolerance for the alignment of the tailstock's AOR *angles* (H&V) relative to the headstock's AOR *angles*.
- **Spindle Axis Parallelism – TS** – this is the *angular* tolerance for the parallelism of the headstock AOR relative to the tailstock guideways.
- **Spindle Axis Parall – Saddle** – this is the *angular* tolerance for the parallelism of the headstock AOR relative to the Saddle/Turret guideways.



The straightness tolerance values are set up as a ± band around zero. In the Alignment Results Summary in **Steps 3** and **4**, a green √ or red **X** indicates if the measured value is within or outside of the tolerances entered here. For example, for a ±.0005 in. straightness tolerance, Lathe10 looks at the absolute of all the values relative to the *Best Fit* line, and if any of those values are higher than .0005, then it will be *out* of tolerance. Therefore, if the maximum of all the *positive* values is .0004 and the *minimum* of all the negative values is -.0003, then the straightness would be *in* tolerance. However, the *TIR Straightness* will be .0007.

STRAIGHTNESS Parameter	Value	+/- Toler.	In/Out
Tailstock Vertical Straightness	0.0033	0.0005	✗
Tailstock Horizontal Straightness	0.0020	0.0005	✗
Saddle Vertical Straightness	0.0031	0.0005	✗
Saddle Horizontal Straightness	0.0007	0.0005	✗

PARALELLISM Parameter	Value	+/- Toler.	In/Out
Tailstock Vertical Parallelism	0.0000	0.0005	✗
Tailstock Horizontal Parallelism	0.0000	0.0005	✗
Saddle Vertical Parallelism	0.0000	0.0005	✗
Saddle Horizontal Parallelism	0.0000	0.0005	✗
Z/W Horizontal Parallelism	0.0000	0.0005	✓
Z/W Vertical Parallelism	0.0001	0.0005	✓

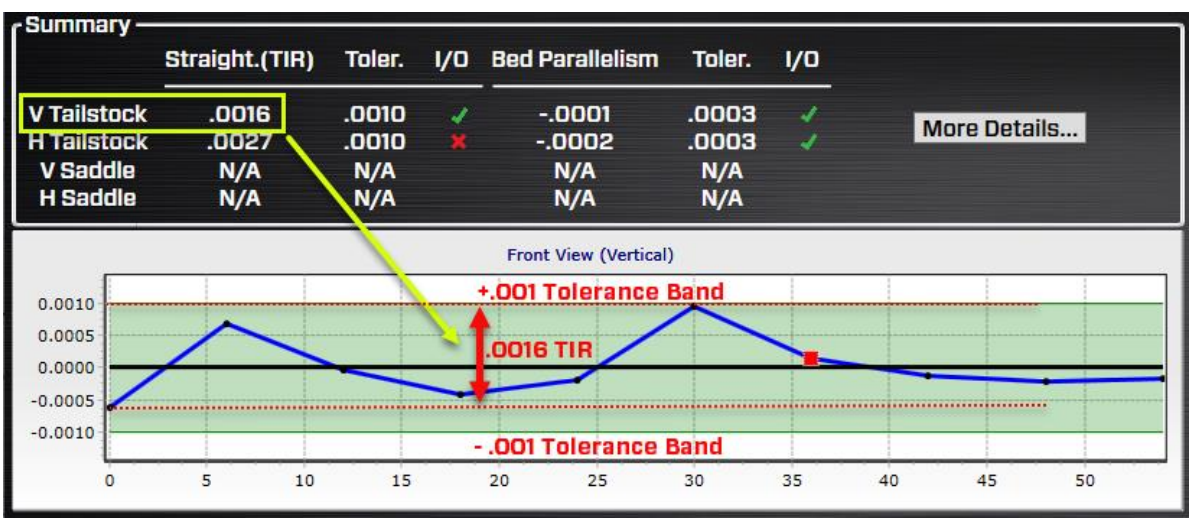


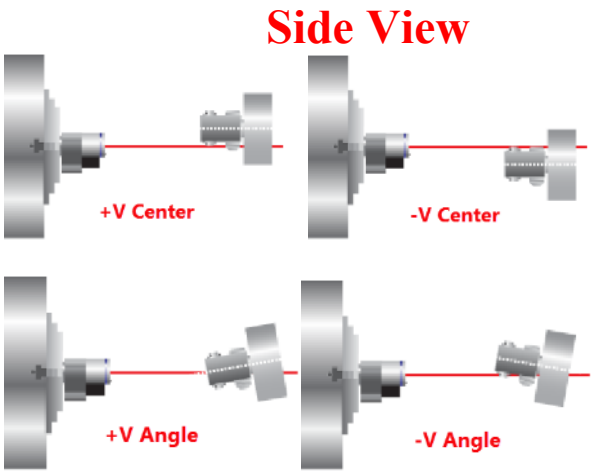
Figure 31 - Step 4 Graphs Tolerance Bands

Interpreting the Plus and Minus Signs in the Live Displays

The signs of the data displays indicate the position (high/low or left/right) of the target relative to the laser beam. See the interpretation below.

Vertical Axis

A **+V** *center* value indicates that the target is higher than the laser beam.
A **+V** *angular* value indicates that the back of the target is *higher* than the front of the target.
A **–V** *center* value indicates that the target is lower than the laser beam.
A **-V** *angular* value indicates that the back of the target is *lower* than the front of the target.



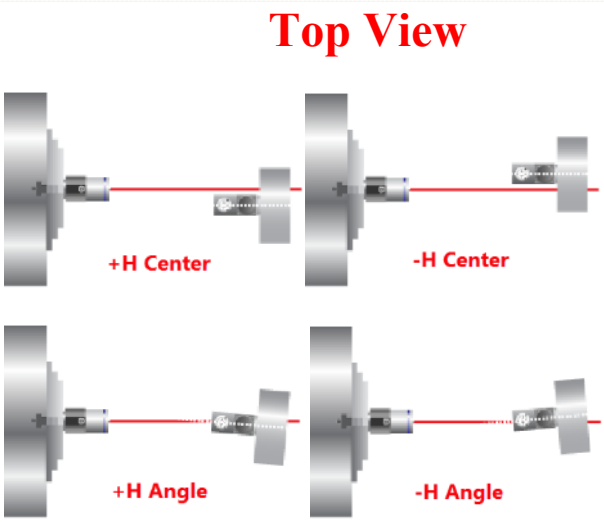
Horizontal Axis

A **+H** *center* value indicates that the target is to the right of the laser beam when looking from the laser *into* the T-261 target.

A **+H** *angular* value indicates that the back of the target is to the *right* of the front of the target when looking from the laser *into* the T-261 target.

A **–H** *center* value indicates that the target is to the *left* of the laser beam when looking from the laser *into* the T-261 target.

A -H *angular* value means that the back of the target is to the *left* of the front of the target when looking from the laser *into* the T-261 target.



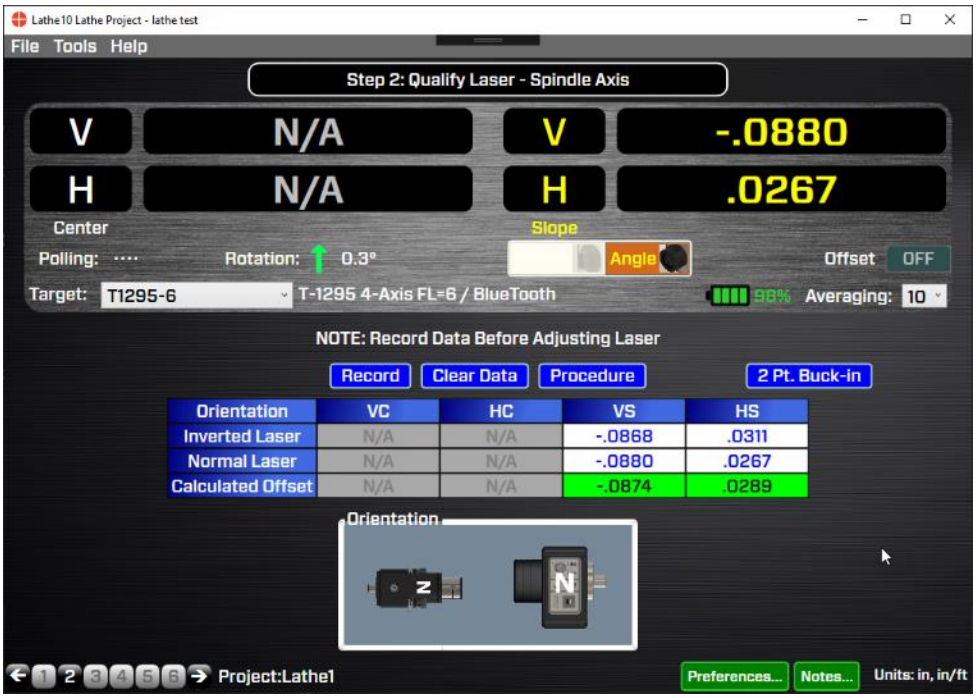
Lathe 10 Screens -Step 2: Qualify Laser

In **Step 2: Qualify Laser** we will be aligning the L-700/L-702SP/L-703S laser beam to the headstock axis of rotation (AOR). This is a very simple procedure that records two data points and applies display offsets, so you simply adjust all the axes to zero and the laser beam is aligned to the headstock AOR.

Note: *The L-702SP and L-703S Lasers do not have center adjustment and only require angular adjustment.*

The L-700 laser has center and angular adjustments, but it is much more important for lathe alignment to align the L-700 ***angular*** *values to the headstock AOR rather than the* ***center*** *values. This is because the closer the laser is aligned in angle to the headstock axis, the more accurate the measurement of the parallelism to the tailstock guideways or saddle guideways. Conversely, when measuring centers, the Lathe10 NORMIN procedure can subtract out any remaining centering errors of the laser beam to the headstock AOR (see Appendix A -The NORMIN Method beginning on Page 77).*

The best that you will be able to align the laser beam to the headstock spindle axis depends on how well the spindle itself repeats. Any center or angular runout in the spindle cannot be subtracted out by Lathe10. This represents the limit of how accurately the alignment can be done.



What the Buttons Do

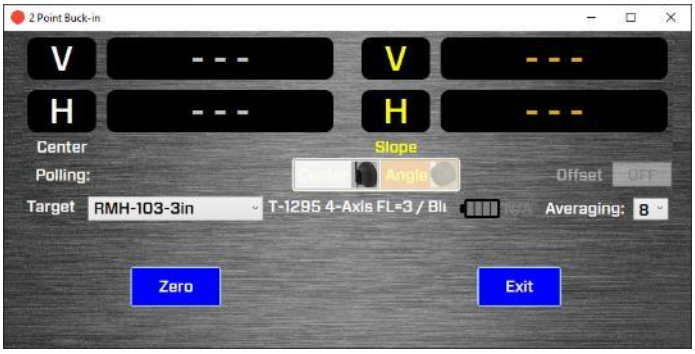
Record – click or press **Record** or press the spacebar to record the data point.

Note: *The values in the displays are recorded instantaneously, so if the values are still updating, you must wait for them to stop changing before recording the point.*

Clear Data – this clears the data from the table, removes the display offsets and moves the cursor to the top to be ready to record data.

Procedure – this opens a PDF section of the manual with the basic procedure to qualify the laser.

2 Pt. Buck-In. – Click on **2-Pt. Buck-In** to open a window that is used for our 2-point buck-in procedure to align the laser to 2 points along an axis. This may be used with the L-702SP-RA Right Angle fixture to align the laser to 2 points along the X axis for checking its straightness.



Averaging – enter values from 1 to 99 and this will change the number of samples Lathe10 uses to average for each of the display values. The default is 10.

Note: *The higher the averaging value, the more noise fluctuations will be dampened out, but also the slower the response time for movements in the laser position. The data updates at four readings per second, so with an averaging value of 24, the data takes about six seconds to update after the laser beam position has started moving.*

Changing Angle & Center Displays

The T-1295/T-1296 Targets can measure in 4 axes but only two at a time. So Lathe10 needs to put the data in the correct displays. To view the Center values, click on the Center/Angle Graphic just below the data displays.

When the displays are set to *Center Mode*, the values will show up in the left-side displays and the font color is *white*. You will also see that the Angle button has been greyed out.

When the displays are set to *Angle Mode*, the values will show up in the right-side displays and the font color is *yellow*. You will also see that the Center button has been greyed out.

Important Note – *You must install the angular lens into the target to get the proper results.*

Figure 32 - T-1295 Target: Inserting Angular Lens

Qualifying the Laser Beam to a Spindle AOR
L-700, L-703 & L-702SP Lasers

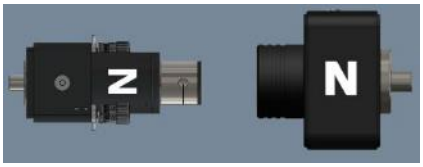
In spindle alignments on lathes and turning centers, it is important to ensure that the laser beam is aligned, or qualified (bucked-in), to the axis of rotation (AOR) of the spindle. This is so the alignment of the headstock to the machine's guideways can be checked.

This procedure describes how to align the laser beam to the spindles' AOR.

The NORMIN Method

The NORMIN method is a way of canceling mounting errors. The word is a contraction of "NORMal-INverted," which briefly describes the method.

To take NORMIN readings, the laser and target fixtures are set in the NORMal position (cable down or switch panel facing toward you) and the readings are recorded. Then the laser or target fixture is rotated 180 degrees to the INverted (cable up or switch panel on the bottom) position and a second set of readings is obtained. With a quick calculation, the 2 sets of readings are averaged to cancel out both laser and target mounting errors (center and angular) and provide a very accurate result. For a complete discussion of the NORMIN method, see *Appendix A*, beginning on **Page 77**.



NORMIN Reading
L-702SP Laser NORMal,
T-1295 Target NORMal

NORMIN Reading
L-702SP Laser INverted,
T-1295 Target INverted

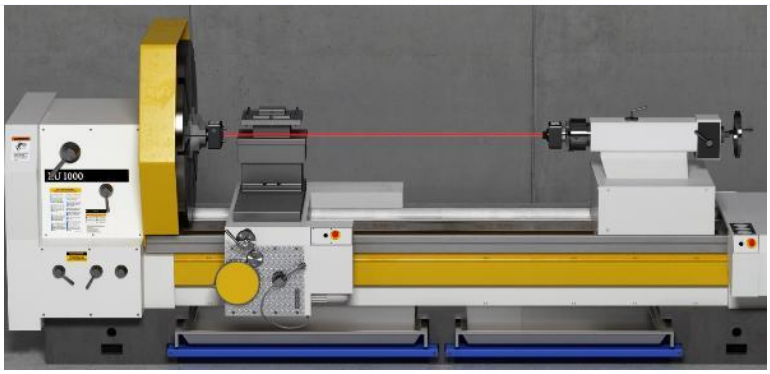
Figure 33 - Taking NORMIN Readings

To qualify or buck-in a laser, error correction readings are taken to cancel out mounting and other errors, and Lathe10 calculates what we call *Set Points*. The laser beam is then adjusted to the *Set Points*, making it parallel to/coincident with the desired axis of rotation.

Procedure for Qualifying the Laser to a Spindle's Rotation Axis
L-702SP/L-703S with T-1295/T-1296 Targets

The following procedure explains how to qualify (buck-in or align) the L-702SP or L-703S laser to the spindle's rotation axis using the T-1295/T-1296 4-axis Target and MultiTurn10 software.

1. **Install the L-702SP/L-703S & T-1295/T-1296 into the headstock and sub-spindle/tailstock chuck.**
   Mount the laser in the headstock spindle and the target in the sub-spindle or tailstock or the T-242 Target Stand. Both the laser and target should be in the *NORMal* position. The *NORMal* position for the laser is with the switch panel facing *toward* you and the level vial facing up.

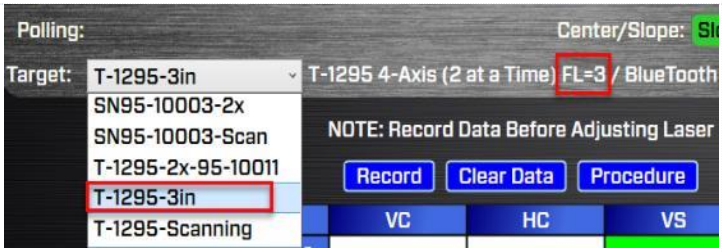


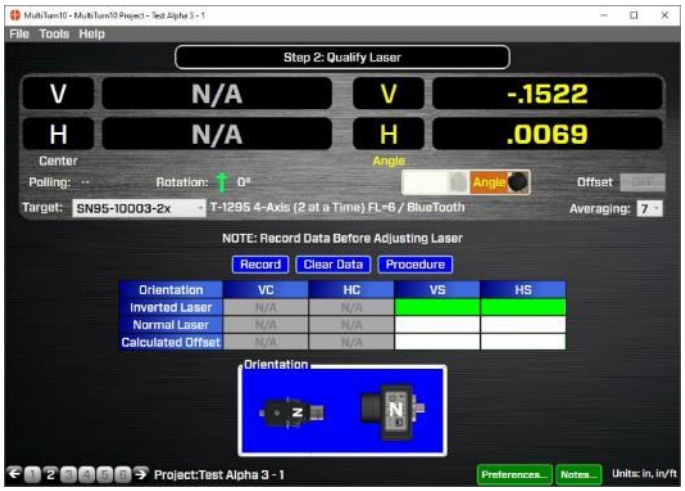
L-702 Switch Panel

2. **Alignment Tolerance**
   The goal is to align the laser to the spindle's AOR to ±-.0001 in/ft (0.012 mm/m) in angle.

3. **Open Lahte10**
   Open Lathe10 using either a saved file or enter a new file name.
   See the *Preferences on page xx above* for details on how to set up the T-1295/T-1296 Targets.

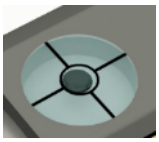
4. **Go to Step 2: Qualify Laser**
   Go to *Step 2: Qualify Laser* and click on Angle to and make sure you are getting readings in the **Angle** displays. Install the T-1295-A-3 (or A-6) Lens and make sure that the target description matches the focal length. ***FL=3*** should be selected for the *T-1295-A-3* lens and ***FL=6*** should be selected for the *T-1295-A-6* lens. See **Preferences** (**Page 33**) for instructions on how to set up a new target. If using the T-1296 Target, select it in a similar manner as above.



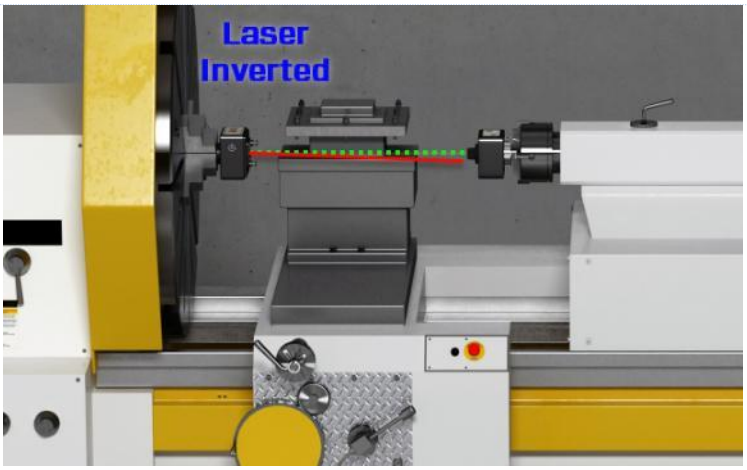


***Note**: for the L-702SP/T-1295 Target there is no centering adjustment, so you will only be adjusting the V & H angular axes.*

5. **Rotate the spindle+L-703S/L-702SP to the INverted Position.**
Rotate the spindle + L-703S/L-702SP to the *INverted* position (A/C connector panel is facing *toward* you), with the target in the *NORMal* (switch panel up) position. Ensure the bubble level is in the center of the circle. Wait for the readings to stabilize (approximately 5 seconds).

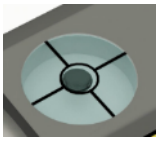


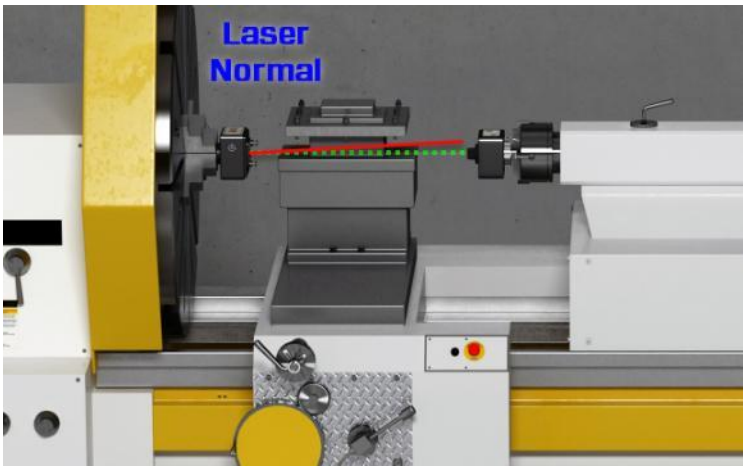
Note: *Do NOT rotate the laser in the collet. Always rotate the laser and spindle TOGETHER as one unit.*



6. **Click RECORD**.
Click or tap **Record** (or the spacebar on a laptop) to record the INverted value. The V & H angular values will be recorded in the table.

7. **Rotate the spindle/laser to the NORMal position.**
Rotate the spindle + L-703S/L-702SP to the *NORMal* position (switch panel facing *toward* you with the level vial leveled), with the target still in the *NORMal* position (cable down) and wait for the readings to stabilize (approximately 5 seconds). Ensure the bubble level is in the *center* of the circle.



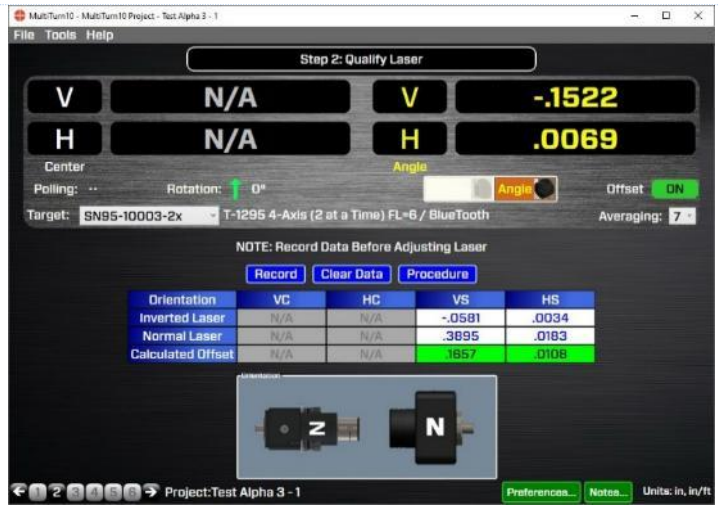


8. Click RECORD.

Click or press **Record** to record the NORMal value.

MultiTurn10 records the NORMal value and automatically calculates display offsets so you can adjust the 2 *angular* adjustment axes to *zero* instead of the calculated Set Point.

Note: *While it is not recommended, if you want to see the raw values, click the* **Offset** *button to turn the offsets off (the green* **ON** *button will turn gray). Click* ***Offset*** *again to turn them back on.*



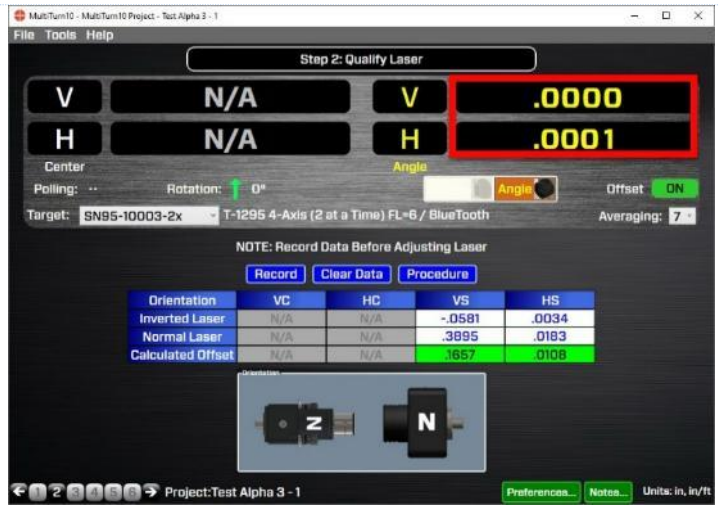
9. Adjust the V and H Angular (slope) Laser Adjustments

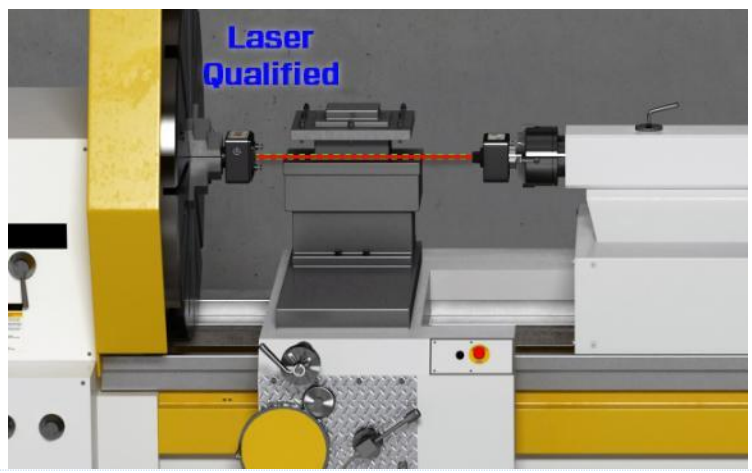
Turn the Pitch and Roll adjustment knobs on the laser until the *Angle* values in the Step 2 display are within ±.0001 in/ft (0.012 mm/m) of zero. For the L-702SP, you can make the coarse adjustments first and then the fine adjustments when the coarse adjustments can't get the value to the recommended tolerance.

For the L-703S, adjust the pitch/roll adjustments until the values are within the recommended tolerance.

In the image here are the V and H *Angular* (*Slope)* values in or close to tolerance.

Note: *There are no center adjustments with the L-703S & L-702SP, since any small centering errors will be averaged out by using the NORMIN procedure in Step 5.*





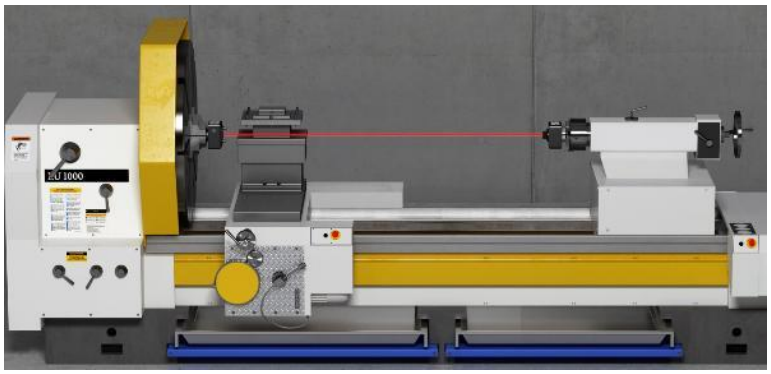
10. Repeat Steps 6-10 to verify the laser is aligned to the spindle rotation axis.

11. The laser is now bucked-in to the C1 axis and the straightness for the main lathe guideways and saddle guideways can be recorded in Step 3.

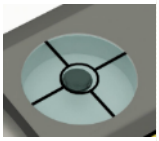
Procedure for Qualifying the Laser to a Spindle's Rotation Axis
L-700 with the T-261 Target

Procedure

1. **Insert the L-700 into the headstock chuck and tighten it very tightly.**
   Note: *The mounting stud is made of hardened steel so tightly clamping on the stud should not damage it.*
2. **Insert the T-261 in the tailstock chuck or subspindle and tighten very tightly.**
   Note: *You can also use a fixture to hold the T-261 on the saddle itself. HLI's T-230 Fixture is an optional fixture that can hold the target on top of the saddle itself.*

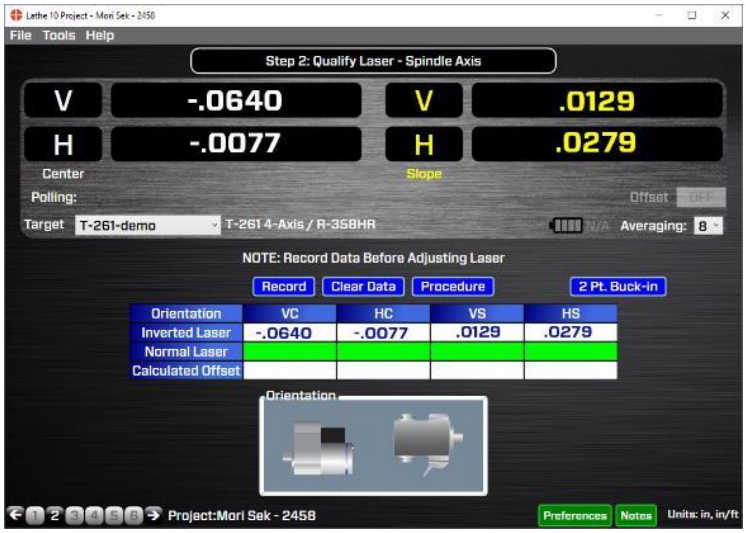


3. **Rotate the headstock spindle with the L-700 Laser 180 degrees to the INverted position. Click/press Record.**
   Rotate the spindle + L-700 to the *INverted* position (battery pack on top), with the target in the *NORMal* (cable down) position. Ensure the bubble level is in the center of the circle. Wait for the readings to stabilize (approximately 5 seconds).

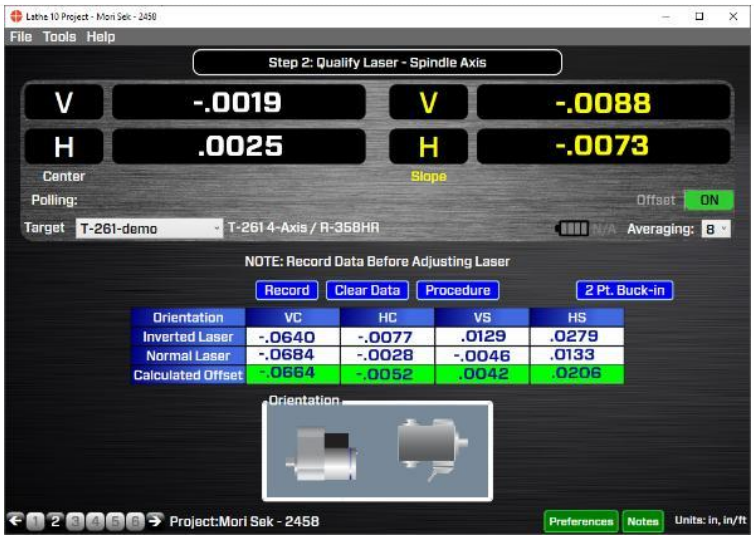


   Note: *Do NOT rotate the laser in the chuck. Always rotate the laser and spindle TOGETHER as one unit.*

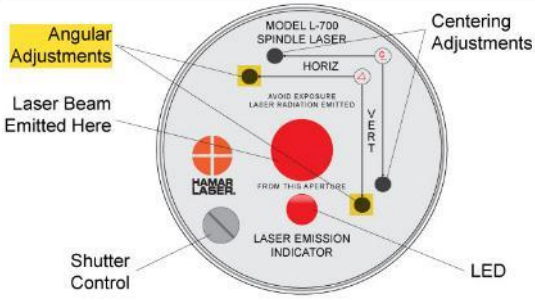
   ***Tip**: When recording data in Lathe10, you can use the spacebar to record the data points.*



4. **Rotate the headstock spindle with L-700 180 degrees back into the NORMal position and click/press Record.** Rotate the laser to the NORMal position (battery pack on the bottom) and press **Record**. Lathe10 automatically calculates Set Points for each axis and calculates display offsets so that you can adjust the 4 alignment axes to zero instead of a Set Point. To toggle the display offsets, click/press ***ON***.



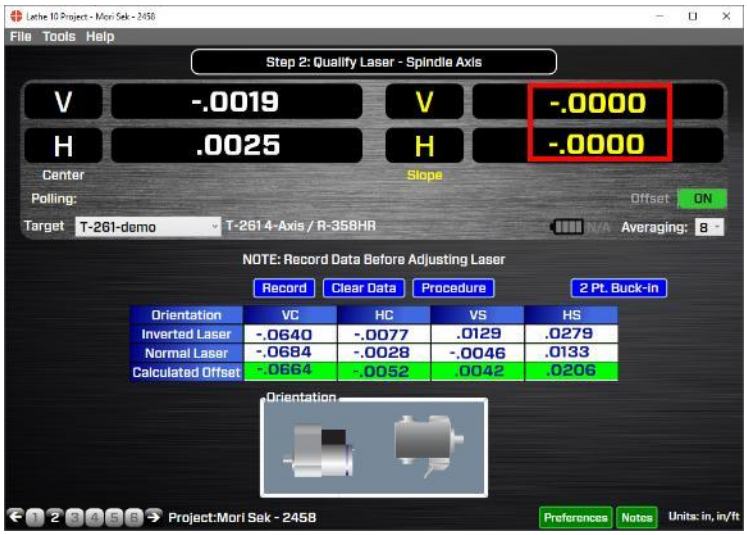
5. Adjust the *V* and *H Angular* (slope) adjustment on L-700 until the *Slope* values are .0000 in/ft or very close to it.



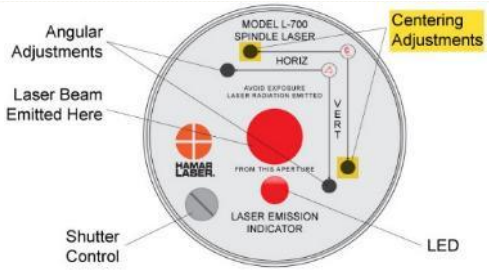
If you run out of range, this is most likely due to the fixturing not being done properly. QC the fixtures to make sure the mounting hole/rotation axis is perpendicular to the axis you are trying to align to.

Warning!!
If the adjustments start getting tight or very loose, STOP! You might cause some damage to the laser adjustments if you turn them too far. The adjustments have about 3 full turns in either direction before they run out of range.

Here, the L-700 V & H *Slope* values are adjusted to zero.

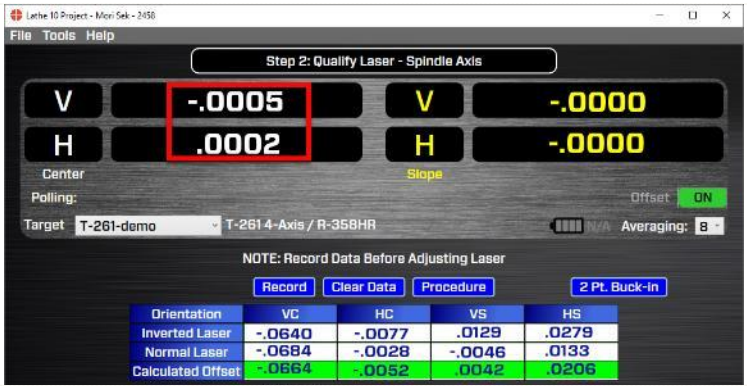


6. Adjust the V and H *Center* adjustment on L-700 Laser until the *Center* values in the display are within ± .001 in/ft (0.025 mm) of zero.



Here, the L-700 V & H *Center* values are in tolerance.
Since the *Center* values were adjusted, the *Angular* values should not change (or should change very little).

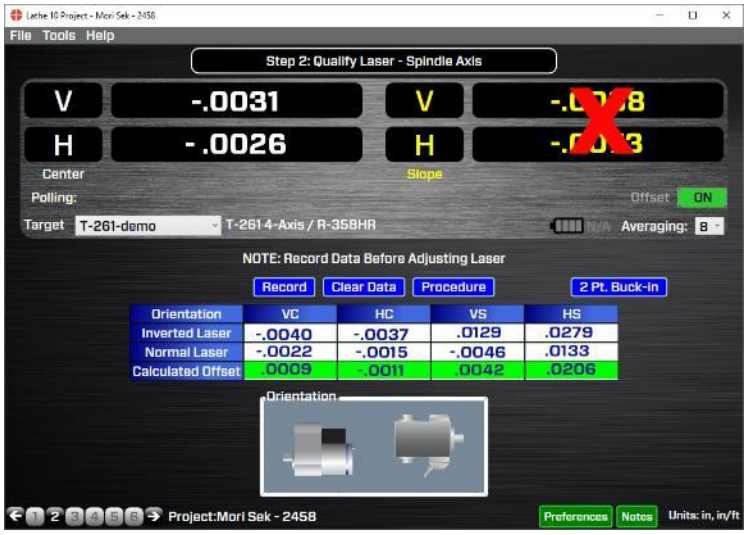
Note: *If you have a large center offset to adjust out, this will probably change the angular values enough to need to be tweaked back into tolerance.*



7. **Repeat Steps 3-6 to verify the laser is aligned to the headstock AOR.**

   Note: *It is much more important for the overall lathe alignment to align the L-700* ***angular*** *values to the headstock AOR rather than the* ***center*** *values. This is because the closer the laser is aligned in angle to the headstock axis, the more accurate the measurement of the parallelism to the tailstock guideways or saddle guideways. Conversely, when measuring centers, Lathe10's NORMIN procedure can subtract out any remaining centering errors of the laser beam to the headstock AOR.*

8. **Ultimate-accuracy headstock parallelism alignment checks (optional).**
   For the highest accuracy in checking the alignment of the headstock's AOR to the bed, you will need to align the laser angular values using a slightly modified method:
   a. Follow the standard Laser Qualification procedure above and align the laser's *angles* as close to zero as possible, preferably .0000 in/ft (0.0083 mm/m).
   b. Move the tailstock /T-261 as far as possible from the headstock up to about 10 ft. (3 m).
   c. In **Step 2**, click **Clear Data**.
   d. Rotate the headstock spindle/L-700 to the INverted position and press **Record**.
   e. Rotate the headstock spindle/L-700 back to the NORMal position and press **Record**. The offsets are applied.
   f. Watching the **CENTER** values *only* (ignore the angular values), adjust the L-700 angular adjustments until the center values are as close to zero as possible.



   Note: *Measurement noise will be a problem at longer distances, so we recommend increasing the data averaging. In addition, the runout on the spindle bearing will have a very large impact on what kind of tolerance you can align the laser to.*

   With the standard procedure using four digits, you can align the L-700 Laser to about .0001 in/ft using the T-261. However, if you use this procedure at 10 feet and align the laser angular values to .0005 in. (using the center displays), then your angular alignment of the laser to the spindle AOR would be .00005 in/ft, as long as you have the bearings to allow it!

Lathe 10 Screens -Step 3: Bed Straightness and Spindle-Axis Parallelism

In **Step 3: Bed Straightness and Spindle-Axis Parallelism**, we will record the straightness of the tailstock guideways, the saddle (turret/subspindle) guideways or both. This is done by inserting the T-1295/T-1296 or T-261 Target into the tailstock chuck or into a fixture on the saddle or turret. Move the tailstock close to the headstock and record the first data point. Move the tailstock + target to the next point and record it. Do the same for the saddle/subspindle or turret.

Figure 34 - Lathe10 Step 3 Straightness - Ready to take data

After the data is recorded, click **Results** and Lathe10 calculates the straightness of the rails using the Least-Squares, Best-Fit algorithm. This mathematically creates a line that "best fits" the straightness data (see graph below). The slope of this best-fit line is then removed from the data and the maximum and minimum values are determined to produce the overall straightness.

The slope of the best-fit line also represents the parallelism of the headstock spindle rotation axis (AOR) relative to the guideways. Lathe10 also calculates the best-fit line for the data for the saddle (turret/subspindle) axis.

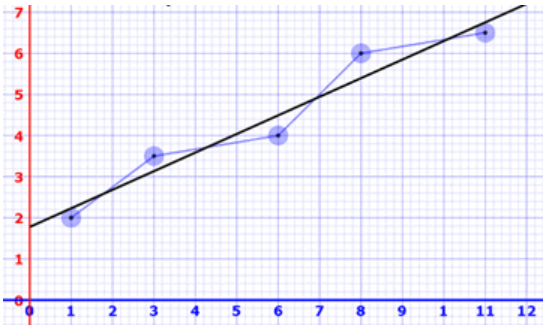


Figure 35 - Least-Squares, Best-Fit line drawn through data

If the parallelism results are out of tolerance, the **Step 3** real-time Move Screen allows the user to correct the headstock parallelism error based on the shim and move values that are automatically calculated when entering the screen. When the errors have been corrected, the straightness data should be retaken to verify that the headstock is now parallel to the bed.

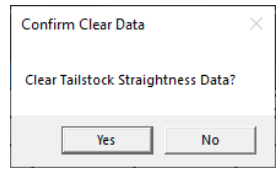
Note: – *It is important to ensure the headstock is aligned to the guideways before taking tailstock or subspindle concentricity data in* **Step 5**. *If the headstock is out of alignment, then re-aligning it will throw off the alignment of the tailstock/subspindle, so it would have to be redone.*

Figure 36 - Lathe10 Step 3 Move Screen

What the Buttons Do

Tabs – In addition to the Tailstock guideways, there may be Saddle guideways. You can record the straightness data for the Saddle guideways by clicking on the *Saddle* tab. *Note – to enable the Saddle tab, you need to click the "Include Saddle" check box in Step 1.*

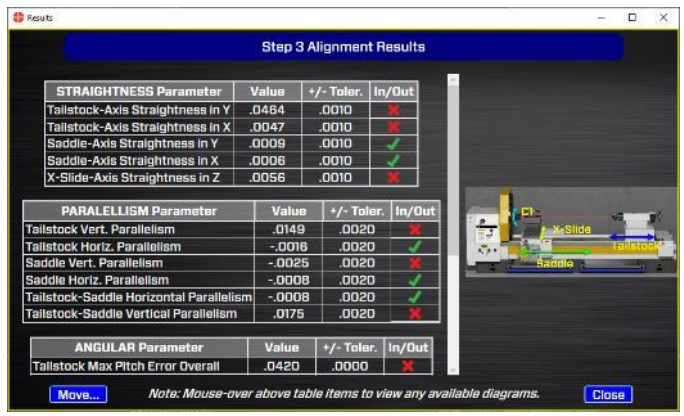
Clear Data – This clears data from the set of guideways selected. If you have selected **Tailstock**, then selecting *Clear Data* clears the data from the four Tailstock straightness rows, but not the *vertical/horizontal slope* rows. To clear data from the Saddle set of rows, first click the *Saddle* tab and then *Clear Data*.



Record – Records the data point. The cursor will automatically move to the next point unless *Auto Step* **-** is unchecked.

Save – Saves the data for all the steps in the project.
Note *– Lathe10 will warn you if you click off of Step 3 and have not saved data yet.*

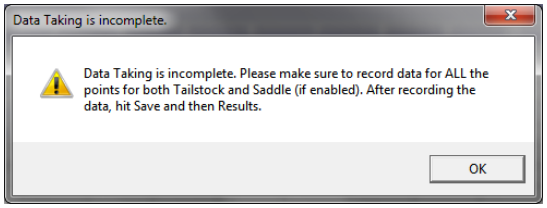
Results – Calculates the straightness results and parallelism values and opens a window with the results.



Auto Step – Clicking **Tailstock** will take data for the Tailstock rows. When a point is taken, the cursor automatically "steps" to the next point. The procedure is the same for **Saddle**. If you turn ***Auto Step*** off, then you must click on the column for the data point you want to take.

Direction Arrow – Click to reverse the direction of **Auto Step**.

Note: *The* **Graph** *and* **Results** *buttons will not work until* <u>*all*</u> *the data has been taken for each of the two sets of guideways A warning message indicates why the screens haven't opened.*



Taking Data

The goal in **Step 3** is to record the straightness and pitch/yaw (if needed) data for:

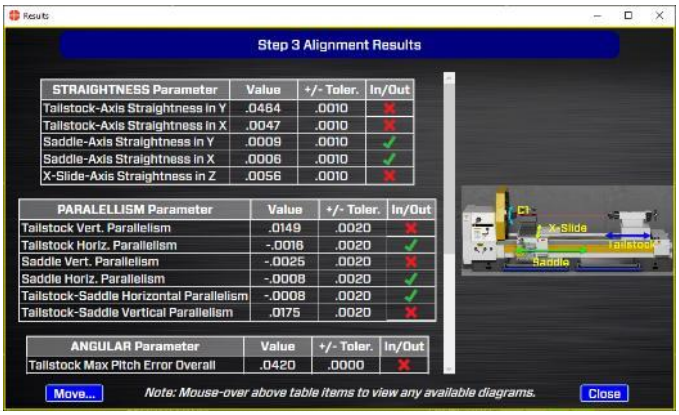
- Tailstock guideways
- Saddle/Subspindle/Turret guideways; or
- Both sets of guideways
- Squareness of Cross Slide (requires L-702SP)

Tailstock Guideways

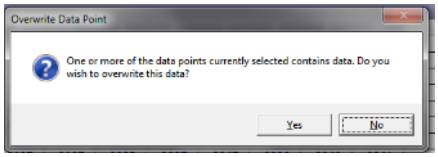
1. Move the tailstock (with the T-1296 securely clamped into the chuck) close to the headstock.
2. Ensure there is data displayed. Click ***Record*** or press the spacebar. You will hear a "beep" indicating the point has been recorded.
3. The green "cursor" (highlight) will move to the next point. Move the tailstock to the next point by the pre-determined distance specified in **Step 1**. **Note:** *The distance is noted at the top row of the data-taking grid.*
4. Wait 5-10 seconds and click **Record**. You may need to wait longer if the Avg is set to a high value (>20).
5. Continue taking data until all the points are taken.

Generating Alignment Results

If all data points are taken, you can now click **Results** to see the **Step 3: Alignment Results** pop-up, which shows the (V) straightness (flatness) and (H) straightness of the tailstock guideways and parallelism (V & H) of the headstock AOR to the guideways.



Retaking Data
To retake any of the data points, click the grid box for the point and click **Record**. A pop-up opens asking if you want to retake the data. Click **Yes** to record the new data point.



Switching Data-Taking Auto-Step Direction
To start data-taking with the tailstock at the far point, moving it toward the headstock, click the left arrow button. The cursor will move to the last point on the right and will advance left after taking a data point.

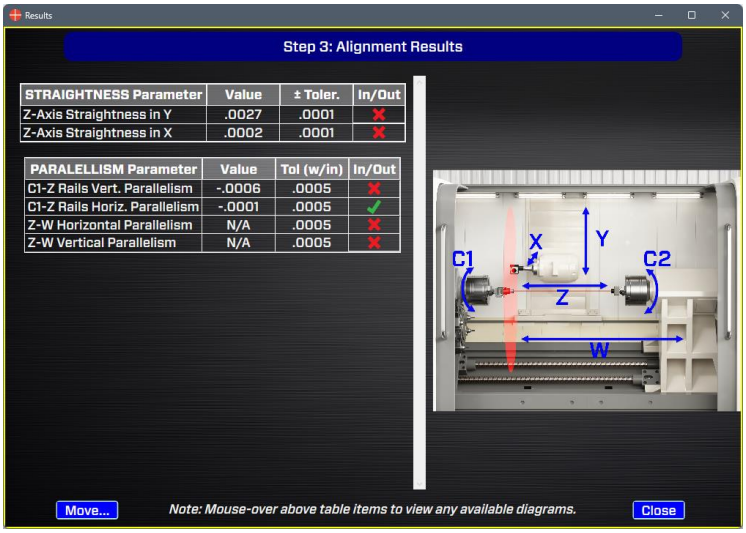
Taking Data for Saddle/Subspindle/Turret Guideways

1. Click the *Saddle* tab in the **Auto Step** box to switch to the data-taking screen for the saddle (subspindle or turret) guideways. The green "cursor" (highlight) will start at Point #1 for the lower set of rows.
2. Move the saddle (subspindle or turret) as described above.

Note** – you must first enable the Saddle Tab in Step 1.* ***See Page 39.

Generating Alignment Results

As described above, click on **Results** to display the straightness and parallelism results for both the Tailstock and Saddle sets of data.



Step 3: Move Screen

If you find that the V or H headstock parallelism is out of tolerance, click the ***Move*** button from the **Step 3: Alignment Results** Popup. A live adjustment screen displays where the parallelism values and a graphic depiction of the headstock AOR alignment relative to the guideways is shown. The display values update in real time and shim values are calculated for either the front or back feet to fix the angular error. Since we only need to fix the parallelism, shim the front *or* the back foot to fix the alignment.

How to Change Shim Values to Back Foot
The default shim calculation is for the front foot. To see the shim for the back foot, click the **Front** shim box and the value displays for the back foot.

What the Buttons Do

Reference Radio Buttons – Click on these buttons to change the parallelism values from the *Results* screen used in the Move Screen. The default is *Tailstock.* If *Saddle* is selected, then the parallelism values from the *Saddle* set of data will be displayed in the display area. If *Averaged Data* is selected, Lathe10 will average both sets of data and those will be displayed in the display areas.
Lock Icon – locks the shims from updating so you don't have to remember the values when inserting the shims.
Results – returns to the **Results** popup.
Step 4 – displays **Step 4: Lathe Bed Straightness Results** and provides a graph of the straightness for both the Vertical and Horizontal axes.
Close – returns to **Step 3**.
Averaging – increases or decreases the number of samples the displays average before showing the value. Increasing this value dampens out measurement noise and slows down the response time for moves.

Changing the Scale

Click on the + or – icon to zoom the scale in or out on the graph.

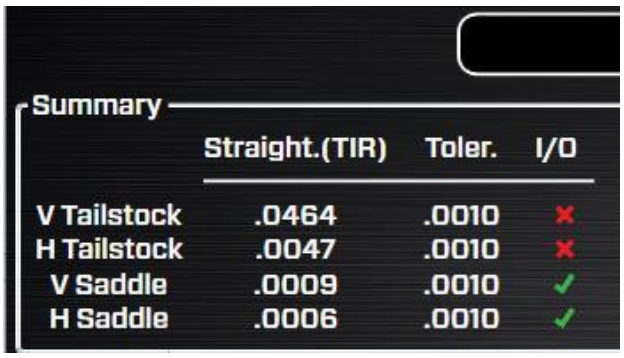
Lathe 10 Screens - Step 4: Lathe Bed Straightness Results

Step 4: Lathe Bed Straightness Results displays a summary of the alignment data taken in **Step 3**, as well as graphing the straightness data. There are several options to graph the data and you can print the alignment report from here.

Results Summary

The top of **Step 4** shows a summary of the lathe-bed alignment results:

- ***V Tailstock*** – Vertical straightness of the Tailstock guideways.
- ***H Tailstock*** – Horizontal straightness of the Tailstock guideways.
- ***V Saddle***– Vertical straightness of the Saddle (Turret or Subspindle) guideways.
- ***H Saddle***– Horizontal straightness of the Saddle (Turret or Subspindle) guideways.
- ***Straight (TIR)*** – This is the total straightness error (max minus min) using the least-squares, best fit algorithm, expressed in inches or mm. TIR = Total Indicated Runout.
- ***Toler.*** – Tolerance for the various axes as defined in **Step 1**.
- ***I/O*** – **X** = out of tolerance, √ = in tolerance
- ***Bed. Parallel***. – Parallelism of the headstock AOR relative to the guideways indicated in the row description. This also equals the slope of the Best-Fit line. Expressed in in/ft or mm/m or mm/100 mm.
- ***Comb. Parallel*** – This is the parallelism of the headstock AOR relative to an average of: a) the tailstock guideway parallelism, and b) the saddle parallelism, which is just the average of the two Best-Fit slopes. The data is expressed in in/ft or mm/m or mm/100 mm. This would be used in cases where there is a large error in the parallelism for both sets of guideways and you want to align to the average of both.



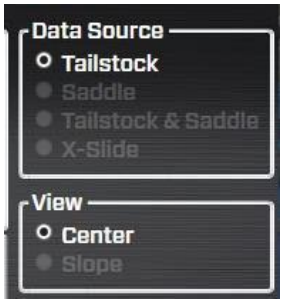
What the Buttons Do

Data Source

- ***Tailstock*** – Graphs the straightness data for the tailstock guideways (default).
- ***Saddle*** - Graphs the straightness data for the saddle guideways.
- ***TS & Saddle*** - Graphs both the straightness data for the tailstock and saddle guideways on the same graph.
- ***X*-Slide** – Graphs the data for the cross slide axis.

View

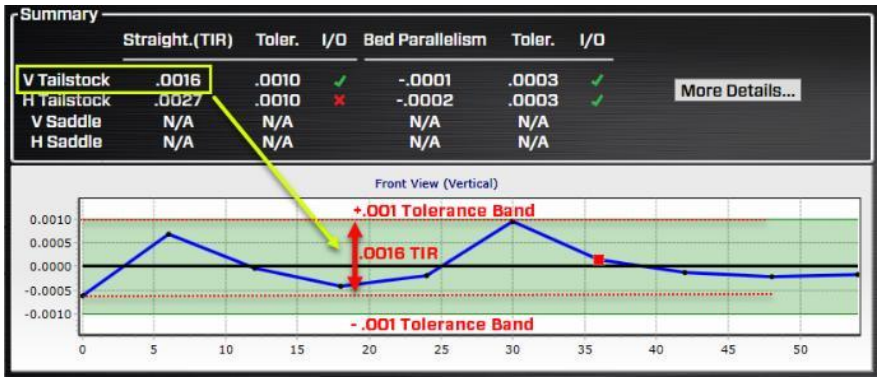
- ***Center*** - Plots the V & H *Center* values (default).
- ***Slope*** - Plots the V & H *Angular* values.



Plot Reference

Best Fit – (default) The straightness data is corrected by subtracting the slope of the Best-Fit line from each data point and then determining maximum and minimum values that deviate from zero. The difference between the max and min values is the overall TIR straightness for that set of data. The data is then plotted with the X Axis line (zero line) being equal to the best-fit line. The straightness tolerance values are set up as a ± band around zero.

In the **Summary Table**, a green √ or red **X** will indicate if the measured value is within or outside of the tolerances entered in Step 1. For example, for a .0005 in. straightness tolerance, Lathe10 will look at the absolute value of all the values relative to the *Best Fit* line and if any of those values are higher than .0005, it will be *out* of tolerance. For example, if the maximum of all the *positive* values is .0004 and the *minimum* of all the negative values is -.0003, then the straightness would be *in* tolerance. However, the *TIR Straightness* will be .0007.



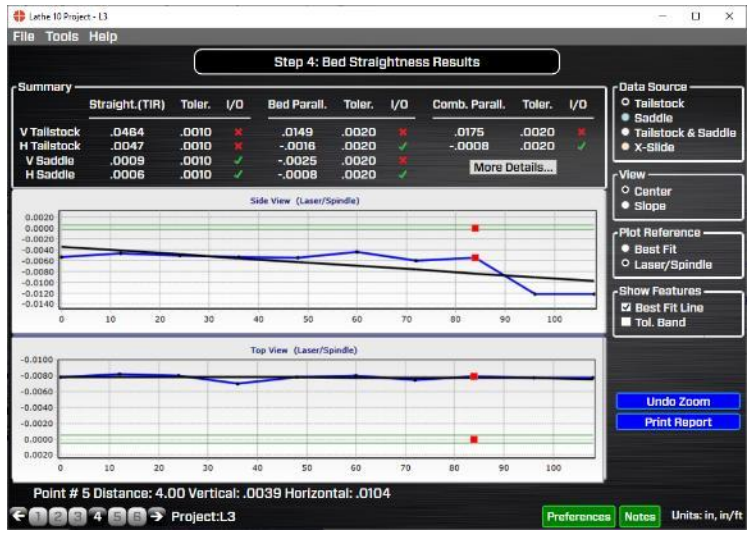
Laser/Spindle – When selected, the raw data is plotted relative to the laser beam (collinear with the headstock spindle's AOR) and the Best-Fit line is drawn through the data. The slope of the Best-Fit line shows which direction and by how much the spindle's rotation axis is tilting relative to the lathe bed.

Graph Using Best-Fit Plot as the Plot Reference

This graph plots the straightness of the V&H axes of the bed, using the best-fit line as the plot reference, which takes out the slope in the data due to the spindle axis not being parallel to the bed. The tolerance bands are drawn and filled in with green. Any values lying outside the bands are *outside* the specified straightness tolerance from **Step 1**.

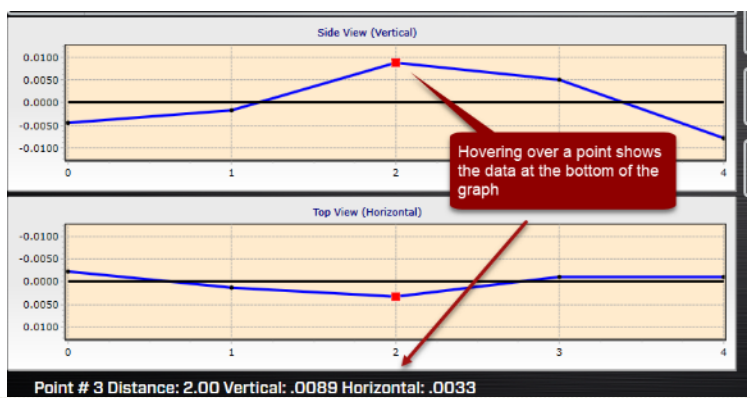
Graph Using Laser/Spindle as the Plot Reference

This graph plots the straightness of the V&H axes of the bed, using the raw data (Laser) as the plot reference. The raw data is plotted relative to the laser beam (headstock AOR). The Best-Fit line is drawn through the data. While the tolerance bands can be drawn, it is recommended that they be turned off since the raw data's first point might not be near zero, so the tolerance band would be meaningless. The slope of the Best-Fit line shows you how far the headstock AOR is tilted relative to the bed.



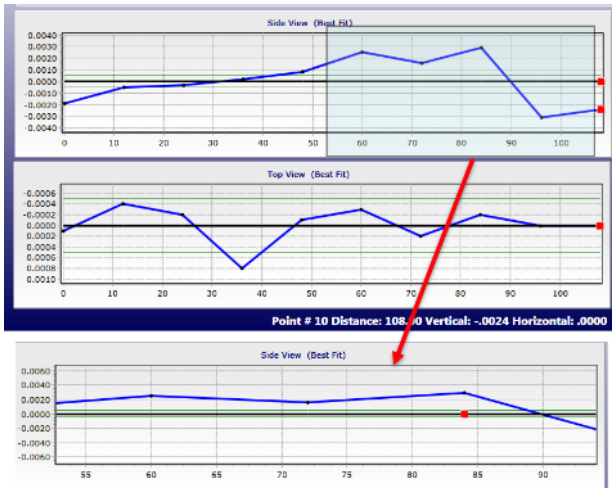
How to See Data for a Point on the Graph

To see the data for any point on the graph, hover over the point with the cursor, where you will see red square dots and the data values will be displayed at the bottom of the graph area.



Zooming in on the Graph

For long-bed lathes with many data points, you can zoom into a section of the graph to look more closely at the data. Click and drag the mouse over a section of the report and it zooms in to that part of the graph. To undo the zoom, click ***Undo Zoom***.

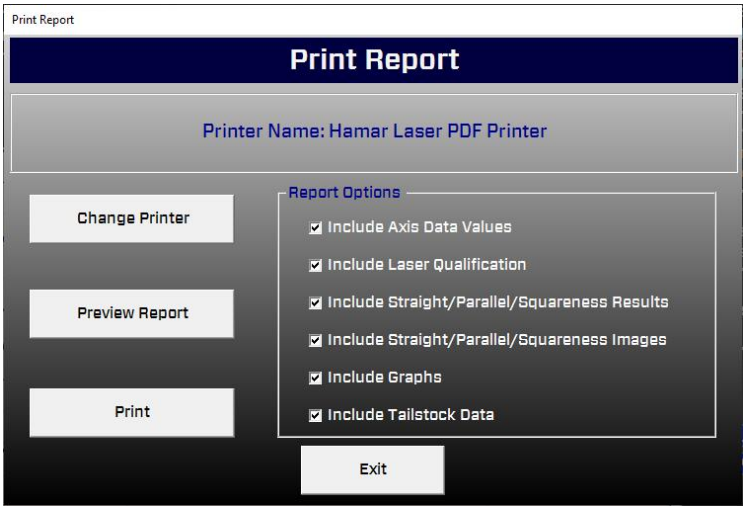


What the Buttons Do (continued)

Show Features

- ***Best Fit*** – Turns the Best-Fit line (black solid line) on or off from the graph display.
- ***Tool. Bands*** – Turns off the tolerance bands from any of the graphs.
- ***Undo Zoom*** – Resets the graph's original view of all the data.

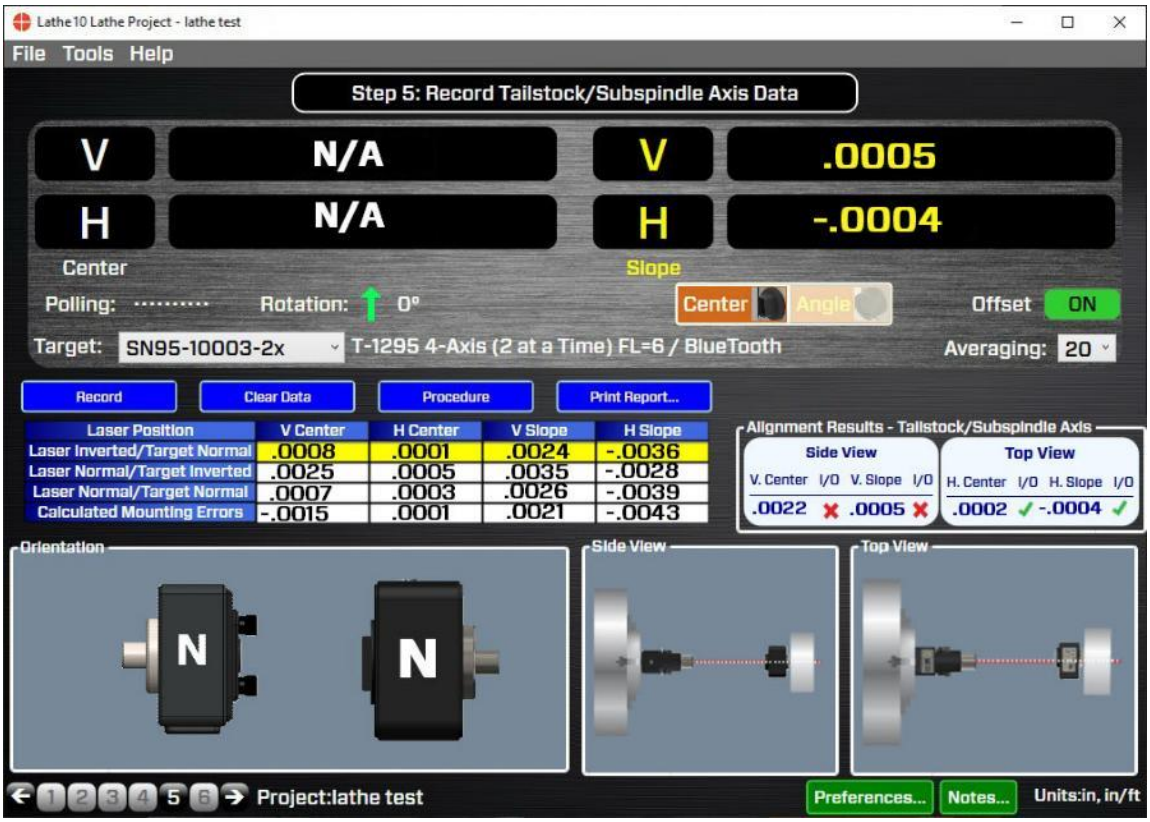
- ***Print Report*** - Opens the **Print Report** screen to make selections and print the report. You can also print from **Step 5**. See **Page 74** for more details on printing the Report.



Lathe 10 Screens - Step 5: Record Tailstock/Subspindle Axis Data

In **Step 5: Record Tailstock/Subspindle Axis Data**, we will be checking the coincidence (in 4 axes) of the headstock AOR to the tailstock centerline, subspindle AOR or turret tool-holder centerline. Once the data is recorded, the mounting errors for the 4 alignment axes are calculated and subtracted from the raw data. The actual alignment results are displayed, along with Side View and Top View spindle graphics to illustrate the direction of the misalignment. The tolerances entered in **Step 1** are then applied to see if the results are in or out of tolerance.

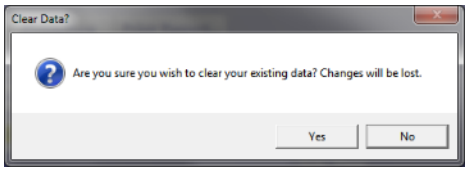
To calculate the results, 6 data points are needed. Click **Procedure** to open a popup providing instructions. On-screen graphics show how to orient the headstock spindle and tailstock/subspindle/turret to take the data.



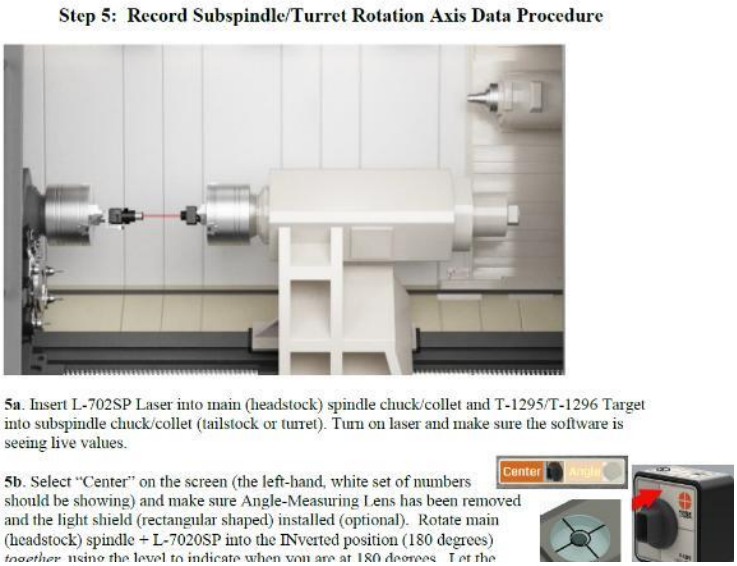
What the Buttons Do

- ***Record*** – Records the 2 axes of data for each point in the procedure. The green "cursor" automatically advances to the next point and updates the laser/target graphics to indicate how they should look when taking the *next* data point.

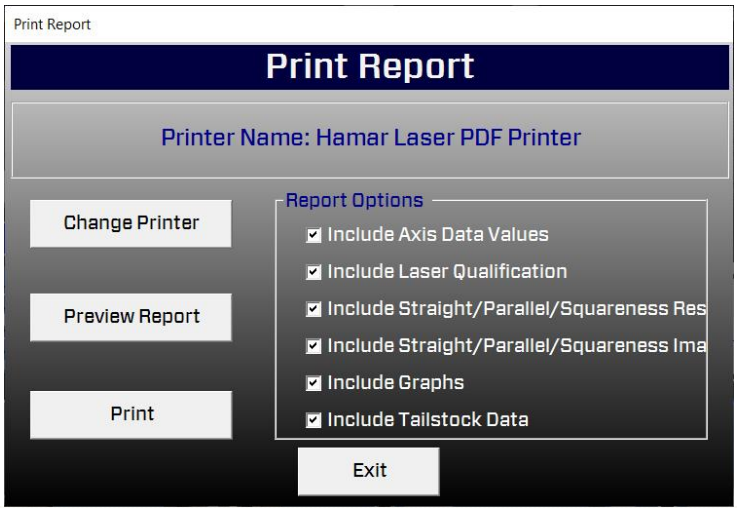
- ***Clear Data*** – Clears the data from the table with a request for confirmation.



- ***Procedure*** – Click here to bring up the section in the manual that has the procedure to take the data.



- ***Print Report*** – Click to print the report. You can also print from **Step 4**. See **Page 74** for more details on printing the Report.



Taking Spindle Alignment Data in Step 5

A simple 6-step procedure is used to take the spindle alignment data.

Note: *When rotating the laser and target, it is very important to rotate the spindle itself (with the laser in it), not the laser or target within the spindle chuck. In other words, never loosen the collet or chuck when taking alignment data of a rotating spindle (be it the headstock spindle or subspindle) during this procedure.*

By rotating the spindle and laser together, you are measuring the axis of rotation (AOR) of the spindle, which is the most important reference to use when aligning a spindle. If we just rotate the laser in the chuck, then we would only be measuring the alignment of the centerline as defined by the chuck jaws (or collet), not the spindle AOR, which, of course, could be ok if the chuck doesn't rotate, such as the tailstock.

Procedure

1. *Invert* the L-703S Laser/spindle, keeping the T-1296 target in the NORMal position. Make sure the level on top/bottom of the laser is level.

   Click **Record** or press the spacebar to record the first data point. Notice the graphics on the screen indicate how to orient the laser and target (Normal or Inverted) for the *next* point.

   Make sure they both are oriented like the images shown in Step 5 *before* you take the data point. It is also a good idea to wait 10 seconds (or longer if the Avg is set >20) after rotating the laser/target before recording the data point to let the data updating settle down.

2. Rotate the L-703S Laser/Spindle back to the NORMal position. For the tailstock, loosen the chuck, rotate the T-1296 to the INverted position, tighten the chuck and click **Record** (or press the spacebar*)* to record the second data point. The same applies if you have a fixture in the turret tool holder.

   If you are measuring a subspindle, then do *not* loosen the chuck or collet but *rotate* the spindle with the T-1296 in it. Wait 10 seconds or so before clicking **Record.**

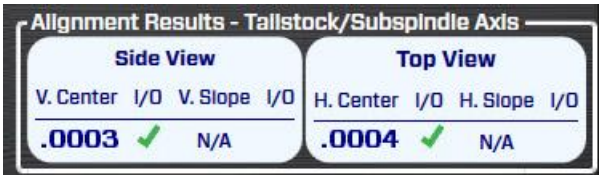
3. Leaving the laser in place, loosen the tailstock chuck, rotate the T-1296 to the NORMal position, tighten the chuck, and click **Record** (or press the spacebar*)* to record the third data point. The same applies if you have a fixture in the turret tool holder.

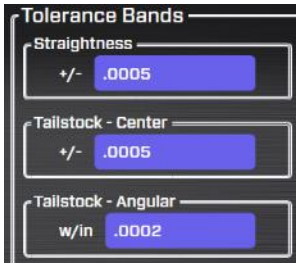
   If you are measuring a subspindle, then do *not* loosen the chuck or collet, but *rotate* the spindle with the T-1296 in it back to the NORMal position. Wait 10 seconds or so before clicking **Record**.

Interpreting the Results

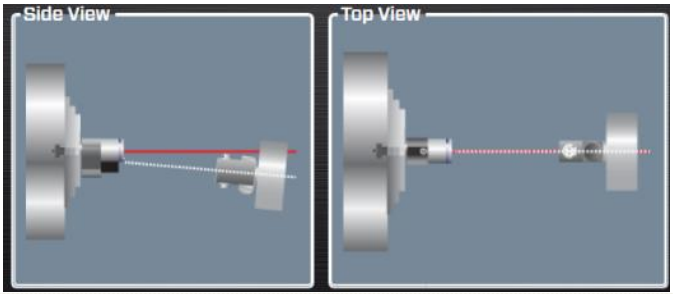
After recording the 3rd point, Lathe10 calculates the mounting errors of the laser and target and subtracts them from the raw data, applying display offsets to the 4 real-time data displays. These values are the actual alignment values of the tailstock chuck centerline, the turret tool holder centerline or the subspindle AOR relative to the headstock AOR.

Alignment results are also shown in the **Alignment Results – Tailstock/Subspindle Axis** area of the screen. The tailstock *Center* and *Angular* tolerances from **Step 1** are applied to the data. An **X** indicates out of tolerance and a green check √ indicates in tolerance.





Static spindle graphics show a *Side View* and *Top View* of the Tailstock/Turret/Subspindle relative to the headstock AR.

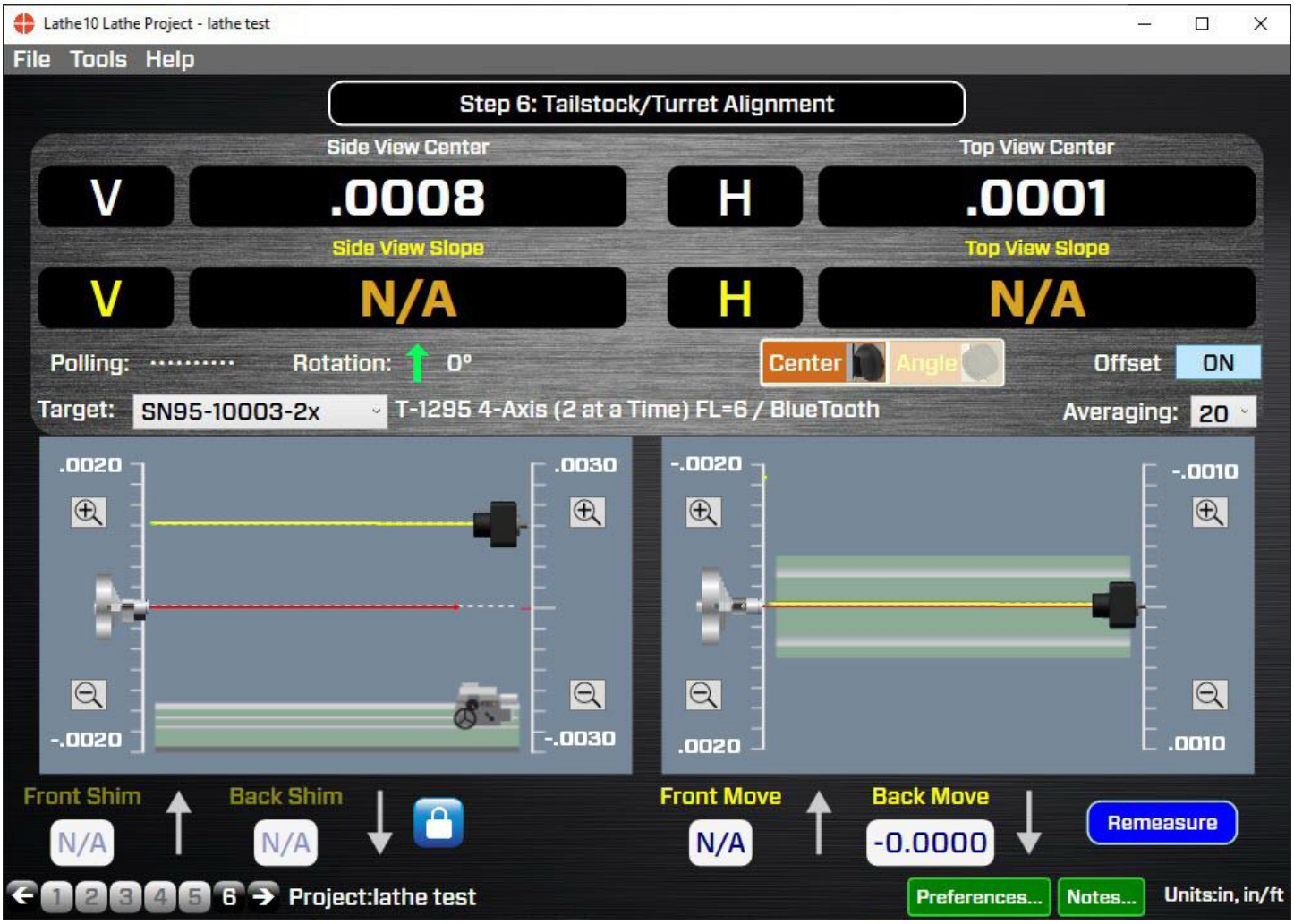


Out of Tolerance

If the alignment of the Tailstock/Turret/Subspindle is out of tolerance, click **Step 6** to go to **Step 6: Tailstock/Turret Alignment**.

Lathe 10 Screens – Step 6: Tailstock/Turret Alignment

Step 6: Tailstock/Turret Alignment provides a real-time, 2-axis display of the 4 alignment values. A target graphic is used to interpret the values for the Vertical and Horizontal axes of the tailstock centerline or subspindle rotation axis. The target graphic will update with changes in the alignment values, so you can watch the tailstock/subspindle come into alignment as you adjust it. Tolerance bands indicating the values entered in **Step 1** are displayed and are color-coded to indicate if the values are in or out of tolerance.



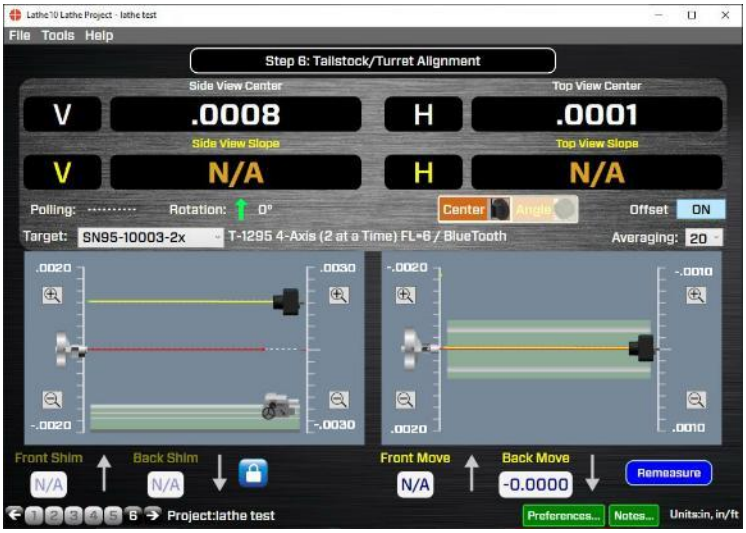
What the Buttons Do

- **Remeasure** - After you add shims and perform moves, click **Remeasure** to return to **Step 5**, which clears the values from the table so you can retake the spindle data to verify it is aligned.

- **Offsets** –This button turns the mounting-error display offsets calculated in **Step 5** on or off. These offsets are applied to the raw target values to remove the mounting errors and display the actual alignment in the four real-time displays. The default setting is **ON** and normally it is not turned off.

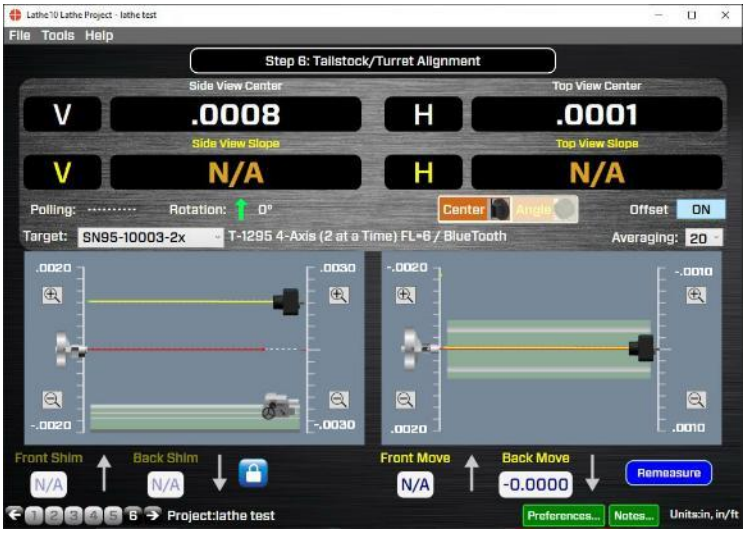
- - Click to "zoom in" (decrease) the scale on the graph to magnify the graphical depiction of the alignment center offset and angle. There are separate Zoom buttons for the *angle* graphics and the *center* graphics

- Click here to "zoom out" (increase) the scale on the graph to decrease the graphical depiction of the alignment offset and angle. There are separate Zoom buttons for the *angle* graphics and the *center* graphics.



Interpreting the Plus and Minus Signs in the Live Displays

The signs of the data displays will tell you what position (high/low or left/right) the target is relative to the laser beam. See the interpretation below.



Vertical Axis

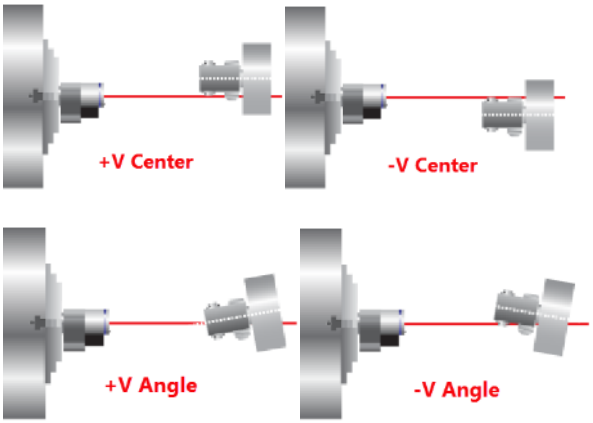
A **+V** *center* value indicates the target is higher than the laser beam.

A **+V** *angular* value indicates the back of the target is *higher* than the front of the target.

A **–V** *center* value indicates the target is lower than the laser beam.

A **-V** *angular* value indicates the back of the target is *lower* than the front of the target.

Side View



Horizontal Axis

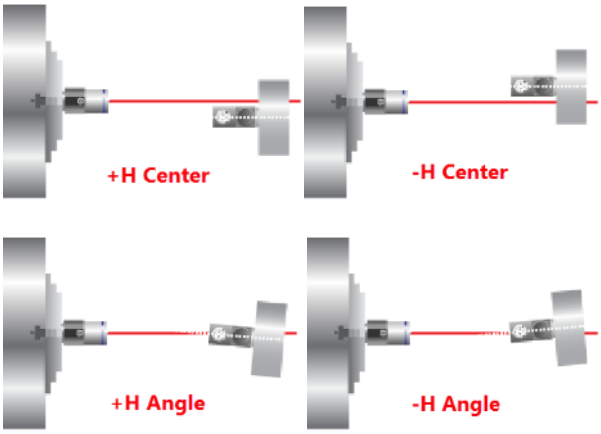
A **+H** *center* value indicates the target is to the right of the laser beam when looking from the laser *into* the T-261 target.

A **+H** *angular* value indicates the back of the target is to the *right* of the front of the target when looking from the laser *into* the T-261 target.

A **–H** *center* value indicates the target is to the *left* of the laser beam when looking from the laser *into* the T-261 target.

A -H *angular* value means the back of the target is to the *left* of the front of the target when looking from the laser ***into*** the T-261 target.

Top View



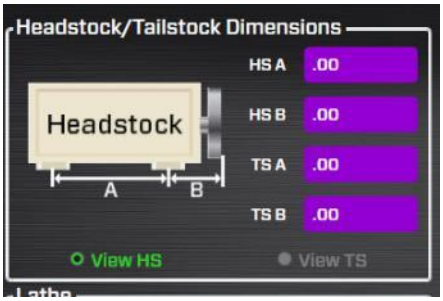
Shim Values

Lathe10 automatically calculates shim values (for the Vertical axis) and move values (for the Horizontal axis) to re-align the tailstock, subspindle or turret. The shim values are calculated using the dimensions entered in **Step 1**.

The *Shim* values are locked while the *Move* values update with changes in the H-axis alignment values.

The Lock Icon will unlock or lock the *Shim* values. Default is *locked*.

Arrows next to the shim/move displays indicate whether to add or remove shims and in which direction to move the "feet" of tailstock/subspindle.



Aligning the Tailstock/Subspindle

In **Step 6**, display offsets are applied to the raw target values to remove the mounting errors. That means that the real-time displays show the *actual* alignment values of the tailstock or subspindle relative to the headstock AOR. The display values and the graphics update in real time with each move of the tailstock.

The graphics show a Side View (V-center, V-angle) and Top View (H-center and H-angle) of the tailstock/subspindle relative to the headstock spindle axis.

When using the T-1295 or T-1296, the data values are shown 2 axes at a time. Either V Center and H Center or V Angle and H Angle. The default setting when first entering Step 6 is Angle. You want to align the angles first. Then you align the center values.

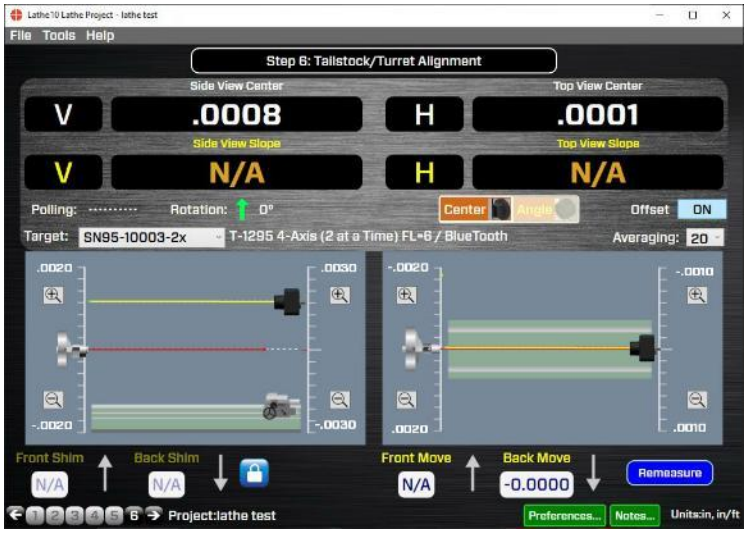
When using the T-261 Target, the data values are showing for all 4 axes simultaneously.

The yellow line attached to the Target graphic shows which way the tailstock/subspindle axis is tilted relative to the headstock AOR, which is represented by the red laser line. For the center values, the yellow line shows the position of the tailstock/subspindle center relative to the headstock center.

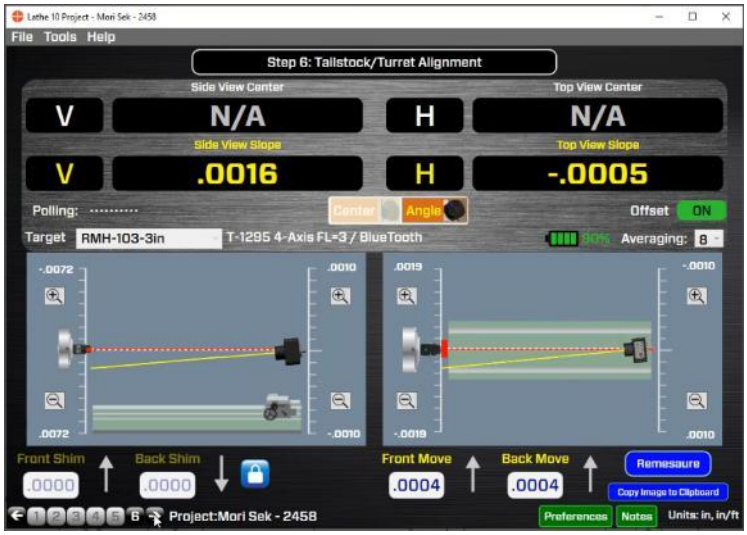
The white dotted line with the laser (reference) represents the centerline of the headstock's rotation axis.

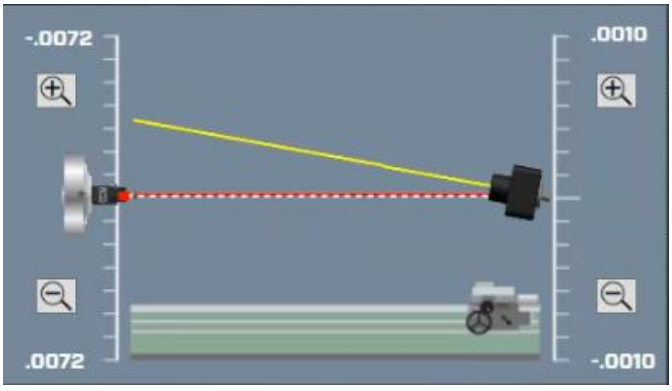
To align the tailstock/subspindle, simply adjust it so that the four alignment values are zero, or within tolerance as specified in **Step 1**. Always begin with the *angular* values and then work on the *center* values. This is because adjusting the angle of the tailstock or subspindle box will also affect the center values.

Center Values Displayed



Angular Values Displayed





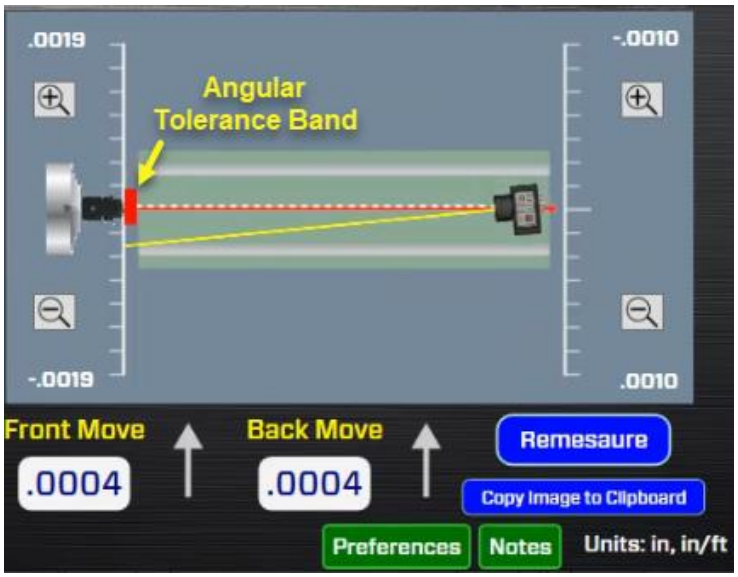
Tolerance Bands

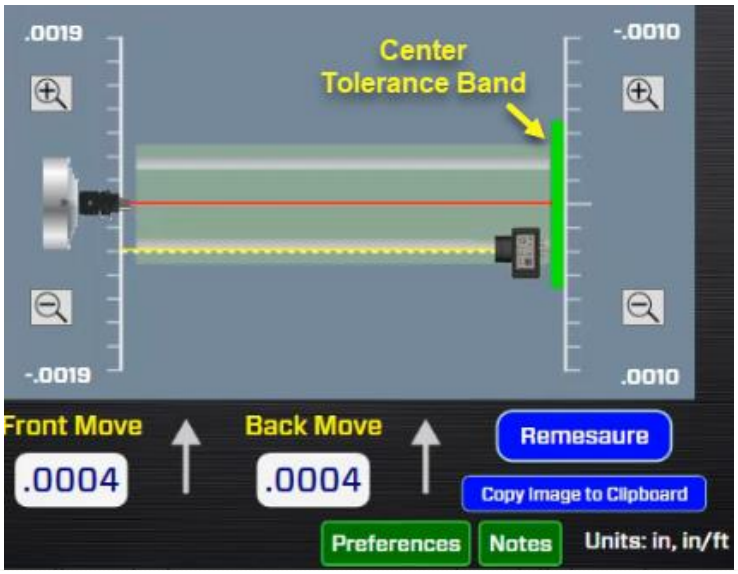
Tolerance bands are displayed in the graph area to indicate whether the alignment is in or out of tolerance, as specified in **Step 1**.

The angular tolerance band is on the left side of the graph and is only displayed when the angular values are selected. The center tolerance is on the right side of the graph and is only shown when the center values are selected.

Red indicates it is out of tolerance

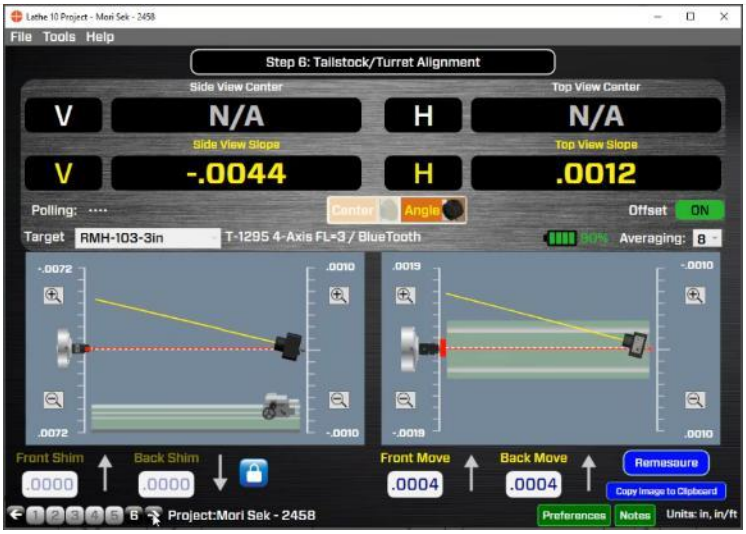
Green indicates the values are in tolerance.





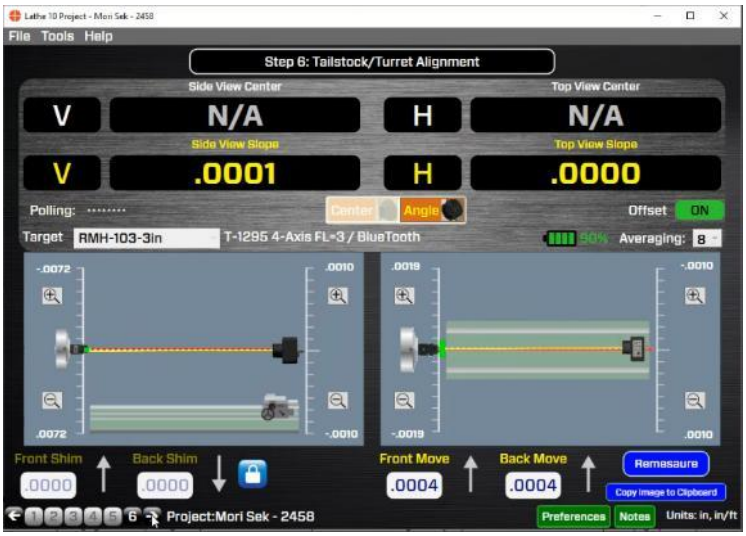
Aligning the Tailstock/Subspindle (continued)

In the screen to the right, both angular values are out of tolerance (the tolerance bands are all red), so the tailstock is *not* aligned.



First, fix the A*ngular* misalignment. This is because changing the angle will affect the center value, depending on where the pivot point is for the tailstock/subspindle.

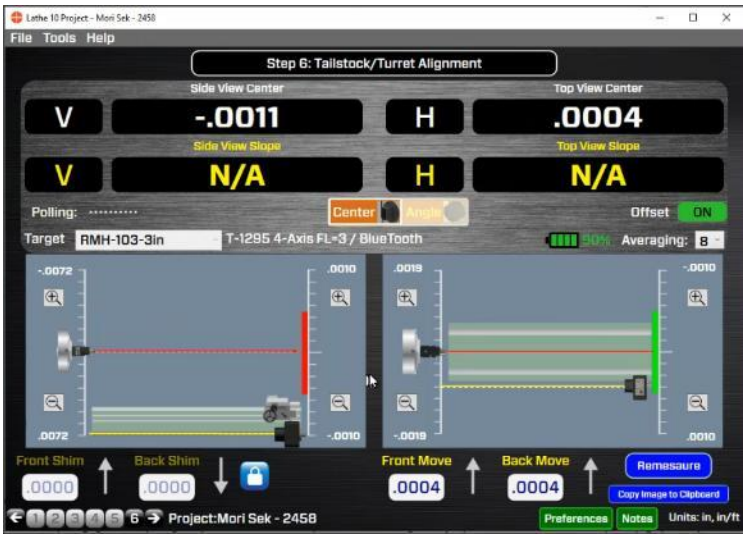
In this screen, the V & H angles are now aligned.



When the angles are aligned, work on the *Center* values.

In the screen to the right, all the V-axis center values are out of the specified tolerances from **Step 1**, as shown by the red tolerance band, so this would need to be aligned.

To verify the alignment, click **Remeasure** to return to **Step 5** and re-take the alignment data. If you want to save a screen capture of the graph, click on **Copy Image to Clipboard**



Printing Reports

You can print a report from **Step 3**, **4** or **5** by clicking **Print Report in the Tools menu.** In Step 5, there is also a print button over the data table.

Clicking the print button opens the *Print Report* dialog box, where you can select a printer, preview the report, hide certain sections of the report and print the report.

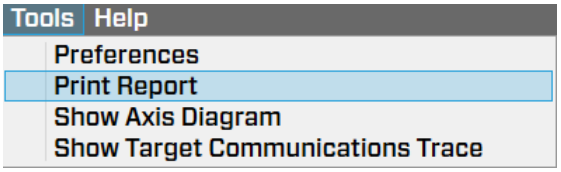


Figure 37 - Step 5 Print Button

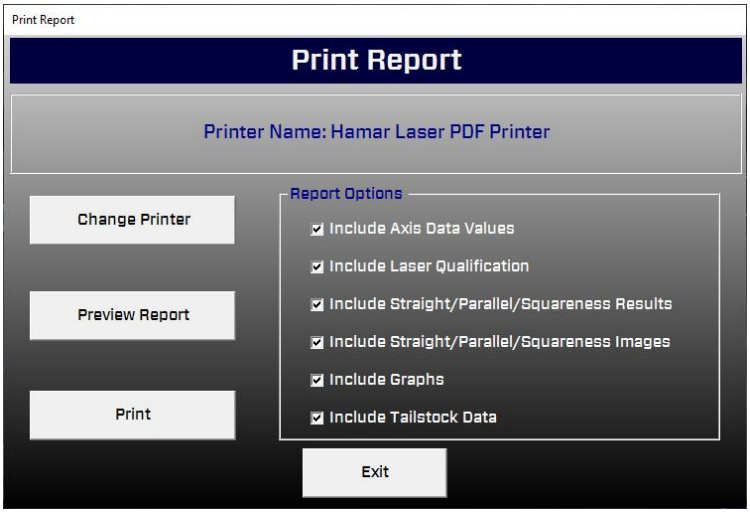
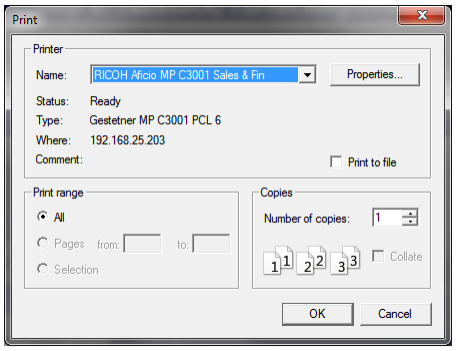


Figure 38 - Print Report Dialog Box

What the Buttons Do

- ***Change Printer*** – This opens the Windows printer dialog box, where you can select either your printer or print the report to a .pdf file for emailing.

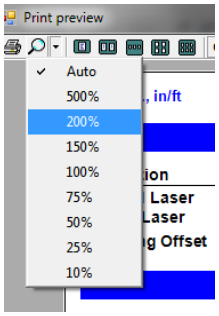
  Note: *Hamar Laser can supply its own PDF printer that will print the report directly to a PDF document for emailing or printing later.*



- ***Preview Report*** – Click to open a preview window of the report. The preview window default shows one page at a time.

  You can show multiple pages at a time by clicking the buttons at the top of the screen.

  Clicking the magnifying glass will zoom in on the pages.



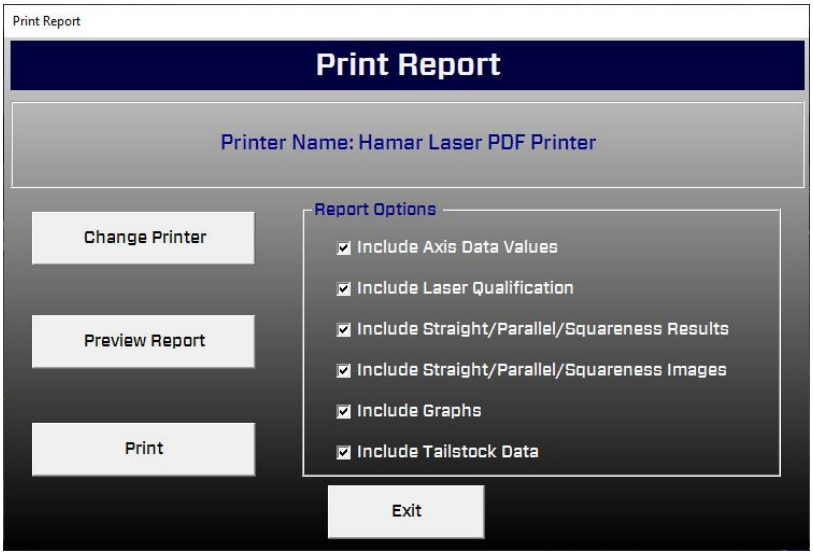
- ***Print*** – Skips the preview and prints the report to the previously selected printer.

- ***Exit*** – Closes the popup and returns to the Lathe10 screen.

Excluding Sections on the Report

To hide a section, uncheck it in the **Report Options** list.

- *Include Axis Data Values* – shows or hides the raw values for the axis data recorded.
- *Include Laser Qualification* –shows or hides the data from **Step 2: Laser Qualification**.
- *Include Straight/Parallel/Squareness Results* – includes or hides the **Step 3: Bed Straightness** data table and the **Step 4: Straightness Graphs**.
- *Include Straight/Parallel/Squareness Images* – includes or the machine graphics that illustrate the alignment.
- *Include Graphs –shows or* hides the summary of the straightness graphs from **Step 4.**
- *Include Tailstock Data* – includes or hides **the Step 5: Spindle Axis Data** and the **Summary of the Alignment**.



Appendix A – The NORMIN Method (Bore and Spindle)

The NORMIN method was developed by Hamar Laser Instruments as a way of compensating for laser or target mounting errors in bore or spindle work. The word is a contraction of "NORMal-INverted," which briefly describes the method. It is similar to the 4 clock readings taken with dial indicators but uses a laser and a target instead. The NORMIN method is used in conjunction with simple fixtures and targets that allow inexpensive, precision measurement. The target/fixture is set in the bore or spindle in the NORMal position (cable down) and the readings are recorded. Then the target/fixture is rotated 180 degrees to the INverted (cable up) position, and a second set of readings is obtained. The 2 sets of readings cancel out centering errors and provide a very accurate result.

There are 3 centers involved in bore alignments: True Bore Center, Target Center, and Laser Reference Centerline. If mounting fixtures were perfect, the Target Center would be located at the True Bore Center, and if perfectly aligned, the True Bore Center would be located at the laser beam center. However, they seldom line up. An example of the three centers with respect to one another is shown in Figure 393.

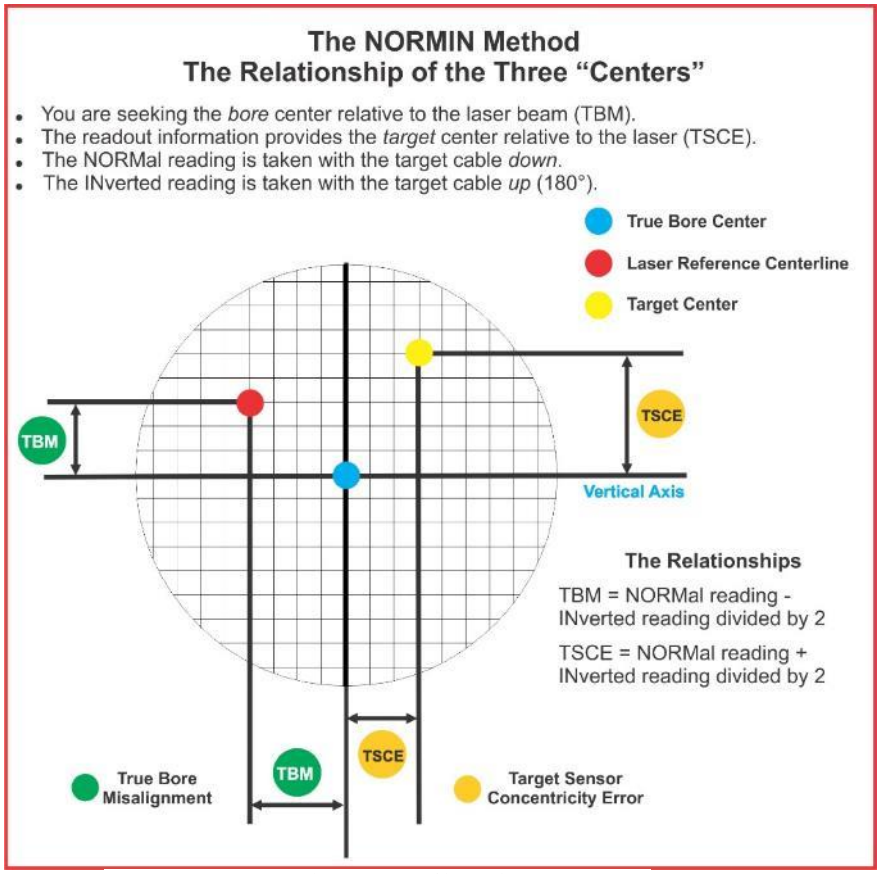


Figure 39 -- *Three centers of bore alignment*

Two relationships can be calculated from these 3 centers and 2 sets of NORMIN readings: Target Sensor Concentricity Error (TSCE) and True Bore Misalignment (TBM). The True Bore Misalignment (TBM) is used when it is desirable to know the true bore centerline position relative to the laser beam center without fixture errors. Usually, the laser beam center is where a bore center *should* be located, and the TBM shows its *actual* location. The Target Sensor Concentricity Error (TSCE) is used if the operator wants to place the laser beam center exactly in the middle of a bore.

The general rule is buck-in to the TSCE and measure the TBM.

The readout always shows the displacement between the Target Center and the Laser Beam Center. When the Target Center is not on the True Bore Center, the numbers and the signs on the readout will change when the target is rotated because the Target Center is moved to a different location in relationship to the laser beam.

Figure 40 represents the target in the NORMal position, with the cable *down*. If each square represents .001", the Target Center is .002 in. higher than the Laser Beam Center (+.002 in.) and is .007 in. to the right of the Laser Beam Center (+.007 in.).

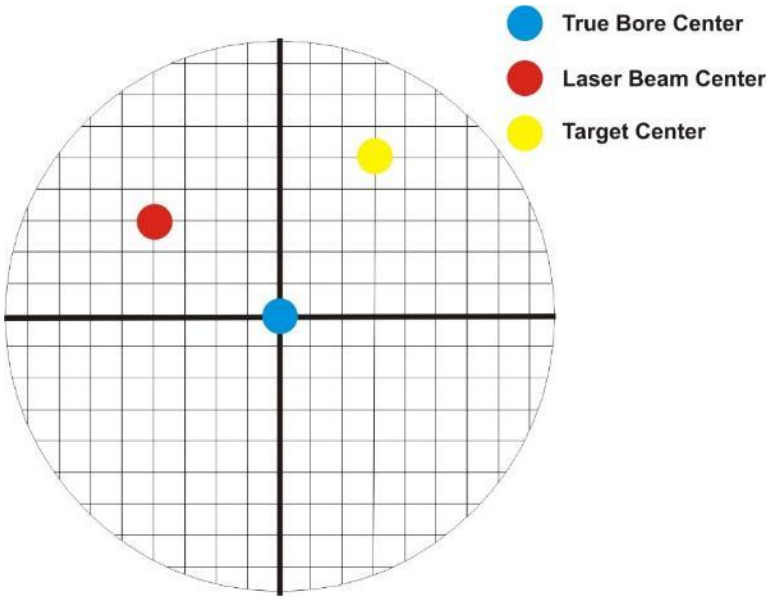


Figure 40 - Target in the NORMal position

Figure 41 represents the target in the INverted position, with the cable *up*. When the target is rotated, the *signs* on the readout are also rotated. Therefore, although the Target Center appears to be to the right of and lower than the Laser Beam Center in, the vertical readings are positive, and the horizontal readings are negative. When the vertical TCE is calculated, (Normal Inverted divided by 2) the Target Center is .004 in. higher and .003 in. to the right of the True Bore Center in the NORMal position.

The table below shows the calculation of the vertical and horizontal TSCE values.

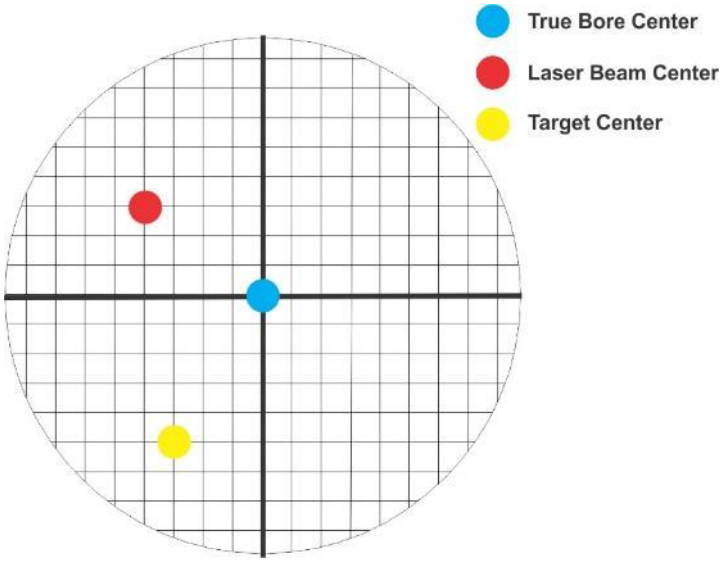


Figure 41 - Target in the INverted position

NORMal Vertical Reading +	+.002 in.		NORMal Horizontal Reading +	+.007 in.
INverted Vertical Reading	+.008 in.		INverted Horizontal Reading	-.001 in.
Total	+.010 in.		Total	+.006 in.
Divide by 2 = **Vertical TSCE**	**+.005 in.**		Divide by 2 = **Horizontal TSCE**	**+.003 in.**

If you place the Laser Beam Center exactly on the True Bore Center with the target in the NORMal position, the readings will show Vertical +.005 in. and Horizontal +.003 in.

Appendix B – Qualifying the Laser – Manual Method (no software)

Lasers must be qualified; that is, the beam must be made parallel (and sometimes centered) to the axis of rotation. This can be either the axis of the laser mounting stud or of a spindle in which the laser is mounted.

Typically, due to mounting errors, it is important to adjust a laser so that it is aligned to the spindle axis of rotation rather than to its own mounting stud. A laser that has been qualified for a particular application will need to be re-adjusted for another. The following procedure is used to qualify the L-700 or L-703S laser to a desired axis.

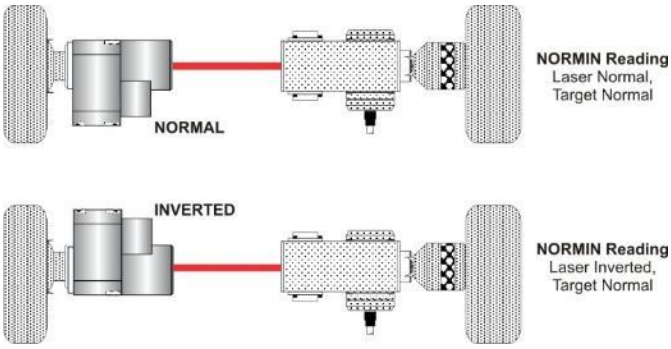
Warning!!
This procedure is for adjusting the laser only. While the software allows the user to adjust the target, targets are factory-qualified and need no field adjustments. Attempting to do so could potentially damage the target

The NORMIN Method

The NORMIN method is a way of canceling mounting errors. The word is a contraction of "NORMal-INverted," which briefly describes the method.

To take NORMIN readings, the laser and target fixtures are set in the NORMal position (cable down) and the readings are recorded. Then the target fixture is rotated 180 degrees to the INverted (cable up) position and a second set of readings is obtained. The two sets of readings cancel out both laser and target center and angular mounting errors and provide a very accurate result.

For a detailed description of the NORMIN method, see Appendix A – *The NORMIN Method*, beginning on **Page 79**.



NORMIN Reading
Laser Normal,
Target Normal

NORMIN Reading
Laser Inverted,
Target Normal

Figure 42 - Taking NORMIN Readings

Adjustments

The L-700 laser has centering and angular adjustments on the faceplate. The beam is emitted from the large hole in the center. The illustration below shows the location of the various adjustment screws.

Warning!!
Avoid direct exposure to the laser beam while adjusting the laser. Do not stare into the beam.

Manual Qualification Using A-801 Fixture

After error correction readings are taken (to cancel out mounting and other errors), a set point is calculated. The laser beam is then adjusted to the set point, making it parallel to/coincident with the desired axis of rotation.

Manually qualifying requires the user to calculate the set point from the error correction readings before adjusting the laser to that point. A computer program, such as LATHE10, calculates the set point for the user and zeroes the display at that point. The user then adjusts the laser beam to zero. While many users find the software-assisted method slightly easier, both procedures are essentially the same, and both will result in a qualified laser.

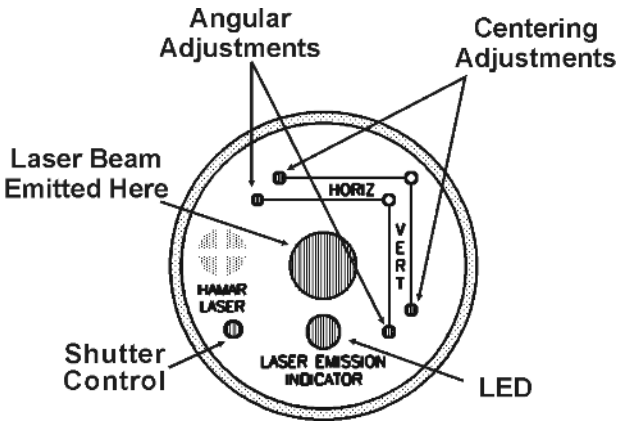


Figure 43 - Laser Adjustment Screws

Hardware Requirements

The common equipment required to perform a qualifying procedure would be a target, an L-700 laser, and the spindle or fixture to hold the laser and target. To measure both the angle and center, a 2-axis target with an angle module (the T-212) or a 4-axis simultaneous target (such as the T-261A) is required. If the laser is being qualified to its own mounting stud axis of rotation, the recommended fixture is the Hamar Laser Model A-801 alignment/calibration fixture.

Each method also has its own additional requirements. The manual procedure requires a readout. The software-assisted procedure requires a computer and interface and Lathe10, Spindle8 or Read8 software.

Manual Qualifying Procedure Using A-801 Fixture

The following procedure explains how to qualify the laser with a 4-axis target and a handheld readout. The best way to do this is to calculate set points for *angle* and adjust the laser angle first. The user then goes back and calculates the *center* set points and adjusts the laser centering.

Setup

1. **Connect the target to the readout.**
   Plug the target into the readout and switch on the readout.

2. **Set the laser and target in the spindle or fixture.**
   If qualifying to a spindle (or spindle mounting fixture), mount the laser in the spindle and the target in the master part. (If the beam does not strike the target cell while mounted in the spindle, move the spindle head until the readout window displays a reading and the "On-Target" light is on.)

If qualifying the laser to its own mounting stud axis, mount the laser and target facing each other in the A-801 calibration fixture.

Adjusting the Laser Angle

1. **INvert the laser with the target in the NORMal position.**
   Set the laser in the Inverted (cable up) position, with the target in the NORMal (cable down) position and wait for the readings to stabilize (approx. 10 seconds). Write down the angular INverted reading.

2. **Rotate the laser to the NORMal position.**
   Rotate the laser to the NORMal (cable down) position, with the target still in the NORMal position, and wait for the readings to stabilize (approx. 10 seconds). Write down the angular NORMal reading.

3. **Calculate set points for each axis.**
   Calculate the set points for each axis--vertical and horizontal angle--with the following formula:

   (NORMal reading + INverted reading) / 2 = Set Point

If, for example, the following vertical NORMIN readings are taken:
NORMal = .0021, INverted = -.0017, the equation would read:

[(.0021) + (-.0017)] / 2 = (.0004) / 2 = .0002

In this case, .0002 would be the vertical angular Set Point. Use the 2 vertical angular readings to calculate the Set Point for vertical angle. The horizontal angle Set Points would be calculated in the same way.

4. **Adjust vertical and horizontal angle to Set Points.**
   Adjust the angle using the angular controls on the laser faceplate until the readout displays the calculated set points.

Adjusting the Laser Centering

1. **INvert the laser with the target in the NORMal position.**
   Set the laser in the Inverted (cable up) position, with the target in the NORMal (cable down) position and wait for the readings to stabilize (approx. 10 seconds). Write down the center INverted reading.

2. **Rotate the laser to the NORMal position.**
   Rotate the laser to the NORMal (cable down) position, with the target still in the NORMal position, and wait for the readings to stabilize (approx. 10 seconds). Write down the center NORMal reading.

3. **Calculate set points for each axis.**
   Calculate the set points for each axis--vertical and horizontal center--with the following formula:

   (NORMal reading + INverted reading) / 2 = Set Point

If, for example, the following horizontal NORMIN readings are taken:
NORMal = -.0014, INverted = -.0006, the equation would read:

[(-.0014) + (-.0006)] / 2 = (-.0020) / 2 = -.0010

Thus, in this case, -.0010 would be the horizontal center Set Point. Use the vertical center readings to calculate the Set Point for vertical centering. The horizontal center Set Points would be calculated in the same way.

4. **Adjust vertical and horizontal center to set points.**
   Adjust the center using the centering controls on the laser faceplate until the readout displays the calculated set points.

Checking Results

To confirm the results, invert the laser. The display should show the ***same reading, same sign*** (+ or -) as it did in the normal position, to within .0002 in. in the calibration fixture (results may be slightly less accurate in a spindle due to bearing runout). If the results are not close enough, recalculate the set points and readjust the laser unit.

The user should get as close to a zero difference on the readout as possible; however, in some fixtures or applications, this may not be practical. If there is any doubt about the consistency of results, check the repeatability of the fixture using the REPEAT function of the Read8 software. This will establish a tolerance within which the user can work.

Appendix C – Target Calibration – T-261 Target Using Read8

Before a new target can be used, it should be calibrated. If the target is purchased as part of a system, it will be calibrated at the factory and the resulting calibration factors will be included with the target, that can be uploaded into the software, such as Lathe10 – see page 33-35 to see how to upload target calibration factors.

If the user wants or needs to calibrate a target, the process involves moving or tilting a target a known amount from center or zero and observing the actual readings. The calibration factors are then calculated and used by the software to adjust the actual target reading to match the actual target displacement.

Four calibration factors (+V, -V, +H, -H) must be set for each 2-axis target. A 4-axis target (T-261, T-266, T-267 and T-212) requires eight factors (+V, -V, +H, -H, for center *and* for slope). Calibration factors may be entered manually, or calibration may be done automatically by the program.

***Note**: the T-1295/1296 Targets are new and can only be calibrated at the factory. Check back soon for a procedure to use the A-807 for these targets.*

Calibration Setup

1. Mount the laser and target.

Note: *Error! Reference source not found. shows the target mounted in the Hamar Laser A-807 fixture stand. In order to take advantage of the automated calibration features available with the Read8 software, this fixture stand must be used for calibrating center and slope targets. Mount the laser in the non-adjustable hole on the fixture. Mount the target in the tilt plate with both the target and laser in the normal position (cord down).*

An appropriate target stand with micrometer stage, such as the Hamar Laser T-230, or any calibrated x-y slide, may be used when calibrating center-only targets (see **Figure 45***).*

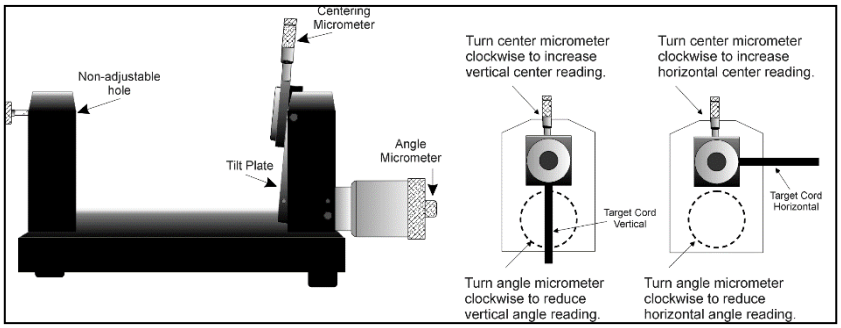


Figure 44 - Model A-807 Calibration Mounting Fixture

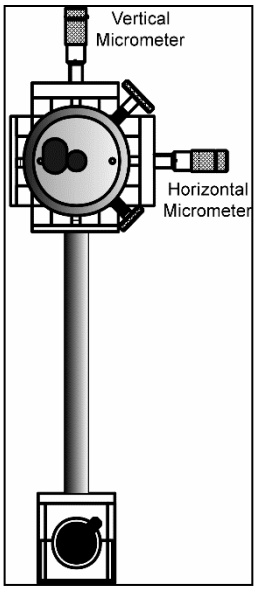


Figure 45 - T-230 Target Stand

2. Check all connections.

Connect the target to the interface, making note of the port to which it is connected, and make sure the interface is connected to the computer. Turn on the laser power supply.

3. **Start the Read8 program and select Target Setup from the Setup Screen.**
   Click the **New Target** button. The New Target screen displays (see **Figure 46**).
   Click the down arrow next to the **Type** list box to see a list of targets. Select the target you want to add. You may enter a new name for the target and the target serial number.

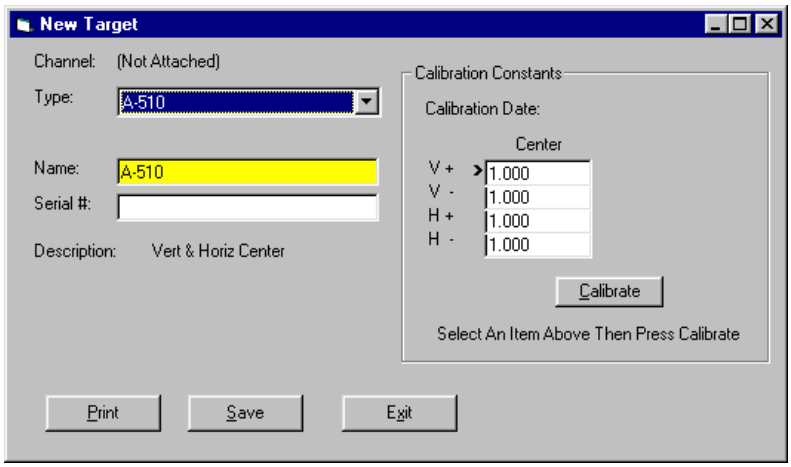


Figure 46 - New Target Screen – 2-axis Target

4. **Select the calibration factor from the list in the Calibration Constants menu, (+V, -V, +H, -H) then click the Calibrate button or Press Alt-C.**

   Note: *The preferred procedure is to calibrate the vertical axes, both center and slope if appropriate, then rotate the target in the fixture 90 degrees and calibrate the horizontal axes. If working with a fixture that has a horizontal micrometer, there is no need to rotate the target.*

   The Select Channel/Port for Target menu displays (see **Figure 47**). Select the channel or the port to which the target is attached and click **OK**. The Calibration Screen displays and indicates the Port or Channel selected (see right arrow in **Figure 48**).

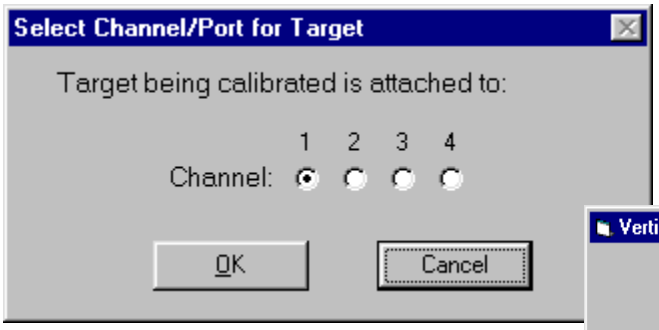


Figure 47 - Channel/Port Selection Screen

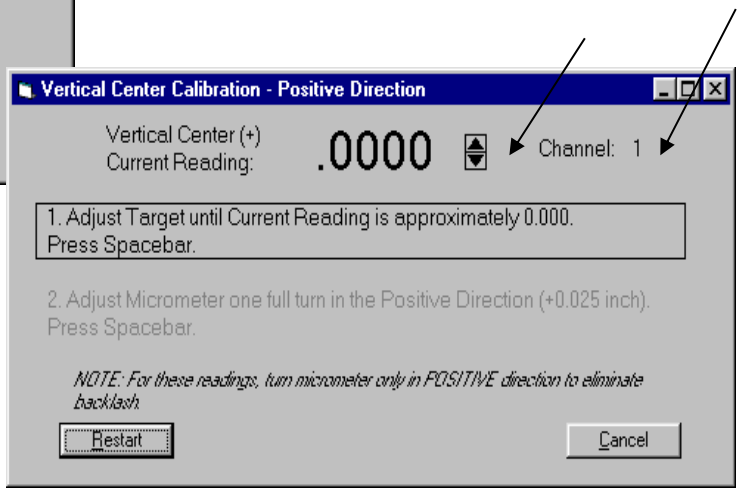


Figure 48 - Calibration Screen

Notes:

- *Once the first calibration factor is recorded, the program adds the calibration date to the Calibration Constants screen.*
- *The double arrows next to the reading are visible only in Manual Data mode and are not available when actual targets are being read (see left arrow in* ***Error! Reference source not found.****).*
- *Ensure that you perform each step slowly so that the values have time to register correctly before you press the spacebar.*

Calibrating a Center-Only Target

1. **For the first reading (in this case V+), center the target using the centering micrometer. This corresponds to Step 1 on the Calibration Screen (see** Figure 46**).**
   The display should read close to 0.000 (within ±.005 in.). Center in such a way as to remove the micrometer backlash; that is, for a *positive* calibration reading, approach zero from a *negative* reading by adjusting the micrometer in a positive direction.

2. **Press the spacebar to record the reading.**

3. **Read the micrometer on the selected axis and move it exactly .025 in. (one full turn), moving in the same direction as Step 1. This corresponds to Step 2 on the Calibration Screen.**
   The displayed reading should be close to +.025 for the positive factors and close to –.025 for the negative factors.

4. **Press the spacebar to record the reading.**

5. **Re-zero the target.**
   Turn the micrometer .025 in. (one full turn) in the direction *opposite* that in **Step 3**. You are now ready to record the next calibration factor.

   Note: *If using the Model A-807 Calibration Mounting Fixture (see* **Figure 44***), then the target must be rotated 90° before performing a horizontal calibration. If the calibration fixture you are using has two centering micrometers, such as the T-230, the horizontal centering micrometer may be used and there is no need to rotate the target.*

6. **Select the next calibration factor from the Calibration Constants menu, and click the Calibrate button or Press Alt-C.**
   Follow Steps 1-5 to obtain the next calibration factor. Repeat this procedure until all the necessary calibration factors have been obtained.

7. **Save the calibration information.**
   When the calibration procedure is completed, click the **Save** button to save the target profile. This target name will now display in the Select Targets to Use section of the Target Setup Screen.

Calibrating a Center-and-Slope Target

In order to use the automated features of the Read8 software, calibration for a center-and-slope target must be performed with the target mounted in the A-807 calibration mounting fixture (see **Figure 44**). This fixture is equipped with both a centering micrometer and an angle micrometer.

The Calibration Constants menu for center-and-slope targets requires that four calibration factors for center and four calibration factors for slope be entered (compare with **Figure 46).** The procedure is the same as that for calibrating a center-only target, however, the calibration factors for slope are obtained by using the angle micrometer.

1. **For the first reading, (in this case V+), center the target using the centering micrometer. This corresponds to Step 1 on the Calibration Screen (see** Error! Reference source not found.**).**
   The display should read close to 0.000 (within ±.005 in.). Center in such a way as to remove the micrometer backlash; that is, for a *positive* calibration reading, approach zero from a *negative* reading by adjusting the micrometer in a positive direction.

2. **Press the spacebar to record the reading.**

3. **Read the micrometer on the selected axis and move it exactly .025 in. (one full turn), moving in the same direction as Step 1. This corresponds to Step 2 on the Calibration Screen.**
   The displayed reading should be close to +.025 for the positive factors and close to –.025 for the negative factors.

4. **Press the spacebar to record the reading.**

5. **Re-zero the target.**
   Turn the micrometer .025 in. (one full turn) in the direction *opposite* that in **Step 3**. You are now ready to record the next calibration factor.

   Note: *If using Model A-807 Calibration Mounting Fixture (see* Figure 44*), the target must be rotated 90° before performing a horizontal calibration. If the calibration fixture you are using has two centering micrometers, such as the T-230, then the horizontal centering micrometer may be used and there is no need to rotate the target.*

6. **Select the next calibration factor from the Calibration Constants menu, and click the Calibrate button or Press Alt-C.**
   Follow Steps 5-9 to obtain the next calibration factor. Repeat this procedure until all the necessary calibration factors have been obtained. ***Ensure that the calibration factors for slope are obtained by using the angle micrometer.***

7. **Save the calibration information.**
   When the calibration procedure is completed, click the **Save** button to save the target profile. This target name will now display in the **Select Targets to Use** section of the Target Setup Screen.

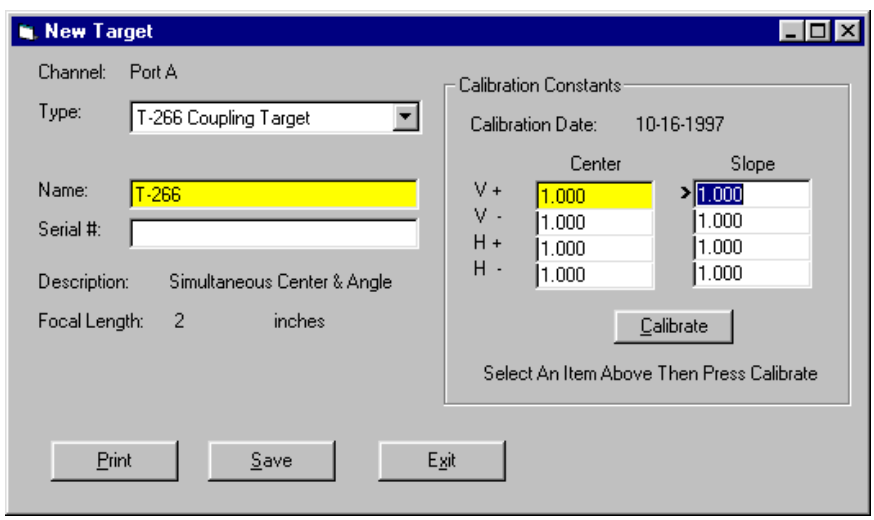


Figure 49 - New Target Screen – 4-axis Target

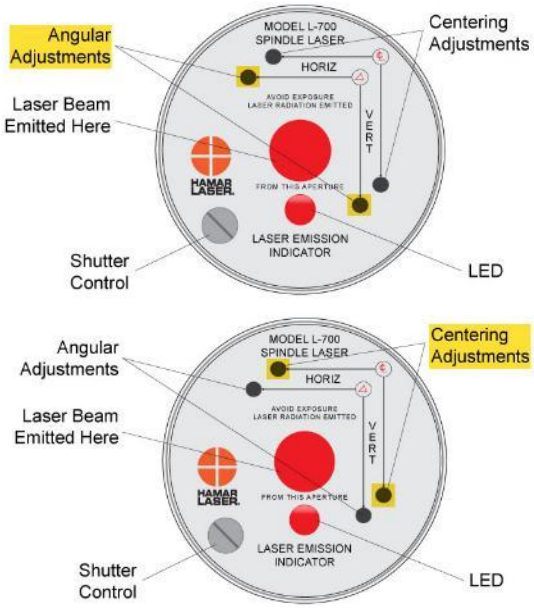
Appendix D – Adjusting the L-700 Vertical and Horizontal Angular Adjustment to Set Points.

Warning!!
If the adjustments start getting tight or very loose, STOP! You might cause some damage to the laser adjustments if you turn them too far. The adjustments have about 3 full turns in either direction before they run out of range.

1. **Adjust the angle using the Angular controls on the laser faceplate until the Angular readout displays the calculated V & H Angular Set Points.**

2. **Adjust the L-700 Vertical and Horizontal *Center* controls on the laser faceplate until the *Center* readout displays the calculated V&H *Center* Set Points**.

Note: *If you have a large center offset to adjust out, then this will probably change the angular values enough that they would need to be tweaked back into tolerance.*



Confirming the Results

To confirm the results, invert the laser again. The two readout displays should show the ***same reading, same sign*** (+ or -) as it did in the NORMal position, to within .0002 in. (0.025 mm/m) for angle and .001 in. (0.025 mm) for center. If the results are not close enough, recalculate the Set Points and readjust the laser unit.

Note: *Even if the numbers are slightly out of the tolerance mentioned above, it will not affect the alignment. During the alignment of a spindle, you will be aligning the laser to the spindle AOR, so these values will change. The main purpose here is to maximize the L-700 adjustment range before getting started. It is probably not worth the time to redo this procedure if the values are slightly out of spec after inverting the target.*

Appendix E – Qualifying the L-700 Laser Beam to its Mounting Stud

All Hamar Laser's L-700 Lasers are factory-qualified (pre-aligned) to the mounting stud. To obtain accurate spindle alignment results, it is important to adjust the laser beam so that it is aligned to the spindle axis of rotation (AOR) to remove any mounting errors, which are always present. After the alignment, it is a good idea to re-qualify the laser to its mounting stud, which puts the L-700 4-axis adjustments in the center of their adjustment range.

The following procedure is used to qualify the L-700 laser to its mounting stud using the A-801 Laser Fixture.

Warning!!
This procedure is for adjusting the laser only. Targets are factory-qualified and need no field adjustments. Attempting to do so could potentially damage the target

The NORMIN Method

The NORMIN method is a way of canceling mounting errors. The word is a contraction of "NORMal-INverted," which briefly describes the method.

To take NORMIN readings, the laser and target fixtures are set in the NORMal position (cable or switch down) and the readings are recorded. Then the target fixture is rotated 180 degrees to the INverted (cable or switch up) position and a second set of readings is obtained. With a quick calculation, the two sets of readings are averaged to cancel out both laser and target mounting errors (center and angular) and provide a very accurate result. For a complete discussion of the NORMIN method, see Appendix A, beginning on Page 77.

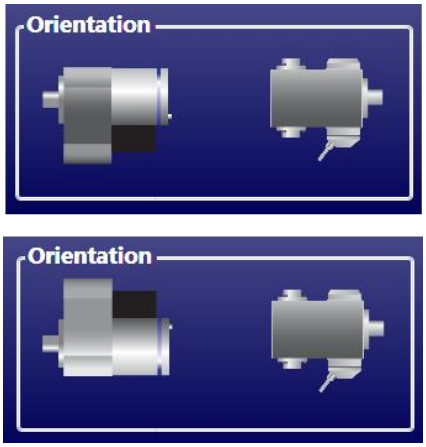


Figure 50 - Taking NORMIN Readings

Adjustments

The L-700 laser has centering and angular adjustments on the faceplate. The beam is emitted from the large hole in the center. The illustration below shows the location of the various adjustment screws. The shutter control slides a metal cover over the glass window to protect it from scratches.

WARNING!!
Avoid direct exposure to the laser beam while adjusting the laser. Do not stare into the beam.

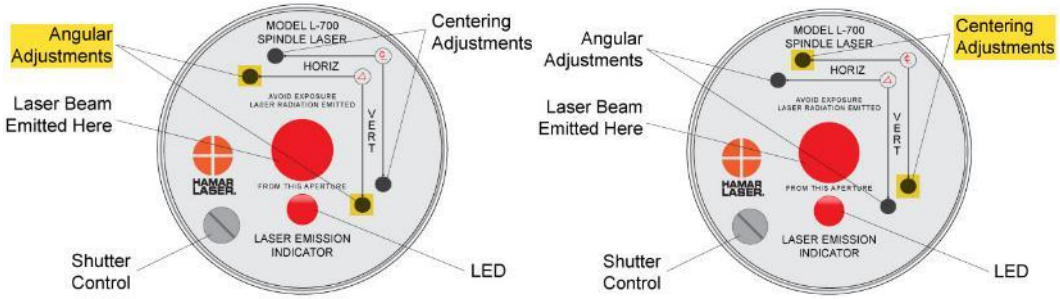


Figure 51 - Laser Adjustment Screws

Manual/Software-Assisted Qualification

To qualify the L-700, error correction readings are taken to cancel out mounting and other errors, and Set Points are calculated. The laser beam is then adjusted to the Set Points, making it parallel to/coincident with the L-700's mounting stud, which puts the L-700's four axes of adjustment in the center of their range. Manual qualifying requires the user to calculate the Set Points from the error correction readings and then adjust the laser to the points.

Lathe10 calculates the Set Points for the user and zeroes the display at that point. The user then adjusts the laser beam to zero.

Hardware Requirements

To qualify the L-700 to its mounting stud, the recommended fixture is the A-801 Alignment Fixture or the A-807 Calibration Fixture. You will also need the L-700 Laser, T-261 4-Axis Target, the R-358 Computer Interface and Lathe10, Spindle8 or Read8 software.

Figure 52 - A-801 Alignment Fixture

If using the manual procedure, then you will need two R-1307 readouts, one for the c*enter* readings and one for the *angular* readings. See Appendix B beginning on **Page 78** for the manual procedure.

Qualifying Procedure - Using Lathe10 Software – L-700 & T-261 Target

The following procedure explains how to qualify the laser with a 4-axis target and Lathe9 software.

Setup

1. **Connect the T-261 Target to the R-358 Computer Interface.**
   Connect the T-261 to the R-358 and screw in the mounting screws to hold the target connector in place. Connect the serial cable to the USB/Serial adapter cable and plug it into the laptop or desktop computer.

Important Note – you must install the software driver for the USB cable BEFORE plugging in the USB cable into your computer. Please see Page 23 for details on how to install the driver.

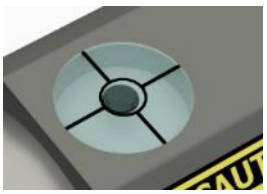
2. **Install the L-700/T-261 into the A-801 Fixture.**
   Mount the laser and target in the normal position in the A-801 calibration fixture and screw in (finger tight) the thumb screws. This procedure is only to align the laser to the mounting stud to maximize the L-700 adjustment range for the next alignment, so there is no need to worry about aligning it to .0001 in. (0.0025 mm).

3. **Alignment Tolerance**
   The goal is to align the laser to the mounting stud to the following tolerances:
   Center: ±-.001 in. (0.025 mm)
   Angle: ±-.0002 in/ft (0.017 mm/m)

4. **Open Lathe10**
   Open Lathe10 using either a saved file or enter a new file name.

5. **Go to Step 2: Qualify Laser**
   Go to **Step 2: Qualify Laser** and ensure you are getting readings in all four displays.

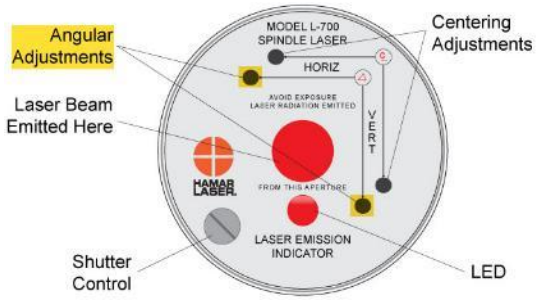
6. **Invert the L-700 with the T-261 in the NORMal position.**
   Rotate the laser to the INverted (switch up) position, with the target in the NORMal (cable down) position and wait for the readings to stabilize (approximately 5 seconds). Ensure the bubble level on the bottom of the L-700 is in the center of the circle.



7. **Click RECORD.**
   Click or press ***Record*** to record the INverted value.

8. **Rotate the laser to the NORMal position.**
   Rotate the L-700 to the NORMal (switch down) position, keep the T-261 in the NORMal position, and wait for the readings to stabilize (approximately 5 seconds). Make sure the top bubble level is in the center of the circle.

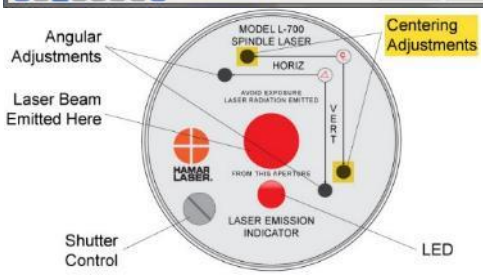
9. **Click RECORD.**
   Click or press ***Record*** to record the NORMal value. Lathe10 automatically calculates display offsets so you can adjust the four adjustment axes to zero instead of the calculated Set Point. While it is not recommended, if you want to see the raw values, click ***Offset*** to turn the offsets off. Click ***Offset*** again to turn them back on.
10. **Adjust the V and H <u>Angular</u> (slope) adjustment on the L-700 until the Slope values in the Step 2 display are within ±.0002 in/ft (0.015 mm/m) of zero.**



Warning!!
If the adjustments start getting tight or very loose, STOP! You might cause some damage to the laser adjustments if you turn them too far. The adjustments have about 3 full turns in either direction before they run out of range. If you run out of range, then there is likely a problem with the fixture or the machine is badly out of alignment. Please check to make sure it is machined properly.

The L-700 V & H Slope values in tolerance.

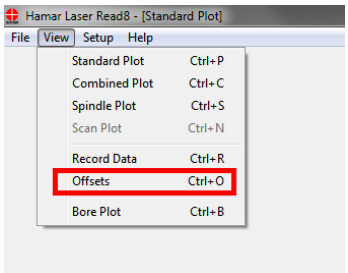
11. **Adjust the V and H Center adjustment on the L-700 until the Center values in the display are within ± .001 in/ft (0.025 mm) of zero.**



Here are L-700 V & H Center values in tolerance.
Since the Center values were adjusted, the Angular values should not change or change very little.
Note: *If you have a large center offset to adjust out, then this will probably change the angular values enough that they would need to be tweaked back into tolerance.*

12. **Repeat Steps 5-9 to verify the laser is aligned to the L-700 mounting stud.**
    Note: *Even if the numbers are slightly out of the tolerance noted above, it will not affect the alignment, since during spindle alignment, you will be aligning the laser to the AOR, so the values will change. The main purpose here is to maximize the L-700 adjustment range before you get started.*

Note on Using Read8 for this procedure.
You may also use Read8 to qualify the laser. After opening Read8 and selecting the T-261 target per the Read8 manual, click **View** and then **Offsets**.



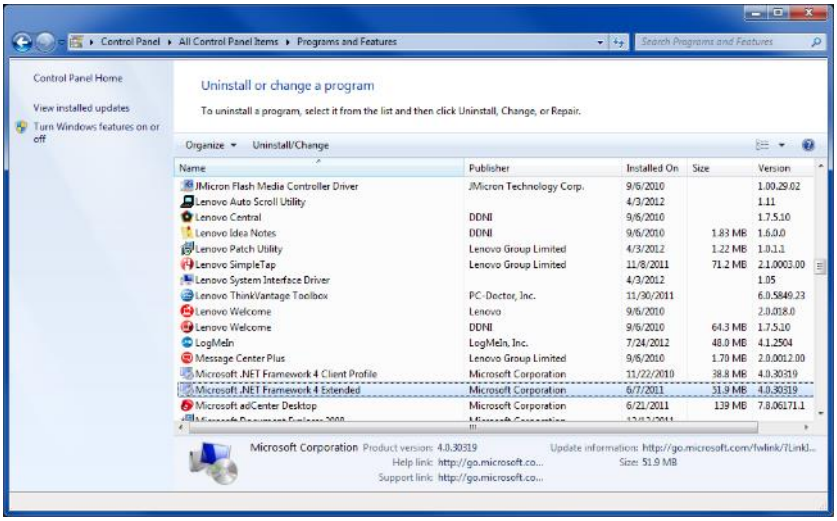
In the **Offsets** screen, click **Qualify Laser** and you will see a similar screen to **Step 2: Qualify Laser.** The instructions are nearly identical, so use Steps 5-12 to align the L-700 laser to its mounting stud.

The procedure for qualifying the L-703S Laser to its mounting stud is exactly the same in Lathe10 as it is in Lathe9 but you only have to do the angular adjustments. See ***Step 2 – Qualifying Laser*** on **Page 42**.

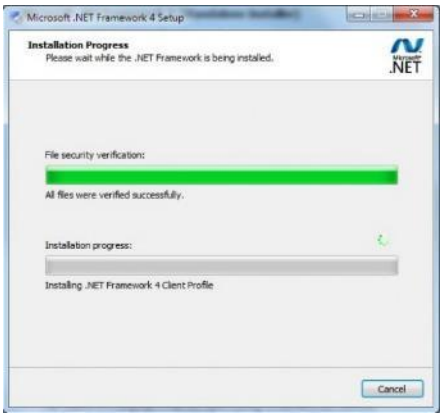
Appendix F – Installing Additional Microsoft Software

Installing Microsoft .NET Framework 4

You must have the Microsoft .NET Framework installed before installing the Lathe10 software. If you are unsure about whether you have Microsoft .NET Framework 4 installed on your computer, open the Control Panel. For Windows XP users, select **Add/Remove Programs**; for Window 7 users, select **Programs and Features**. Scroll down the list of installed software to locate Microsoft .NET Framework 4. If the program is not installed, follow the instructions below.



1. To install Microsoft .NET Framework 4, locate the folder **MS_Framework_4_X86_X64** on the Lathe10 installation USB drive. Open the folder and double-click **DOTNETFX40_FULL_X86_X64** to begin the installation. Follow the on-screen prompts to complete.



2. When the installation is complete, click **Finish** to close the installation program.