

Lathe9 Alignment Software
for Aligning Lathes and Turning Centers

Operations Manual

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Revision D



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Lathe9 Lathe and Turning Center Alignment Software

Lathe9 is used with the L-700 Spindle Alignment system to align lathes and turning centers. A 6-step process guides the user through the alignment in two 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 in parallel to the guideways, then a 4-axis check of the alignment of tailstock or subspindle axis to the headstock spindle axis is performed.

The L-700 Laser is mounted in the headstock spindle and the T-261 4-Axis Target is mounted in the tailstock chuck (or fixture) or subspindle. The L-700 is aligned to the headstock axis of rotation (AOR) and the alignment checks are performed using the T-261.

The T-261 is connected through the R-358 Computer Interface to a computer running the Lathe9 software, which provides a real-time graphic display of the alignment process. Lathe9 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 Four-Axis Target
- R-358 Computer Interface
- Lathe9 Software
- Laptop or tablet with Microsoft® Windows 10 (optional with system purchase).

Computer System Requirements

- Physical memory (RAM): 2 GB recommended.
- Processor: Intel Pentium4 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 Professional editions.

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 Lathe9 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.
- **Dynamic Misalignment 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.

Lathe9 Hardware Overview

This section provides a description of the hardware used in spindle alignment.

Model L-700 Spindle Laser

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. Vertical and horizontal controls on the front 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 30 ft. (9.1 m). The L-701, which is identical in appearance and function to the L-700, has a slight modification to the beam pointing mechanism which allows finer angular adjustment over long distances, extending the adjustment operating range to 100 ft. (30.5 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 .5 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-700 and L-701 work 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
- Boring bars
- Turning applications (cylindrical, OD/ID grinders, lathes)
- Twin-barrel extruders



Figure 1 – L-700 Spindle Laser

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 2). When the laser beam is turned on, the red LED on the faceplate lights up to safely indicate that the unit is powered on.

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 3). 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. Figure 3 shows the location of the various adjustment screws.

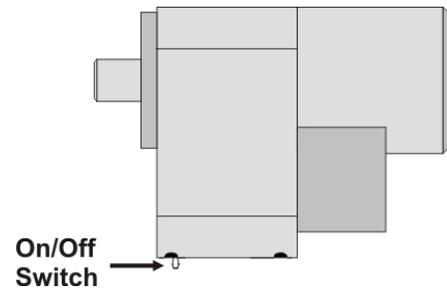


Figure 2 – On/Off Switch

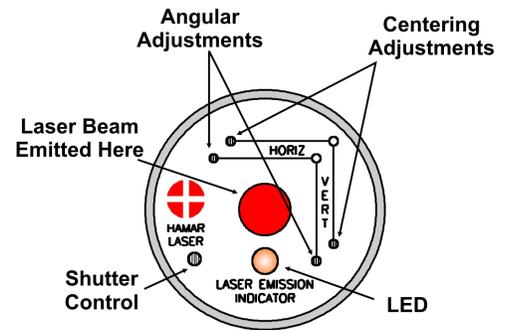


Figure 3 – Shutter Control and Adjustments

Replacing the Battery

The L-700 and L-701 Lasers use a standard, replaceable 9-volt battery for up to eight 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.

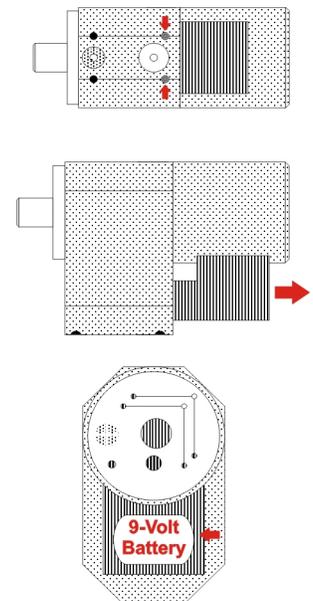


Figure 4 – Replacing the L-700 Laser battery

The T-261A Four-Axis Target

The T-261 Four-Axis Target reads both center and angle (pitch and yaw) simultaneously, allowing a real-time display of misalignment. The resolution is .00001 in/ft (0.00083 mm/m) in angle and .00001 in. (0.00025 mm) for center. 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 57).

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 Lathe9. 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 63.



Figure 5 – 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 Lathe9. Older programs include Spindle8 and Read8.



Figure 6 – Lathe9, 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

Lathe9 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-700 has 4-axis adjustment to align the laser beam to the spindle's AOR in:

- Vertical *Center*
- Horizontal *Center*
- Vertical *Angle*
- Horizontal *Angle*

In lathe alignment, it is best to use the tailstock or saddle guideways as a reference to align the headstock spindle axis. To do this, the L-700 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-700 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 subspindle AOR be checked for alignment to the headstock AOR. The T-261 offers a live 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.

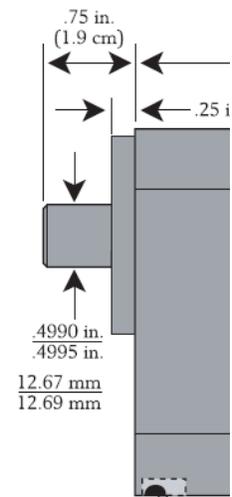


Figure 7 – Mounting Stud

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 unit realistically travels during use, not the full distance of which it is capable 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

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 Lathe9 **Step 2: Qualify Laser**. This is 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 59).

The T-261 Target 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 Lathe9. 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 63.

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.

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 an 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 **BEFORE** plugging in the USB cable into your computer. The driver is located on the same thumb drive as Lathe9 software. Please see Page 8 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/adaptor 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.

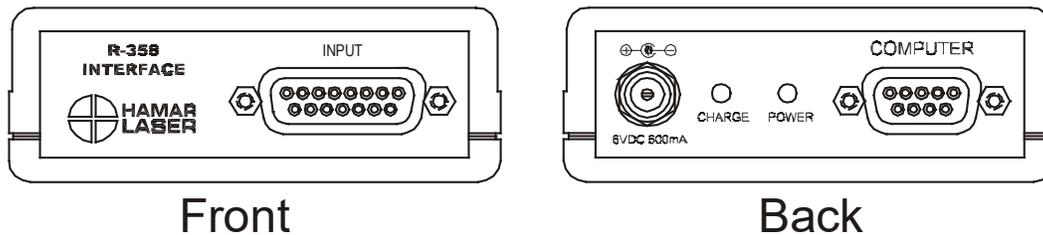


Figure 8 – R-358 Interface Connections

Note: The R-358 is powered on by the software. When you click any of the Lathe9 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 to the RS-232 extension cable and then into computer USB port. The connector for the cable is located on the BACK of the unit.

3. Power on the computer.

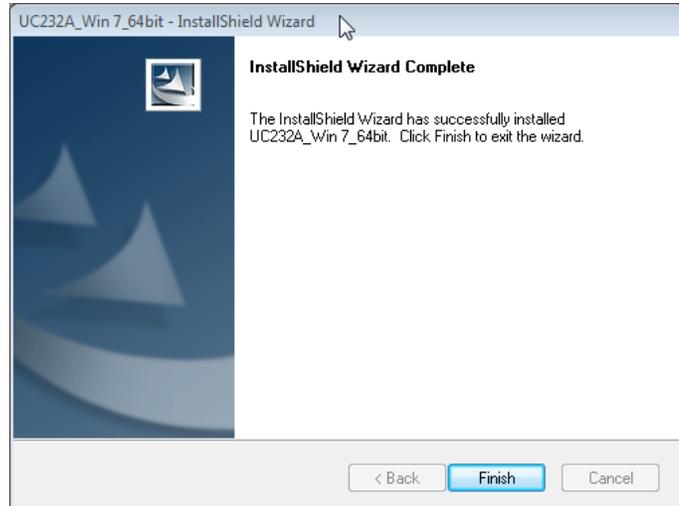
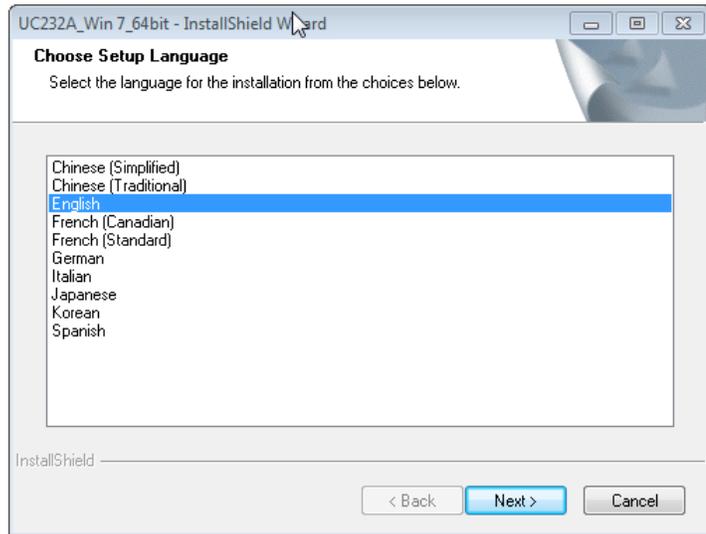
Installing the (RS-232) USB to Serial Driver

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: You must pre-install this driver prior to connecting the device(s) to the computer through the USB port.

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.



Lathe9 Alignment Software System Requirements

- Physical memory (RAM): 2 GB recommended
- Processor: Intel Pentium4 or later version or AMD equivalent, 1.3 GHz minimum speed
- Available Hard Drive space: 10 GB minimum
- Video Resolution: 1024 x 600 minimum (32-bit color) with hardware acceleration and dedicated video memory.
- Windows 7/8/10 professional editions.

The following Microsoft Windows operating systems have *not* been tested with Lathe9:

Windows 7 Ultimate x86, Windows 7 Ultimate N, Windows 7 Enterprise x86, Windows 7 Enterprise N, Windows 7 Enterprise x64, Windows 7 Professional x86, Windows 7 Professional N, Windows 7 Professional x64, Windows 7 Home Premium x86, Windows 7 Home Premium N, Windows 7 Home Premium x64, Windows Vista Ultimate, Windows Vista Enterprise, Windows Vista Enterprise x64 Edition, Windows Vista Home Premium, Windows Vista Home Premium x64 Edition, Windows XP Professional x64 Edition

The following Microsoft Windows operating systems are *not* recommended for use with Lathe9:

Windows7 Home Basic x86, Windows 7 Home Basic N, Windows Vista Home Basic, Windows XP Home Edition.

Before installing Lathe9, ensure that your computer has the latest Windows Service Pack and critical updates. To find security updates, visit www.windowupdates.com. If you are installing on Windows XP 64 bit you might need to install the Windows Imaging Component. The Windows Imaging Component 32-bit can be found at:

<http://www.microsoft.com/en-us/download/details.aspx?id=32>

The Windows Imaging Component 64-bit can be found at:

<http://www.microsoft.com/en-us/download/details.aspx?id=1385>

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.

Prerequisites for Installing the Bore9 Alignment Software

.NET Framework

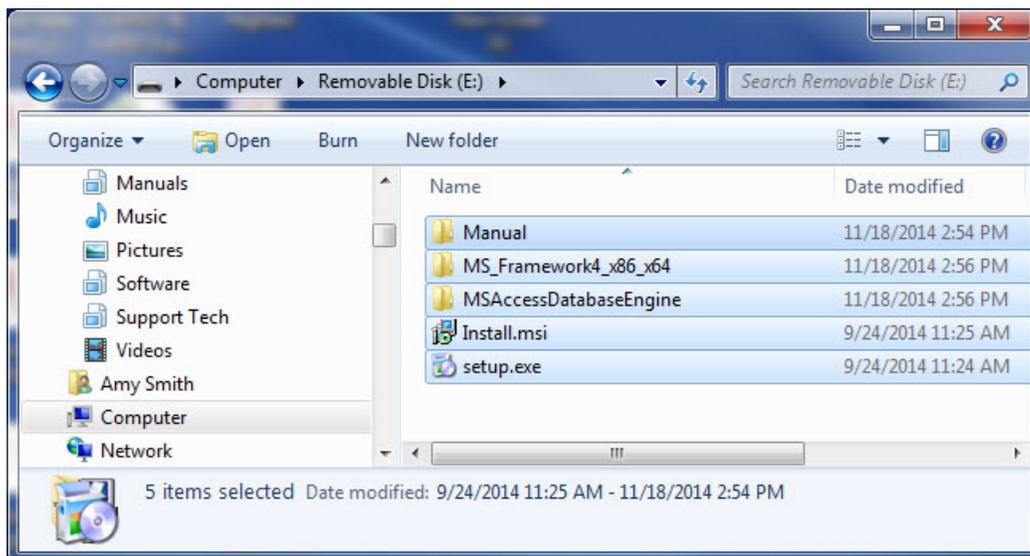
You will need Microsoft .NET Framework 4 installed on your computer for Lathe9 to store data. If you are not sure if the .NET framework is installed please see Appendix F on Page 74 for more information).

1. Microsoft Access Database Engine

The Microsoft Access Database Engine must be installed on your computer before installing the Bore9 software. This file is usually on your computer if you have a full version of Microsoft Office installed. If you don't have it installed, please see Appendix F on Page 74 for more information.

Installing Lathe9

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 9 if you are unsure if this has been installed.*
4. Click **setup.exe** to begin the Lathe9 installation.



Getting Started with Lathe9

Hamar Product Registration

In order to protect against software pirating, 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 9). 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 10). Enter the Product Registration Code and click **Register Product**. The product is now registered.



Figure 9 – Product Registration Screen

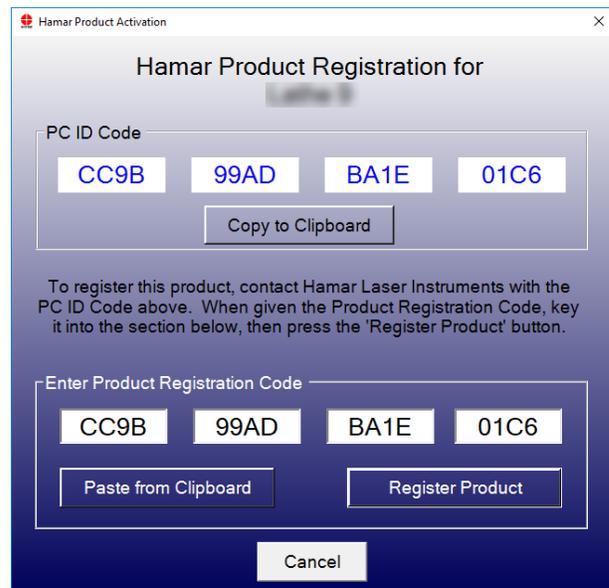


Figure 10 – Enter Product Registration Code

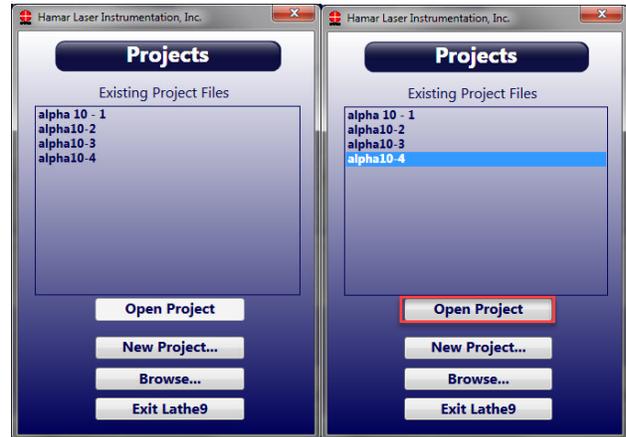
To begin using Lathe9, double-click the Lathe9 icon or select the program from the Windows Start Menu. The initialization screen displays, providing the number of the current software version.

Creating a New Project File or Opening an Existing Project File

When Lathe9 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 Lathe9** – this closes Lathe9.

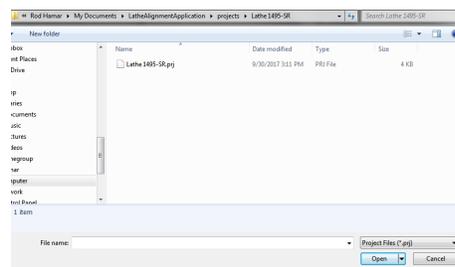
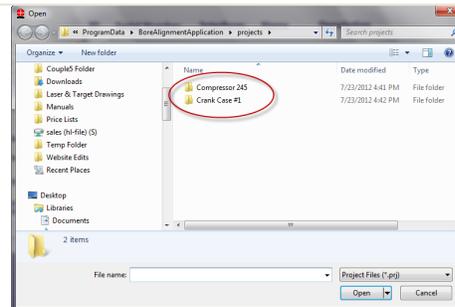
Note: This screen can also be accessed by clicking **Open Project** from the **File** menu.



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** popup, browse to the desired folder and double-click the project folder.



Saved Projects File Location

Note: Files are saved in the My documents / LatheAlignmentApplication / projects folder.



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

Name	Date modified	Type	S
alpha10 - 1	9/18/2017 5:58 PM	File folder	
alpha10-2	9/19/2017 12:49 PM	File folder	
alpha10-3	9/19/2017 1:26 PM	File folder	
alpha10-4	9/22/2017 10:20 AM	File folder	

In each folder, there are several data files.

- The *****.QualifyLaser.csv** file contains the raw laser qualification data for **Step 2**.
- The *****.LatheBedStraightness.csv** file contains the raw straightness data for **Step 3: Lathe Bed Straightness**.
- The *****.RecordSpindle.csv** file contains the raw mounting error correction data for **Step 5: Record Data – Spindle**.

The data format in these CSV files is:

- microns (1 micron = 1 mm/1000) for dimensions and center values; and
- mm/mm for angular values.

These files can be opened in Excel for your own data analysis. To use the full Excel functionality, you must select **Save As** and change the file type to *.xls or *.xlsx.

alpha10-3.LatheBedStraightness.csv	9/20/2017 6:10 PM	Microsoft Excel C...	2 KB
alpha10-3.prj	9/20/2017 2:00 PM	PRJ File	4 KB
alpha10-3.QualifyLaser.csv	9/20/2017 6:10 PM	Microsoft Excel C...	1 KB
alpha10-3.RecordSpindle.csv	9/22/2017 10:19 AM	Microsoft Excel C...	1 KB
alpha10-3.txt	9/20/2017 2:01 PM	Text Document	1 KB

Warning! Do not delete or modify the CSV files in these folders as Lathe9 will be unable to open the project. If you want to use these files, first make a copy and move the copy to another folder. Then they will be safe to modify.

Converting Raw Data Values in CSV files to Inches or Millimeters

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

Lathe9 Main Features

Step 1: Set Up Lathe9- Enter the headstock and tailstock dimensions, choose the number of points to be recorded 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 - Align the laser to the headstock spindle axis by following the NORMIN procedure. Display offsets are automatically calculated and applied, so the user zeros out the laser's four axes of adjustment to make it parallel and coincident the spindle axis of rotation (AOR).

Step 3: Bed Straightness & 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**. Lathe9 records four axes of data (V-center, H-center, V-angle, H-angle) 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 the 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.

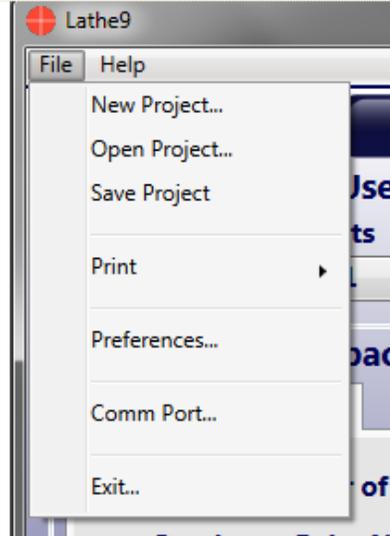
Step 5: Record Tailstock/Subspindle Axis Data

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 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**. Lathe9 automatically applies display offsets, so the 4-axis display shows 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.

The File Menu

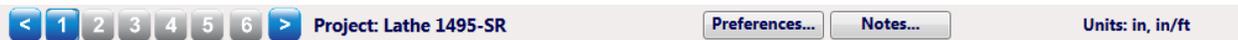
New Project	Opens a popup to enter a filename for a new project.
Open Project	Browse folders to open a saved project.
Save Project	Saves current project.
Print Report	View and print current project.
Preferences	Contains Tabs for entering Company Information, Units, Data Grid Displays, Decimal Displays, Target Setup and Record Mode.
Comm Port	Select the COM port that the computer interface is assigned to (this is not normally used)
Exit	Stores all current settings, prompts the user to save any unsaved data, and exits Lathe9.

A screenshot of the Lathe9 software interface showing the File menu. The menu items are: New Project..., Open Project..., Save Project, Print (with a right-pointing arrow), Preferences..., Comm Port..., and Exit... The window title is 'Lathe9' and the menu bar includes 'File' and 'Help'.

Navigating Lathe9 with the Status Bar

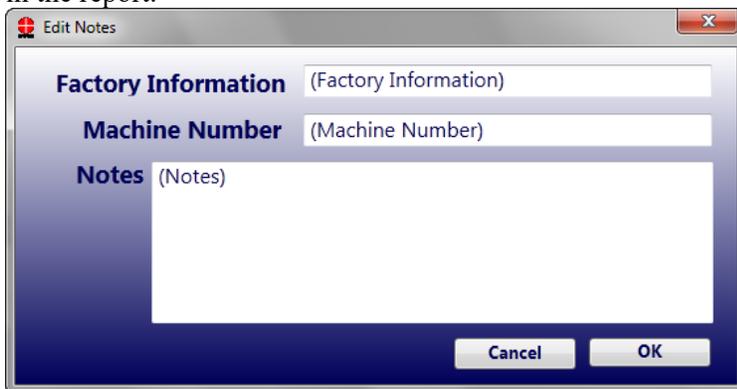
Software Steps

The *right* blue arrow and *left* blue arrow advances to the next screen, or click any 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 16).

Preferences Screen

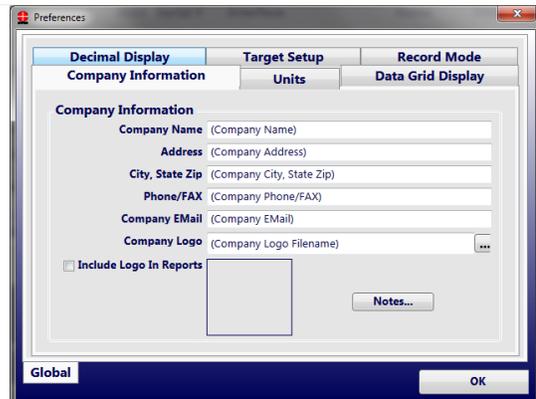
Click **Preferences** to open a popup to change Lathe9 settings.

Note: If you are installing the software yourself, you will need to go to **Target Setup** (see Page 17) 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.

Company Information

Enter company contact information for 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 15) to enter notes. The information will be stored in the Notes Popup and be accessible from the *Status Bar* in all steps of Lathe9.



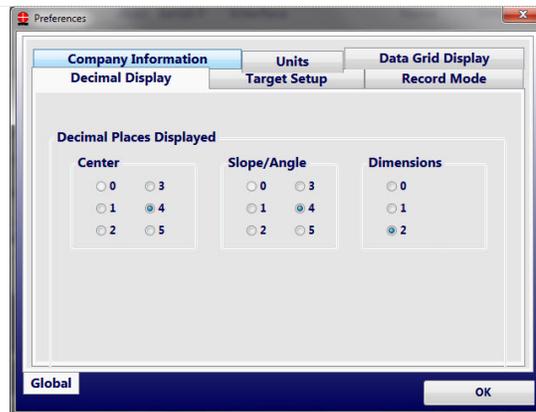
The screenshot shows the 'Company Information' tab of the Preferences dialog. It features several text input fields: 'Company Name', 'Address', 'City, State Zip', 'Phone/FAX', 'Company EMail', and 'Company Logo'. There is a checkbox for 'Include Logo in Reports' and a 'Notes...' button. The dialog has a 'Global' label and an 'OK' button at the bottom.

Decimal Display

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

For inches, we recommend 4 decimal points for center and angular values. For mm, we recommend 2 for center and for angular values.

Note: If choosing a higher resolution than noted above, we recommend changing the data averaging to 30 or higher to help reduce measurement noise for the last digit. This will, however, cause any position movements (update rate) in the target or laser to slow down considerably (see Page 20).



The screenshot shows the 'Decimal Display' tab of the Preferences dialog. It displays three groups of radio buttons: 'Center' (0, 1, 2, 3, 4, 5), 'Slope/Angle' (0, 1, 2, 3, 4, 5), and 'Dimensions' (0, 1, 2). The '4' option is selected for Center and Slope/Angle, and the '2' option is selected for Dimensions. The dialog has a 'Global' label and an 'OK' button at the bottom.

Units

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 per 12 in. Lathe9, however, automatically adjusts the angular data displays to show the correct angular units chosen here.

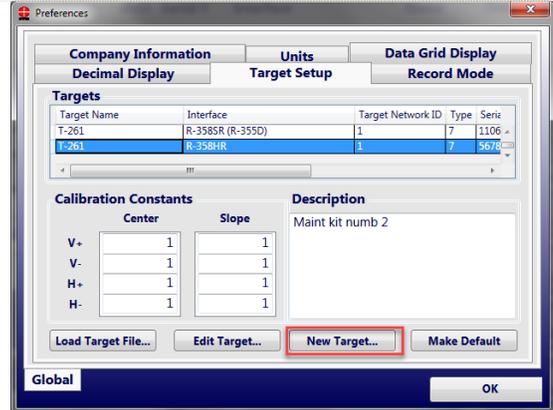


The screenshot shows the 'Units' tab of the Preferences dialog. It has two sections: 'Units' with radio buttons for 'Imperial (Inches)' (selected) and 'Metric (millimeters)'; and 'Center/Slope/Dimensions Units' with radio buttons for 'inches/ft' (selected) and 'inches/inch'. The dialog has a 'Global' label and an 'OK' button at the bottom.

Target Setup Procedure

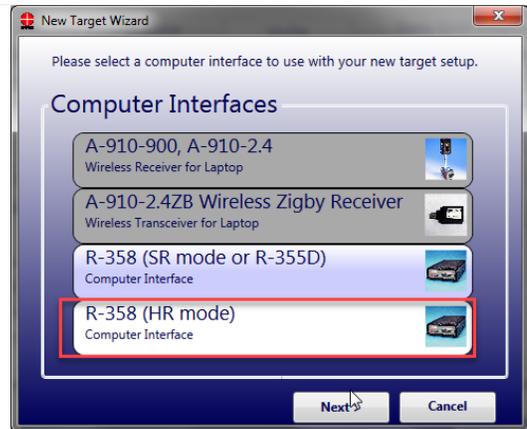
When you buy a new system and laptop from HLI, target setup and calibration factors are already pre-configured into Lathe9. However, if you are installing Lathe9 on your laptop, then you must follow this procedure to set up the target and enter calibration factors.

1. Click the **Target Setup** tab.
2. Click **New Target** to specify and set up a computer interface and to select a target that reflects the type of work being performed.

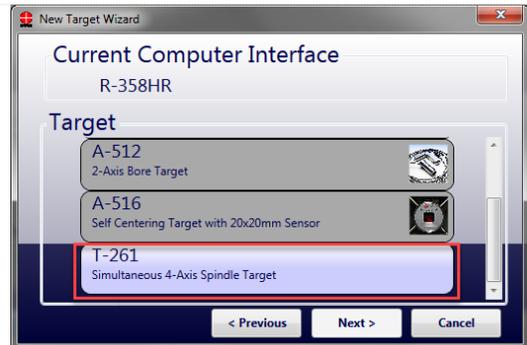


- a. Choose the R-358 (HR Mode) computer interface.

Note: 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 Lathe9.

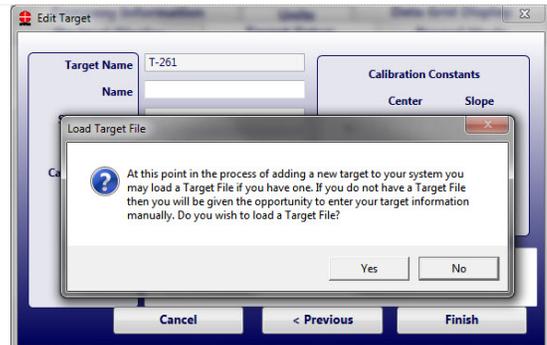


- b. Select the T-261 target.



- c. A popup message asks if you want to upload target calibration factors. These factors are usually supplied with a new system on the USB drive. However, this is not currently supported by Lathe9, so click **No** to manually enter the target name, serial number and description.

Note: - Clicking **Yes** opens the Open File dialog box where, in the future, you can browse to find the calibration factor file. If you select **Yes** accidentally, click **Cancel** to return to Lathe9.

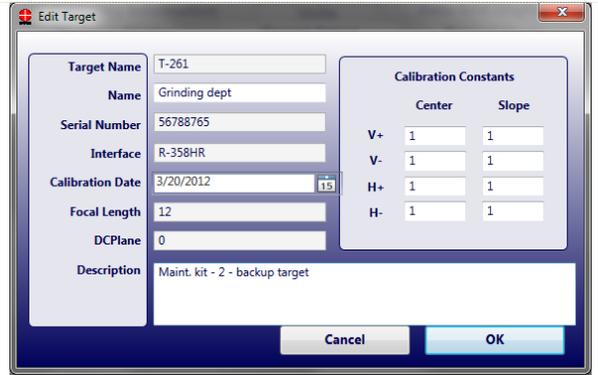


- d. Enter name, serial number, calibration date and description.

Note: The text for Name and Description display at the top of Step 1, so you can see the ID information on the target selected. For Name you have about 10 characters before the name is clipped in Step 1. For Description, you have up to 33 characters before the text is clipped. Leave Focal Length Set to 12.

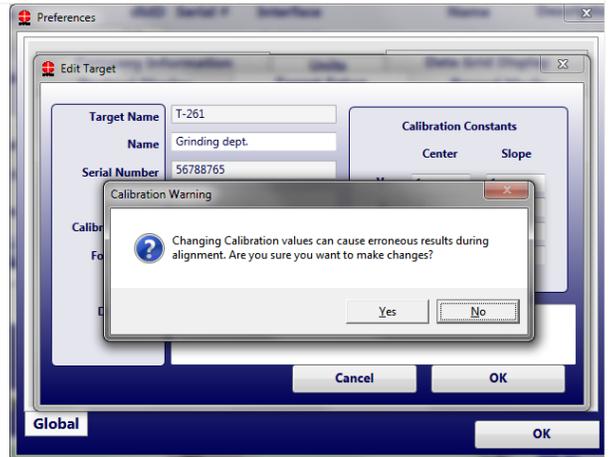


You can set up multiple T-261 targets if desired. To select a target in Step 1, choose from the dbID dropdown list where up to 10 target setups may be stored.

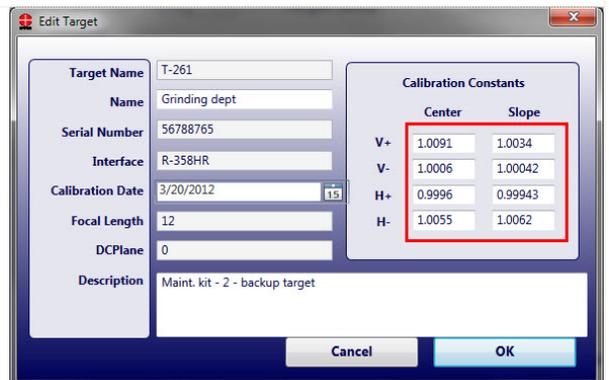


- e. Locate the calibration factor sheet supplied with the system. Click any value in the Calibration Constants area of the Target Setup popup to edit. A confirmation warning messages displays. Click Yes. Please pay close attention to each of the eight calibration factors and enter them in the matching field. Entering the wrong calibration factor can cause significant errors.

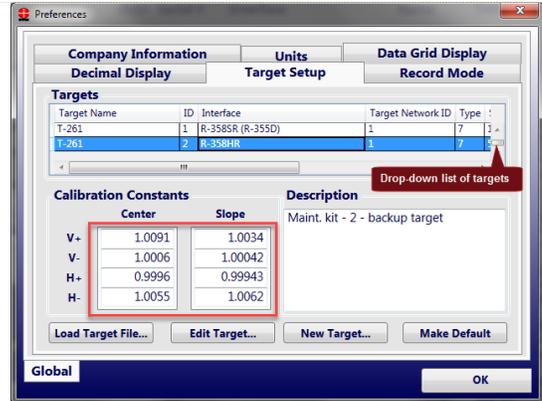
Note: The calibration factors are limited from .9 to 1.1. This value will be multiplied times the matching target axis value to calibrate the Span Error. A Span Error is a percentage error calculated by putting the target into a calibration fixture and moving the target a known/calibrated amount, usually .025 in. (0.635 mm) and calculating the percent error. For example, if the target V Center values shows .0235 in. for a .0250 in. move, then the cal factor will be $1 - .0235/.0250 = .06$, so the cal factor will be 1.06. The PSD max error is spec'd out at 5%, so the cal factors are rarely over 1.05 or under .95.



The screen to the right shows all the calibration factors entered. Click OK to save the factors.

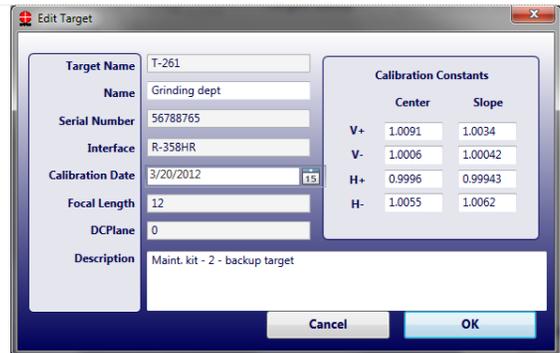


When the target is selected from the dropdown list, the name, description and calibration factors display.



Editing a target description and calibration record

Click the dropdown list to select a target and then click **Edit Target** to open the editing window. You can edit the Target Name, Name, Serial Number, Calibration Date and Description. Focal Length and DC Plane are legacy items and are ignored. Click **OK** to save.



Make Default

Click **Make Default** to make the selected target the default target when Lathe9 opens. Otherwise, you will need to select your preferred target in **Step 1** under the *dbID* dropdown list each time you open Lathe9.



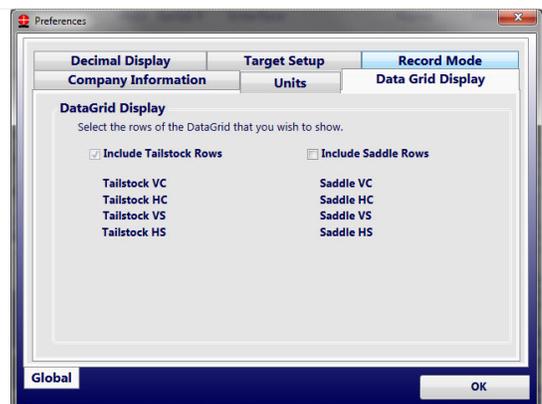
Load Target Files

This feature is not currently supported.

Data Grid Display

This control gives you the ability to select which sets of data points to measure in **Step 3**. The default is **Include Tailstock Rows**. Clicking **Include Saddle Rows** adds a second set of four rows to record the straightness of the saddle or turret guideways.

Note: If you select *Saddle Rows*, you are required to take the data for all the points in *Tailstock* and *Saddle* rows before the **Results** button is enabled. If you selected **Include Saddle Rows** by accident and receive an error message when trying to see the results for your *Tailstock* data, open this tab and de-select **Include Saddle Rows** to enable the **Results** button.



Record Mode

Number of Samples for Averaging – this controls the number of samples the data averaging routine uses to display the live alignment data. Increasing this number will smooth out noise fluctuations in noisy environments but will also slow down the response to movement in the laser beam position on the PSD. This can also be changed in **Step 2** and **Step 5**.

Beep on Record – when taking a data point, a beep will indicate that the point has been taken.

The features in *Default Data Description* are not currently supported.

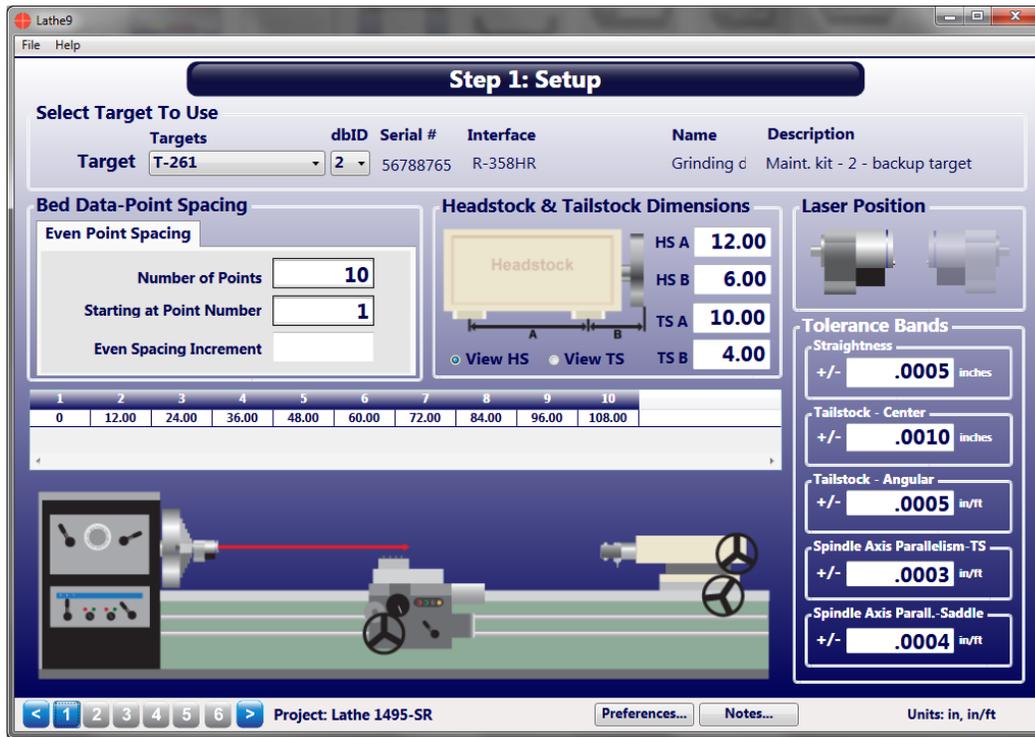
The screenshot shows a software window titled "Record Mode" with several tabs: "Company Information", "Units", "Data Grid Display", "Decimal Display", "Target Setup", and "Record Mode". The "Record Mode" tab is active. It contains three main sections:

- Number Of Samples for Averaging:** A text input field containing the number "10".
- Recorded Data:** A section with a checkbox labeled "Beep on Record", which is currently unchecked.
- Default Data Description:** A section with two checkboxes: "Include Time" and "Include Date", both unchecked. To the right of these is a checkbox labeled "Include Text (below)" which is also unchecked, followed by an empty text input field.

At the bottom of the window, there are two buttons: "Global" on the left and "OK" on the right.

Step 1: Dimensions and Tolerances

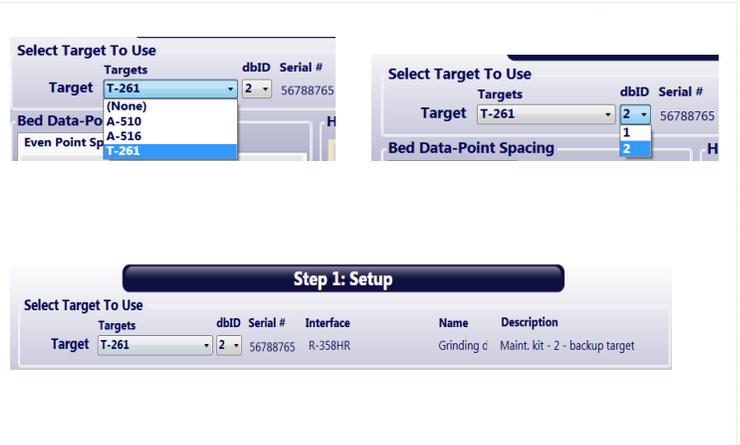
After entering a new project name, enter some parameters for the alignment in **Step 1: Setup**. Enter the number of points to take, the distance between points, the headstock and tailstock bolt dimensions and the alignment tolerances.



Select Target to Use

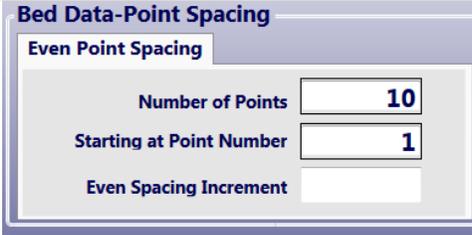
First select the target type under the **Target** dropdown menu. For most Lathe9 installations, there is only one type of target (the T-261). Next, select the **dbID**, which is a submenu of different T-261 targets, each with different descriptions and calibration factors. For most installations, there will only be one **dbID**.

The *Serial Number*, *Computer Interface*, *Name* and *Description* are displayed in the upper part of the screen to help identify the target.



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**.

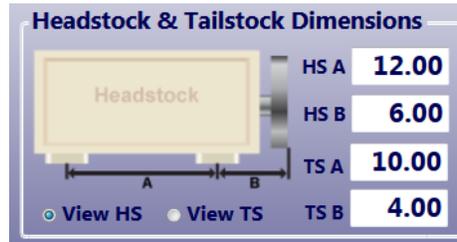


Headstock/Tailstock Dimensions

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 $\pm 1/8$, if possible, to ensure the accuracy of the shim calculations.*

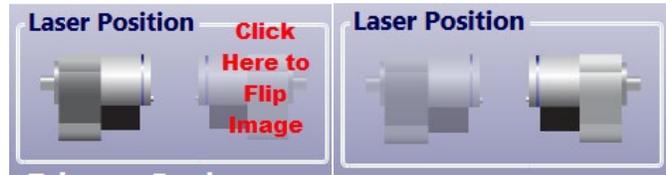


Laser Position

Lathe9 gives you the flexibility to flip the lathe graphics if you find yourself on the wrong side of the machine. The default is **Laser Left**. Click on the grayed-out **Laser Right** icon to view the lathe with the laser on your right.

This will also flip the data table in **Step 3: Bed Straightness & Spindle Axis Parallelism**, so you can start taking data from right to left instead of the default left to right.

The graphics in **Step 3: Move Screen** and **Step 6: Tailstock/Turret Alignment** will also flip so the laser image is on the right.



Also note that the number of points and distance between points displays on the lathe graphic. This data also switches when clicking Laser On Right.

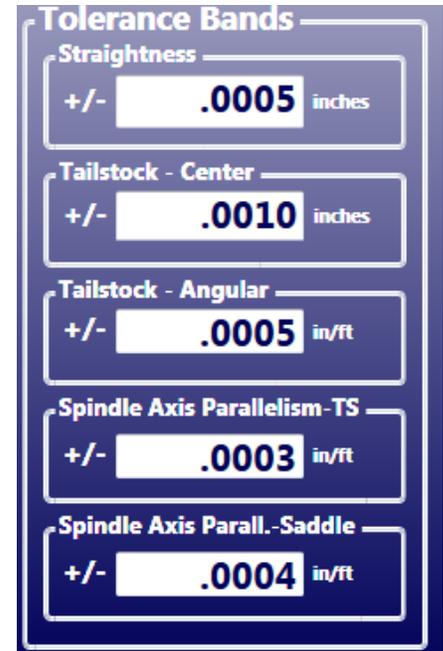


Laser On Right

Tolerances

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 Center** – this is the *center* tolerance for the alignment of the tailstock *center* (or subspindle AOR center) relative to the headstock AOR's center.
- **Tailstock – Angular** – this is the *angular* tolerance for the alignment of the tailstock *angle* (or subspindle AOR *angle*) relative to the headstock AOR *angle*.
- **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.

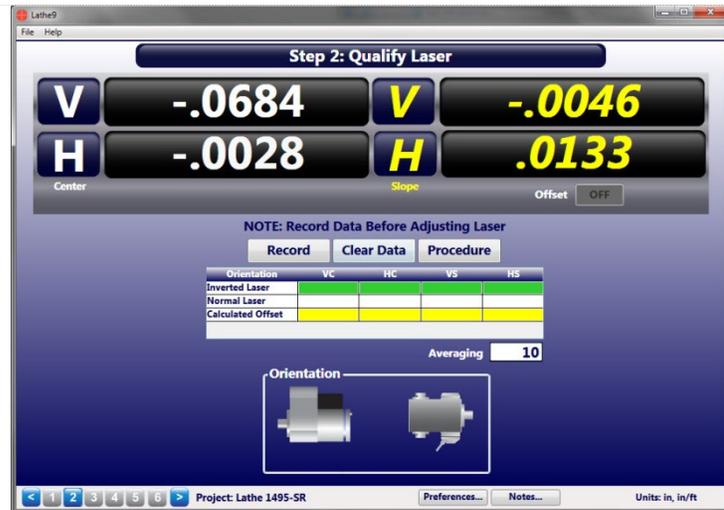


The straightness tolerance values are set up as a \pm band around zero. In the Alignment Results Summary in **Steps 3** and **4**, a green \checkmark or red \times indicates if the measured value is within or outside of the tolerances entered here. For example, for a .0005 in. straightness tolerance, Lathe9 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 the 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.

Step 3 Alignment Results						
Item	Tailstock Data			Saddle Data		
	Value	+/- Toler.	In/Out	Value	+/- Toler.	In/Out
V Straightness	.0014	.0005	\times	N/A	.0005	
H Straightness	.0003	.0005	\checkmark	N/A	.0005	
V Parallelism	.0000	.0003	\checkmark	N/A	.0003	
H Parallelism	.0000	.0003	\checkmark	N/A	.0003	

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 is relative to the laser beam. See the interpretation below.



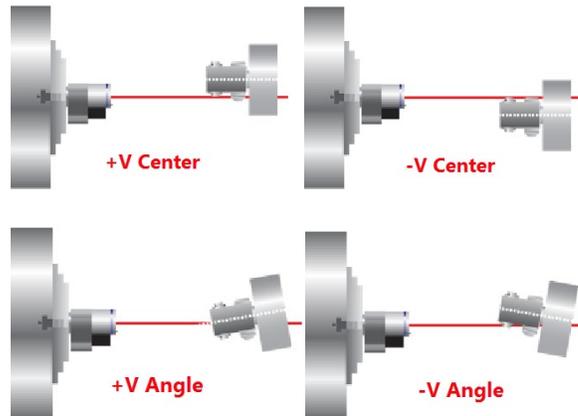
Vertical Axis

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.



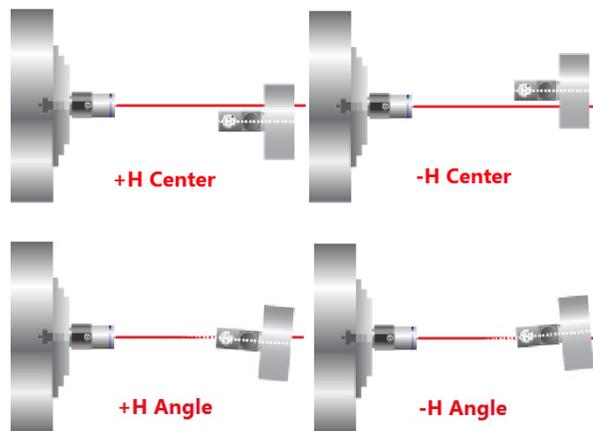
Horizontal Axis

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.



Step 2: Qualify Laser

In **Step 2: Qualify Laser** we will be aligning the L-700 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: *It is much more important to the 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 Lathe9 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 57).*

The best that you will be able to align the L-700 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 Lathe9. This represents the limit of how accurately the alignment can be done.

Step 2: Qualify Laser

V	-.0684	V	-.0046
H	-.0028	H	.0133

Center Slope Offset OFF

NOTE: Record Data Before Adjusting Laser

Record Clear Data Procedure

Orientation	VC	HC	VS	HS
Inverted Laser				
Normal Laser				
Calculated Offset				

Averaging **10**

Orientation

Project: Lathe 1495-SR Preferences... Notes... Units: in, in/ft

What the Buttons Do

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

Note: *The values in the four 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 screen that contains the basic procedure to qualify the laser.

Averaging – enter values from 1 to 99 and this will change the number of samples Lathe9 uses to average for each of the display values.

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.*

Procedure

1. Insert the L-700 into the headstock chuck and tighten 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.*

NOTE: Record Data Before Adjusting Laser

Record Clear Data Procedure

Step 2 Laser Setup Procedure

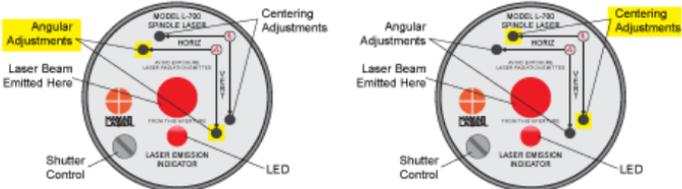
2a. Check to see if L-700 Laser adjustments are centered to the mounting stud using the A-801 Alignment Fixture. See Lathe9 Manual for details.

2b. Insert L-700 Laser into spindle and T-261A Target into saddle or tailstock chuck. Make sure T-261A is getting a reading.

2c. Rotate L-700 to INverted position. Press Spacebar or click Record.

2d. Rotate L-700 to NORMAL position. Press Spacebar or click Record. Offsets will be calculated and applied to displays.

2e. Insert allen wrench (key) into Horiz Angular Adjustment hole (see graphic below left) and adjust the Slope (angular) value, displays on the right side of the screen, until it is zero. Repeat this for Vert axis.



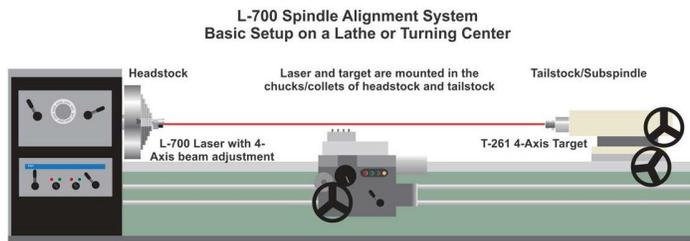
2f. Click "Clear Data" and repeat steps 4 & 5 to verify the V and H angular values are .0001"/ft (0.009 mm/M) or less. Note: if you can't get them less than these values do a repeatability test. See Manual for details.

2g. Check V & H Center values (displays on left side of screen). If the values are less than .015" (0.38 mm), then you are done and the laser is qualified go to Step2c. If not then go to Step 2h.

2h. Insert allen wrench (key) into V Center Adjustment hole (see graphic above right) and adjust the Vert center (offset) value until it is zero. Repeat this for the Horiz axis. Warning: Do not adjust V Center or H Center more than .010" or 0.25 mm.

2i. Repeat steps 2c & 2d to verify the V & H Angular values are less than .0001"/ft (0.009 mm/M) and V & H Center values are less than 0.15" (0.38 mm).

Averaging 10

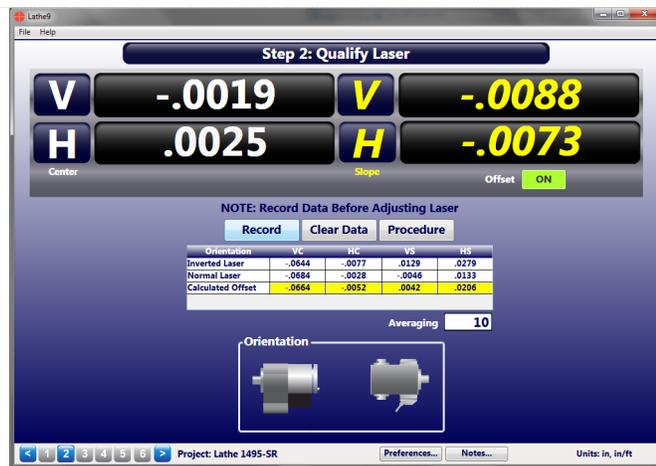


3. Rotate the headstock spindle with the L-700 Laser 180 degrees to the INverted position. Click/press Record.

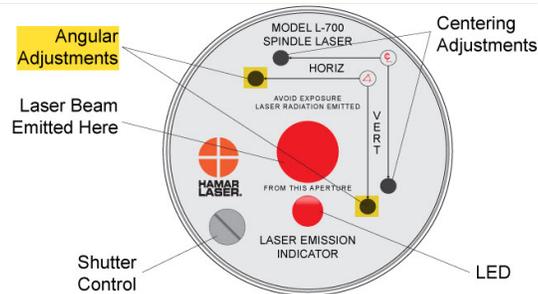
Tip: When recording data in Lathe9, you can use the spacebar to record the data points.



4. Rotate the headstock spindle 180 degrees back into the NORMAL position and click/press Record. Lathe9 automatically calculates Set Points for each axis and calculates display offsets so that you can adjust the four alignment axes to zero instead of a Set Point. To toggle the display offsets, click/press ON.

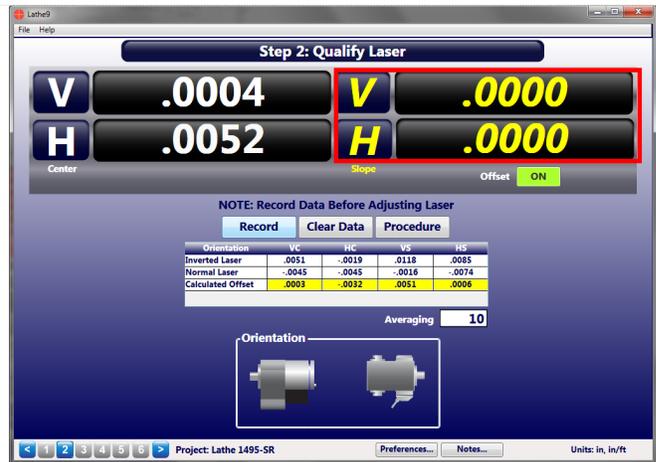


5. Adjust the V and H Angular (slope) adjustment on L-700 until the Slope values are .0000 in/ft or very close to it.

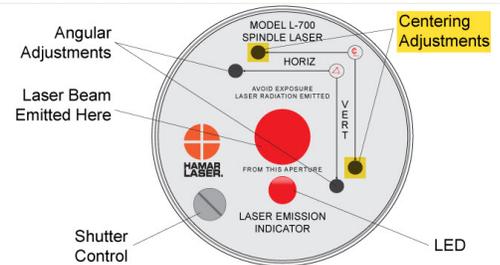


Warning!!
If the adjustments start getting tight or very loose, STOP! You might cause some damage to the laser adjustments if you turn them too far. The adjustments have about 3 full turns in either direction before they run out of range.

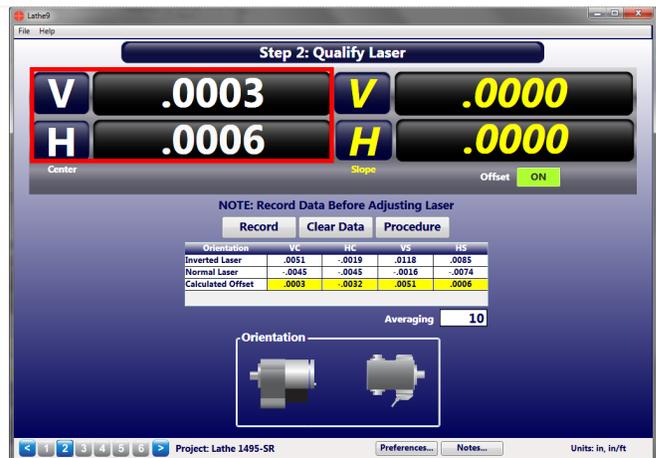
Here the L-700 V & H Slope values are adjusted to zero.



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



Here 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 2-6 to verify the laser is aligned to the headstock AOR.

Note: It is much more important to 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, Lath9's NORMIN procedure can subtract out any remaining centering errors of the laser beam to the headstock AOR.

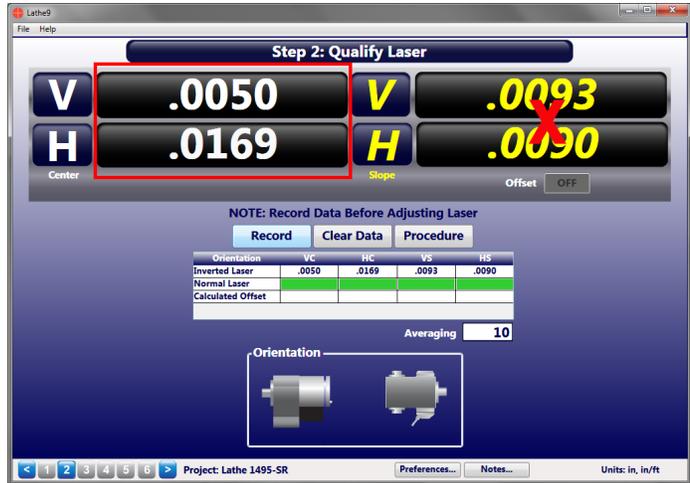
8. Ultimate-accuracy headstock parallelism alignment checks (optional).

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:

- 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).
- Move the tailstock /T-261 as far as possible from the headstock up to about 10 ft. (3 m).
- In **Step 2**, click **Clear Data**.
- Rotate the headstock spindle/L-700 to the INverted position and press **Record**.
- Rotate the headstock spindle/L-700 back to the NORMal position and press **Record**. The offsets are applied.
- 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!



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-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/T-261 to the next point and record it. Do the same for the saddle/subspindle or turret.

After the data is recorded, click **Results** and Lathe9 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. Lathe9 also calculates this best-fit line for the data for the saddle (turret/subspindle) axis.

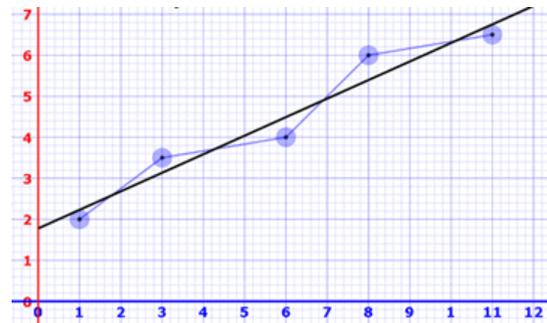


Figure 11 – Least-Squares, Best-Fit line drawn through data

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 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.

What the Buttons Do

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 rows, but not the **Saddle** set of rows (if enabled in **Preferences**). To clear data from the Saddle set of rows, first click **Saddle** and then **Clear Data**.

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

Save – Saves the data for all the steps in the project.

Graph – Calculates the results and takes you to **Step 4: Lathe Bed Straightness Results**.

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

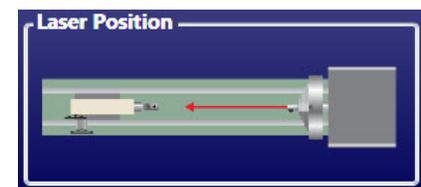
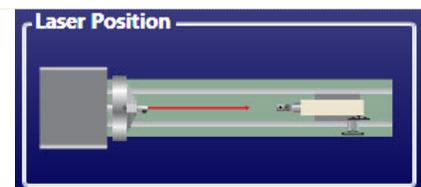
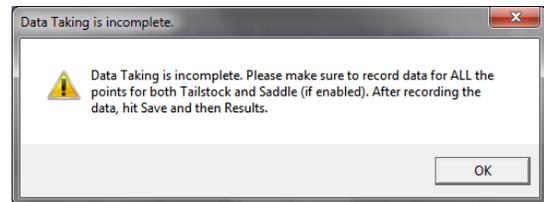
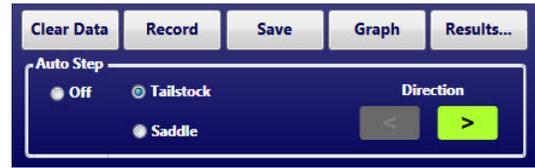
Auto Step – Clicking **Tailstock** will take data for the Tailstock rows. When a point is taken, the cursor automatically “steps” to the next point. The procedure is the same for **Saddle**. If you turn **Auto Step** off, then you must click on the column for the data point you want to take.

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

Note: *The **Graph** and **Results** buttons will not work until all the data has been taken for each of the two sets of guideways. If only **Tailstock** is selected in **Preferences**, then all the points for the **Tailstock** data needs to be recorded before the buttons will operate. A warning message indicates why the screens haven't opened.*

Laser position

This graphic indicates which side is selected in **Step 1** for the laser position. To change the Laser Position, return to **Step 1** and click the laser icon.



Taking Data

The goal in **Step 3** is to record the straightness data for:

- Tailstock guideways
- Saddle/Subspindle/Turret guideways; or
- Both sets of guideways

Tailstock Guideways

1. Move the tailstock (with the T-261 securely clamped into the chuck) close to the headstock, leaving it about 8 in. (200 mm) between the L-700 and T-261.
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.

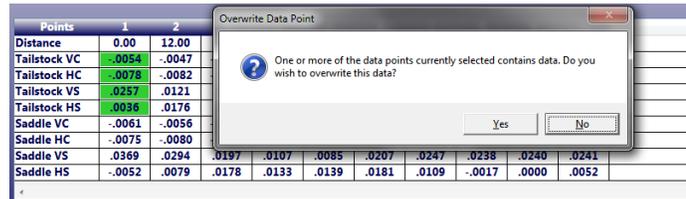
Generating Alignment Results

If all data points are taken, and only **Include Tailstock** is selected in the data grid (see Data Grid Display tab in **Preferences** on Page 19), you can now click **Results** to see the **Step 3: Alignment Results** popup, 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 column for the point and click **Record**. A popup opens asking if you want to retake the data. Click **Yes** to record the new data point.



Switching Data-Taking Auto-Step Direction

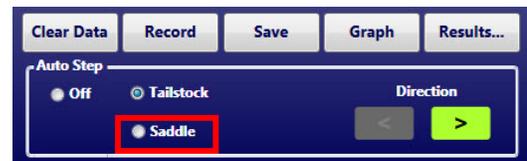
To start with the tailstock at the last point and move it closer to the headstock as you take data, click the button with the left arrow. The cursor moves to the last point. Click **Record** to move the cursor left to the next point and continue in this way until the last point (#1) has been recorded.



Saddle/Subspindle/Turret Guideways

1. In **Preferences** under the **Data Grid Display** tab, (Page 19) ensure **Include Saddle Rows** is selected.
2. Click **Saddle** in the **Auto Step** box to enable data taking for the saddle (subspindle or turret) guideways. The green “cursor” (highlight) will start at Point #1 for the lower set of rows.
3. Move the saddle (subspindle or turret), with the T-261 securely fixtured in place or clamped into the chuck close to the headstock, leaving about eight inches (200 mm) between the L-700 and T-261.
4. Ensure data is displayed and click **Record** or press the spacebar. You will hear a “beep” indicating the point has been recorded.
5. The green “cursor” will move to the next point. Move the saddle, subspindle or turret 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.



6. Wait 5-10 seconds and click **Record**. You may need to wait longer if the Avg is set to a high value (>20).
7. Continue taking data until all the points are taken.

Generating Alignment Results

If you recorded all the points for both the Tailstock and Saddle, click **Results** to view the **Step 3: Alignment Results** popup, which shows the (V) straightness (flatness) and (H) straightness of both the Tailstock and Saddle (turret or subspindle) sets of the guideways, and parallelism (V & H) of the headstock AOR to both sets of guideways.

Step 3 Alignment Results						
Item	Tailstock Data			Saddle Data		
	Value	+/- Toler.	In/Out	Value	+/- Toler.	In/Out
V Straightness	.0016	.0005	✗	.0016	.0005	✗
H Straightness	.0012	.0005	✗	.0007	.0005	✗
V Parallelism	.0000	.0003	✓	.0000	.0003	✓
H Parallelism	.0000	.0003	✓	.0000	.0003	✓

TS/Saddle Parallelism			
Item	Value	+/- Toler.	In/Out
V Parallelism	-.0001	.0004	✓
H Parallelism	.0000	.0004	✓

Retaking Data

To retake any of the data points, ensure **Saddle** is selected, click on the column for the point and click **Record**. A popup opens asking if you want to retake the data. Click **Yes** to record the new data point.

Points	1	2
Distance	0.00	12.00
Tailstock VC	-.0054	-.0047
Tailstock HC	-.0078	-.0082
Tailstock VS	.0257	.0121
Tailstock HS	-.0036	.0176
Saddle VC	-.0061	-.0056
Saddle HC	-.0075	-.0080
Saddle VS	.0369	.0294
Saddle HS	-.0052	.0079

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.

Item	Tailstock Data			Saddle Data		
	Value	+/- Toler.	In/Out	Value	+/- Toler.	In/Out
V Straightness	.0004	.0005	✓	N/A	.0005	
H Straightness	.0001	.0005	✓	N/A	.0005	
V Parallelism	-.0010	.0003	✗	N/A	.0003	
H Parallelism	.0000	.0003	✓	N/A	.0003	

TS/Saddle Parallelism			
Item	Value	+/- Toler.	In/Out
V Parallelism	N/A	.0004	
H Parallelism	N/A	.0004	

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

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 – increase or decrease 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.

Locking the Shim

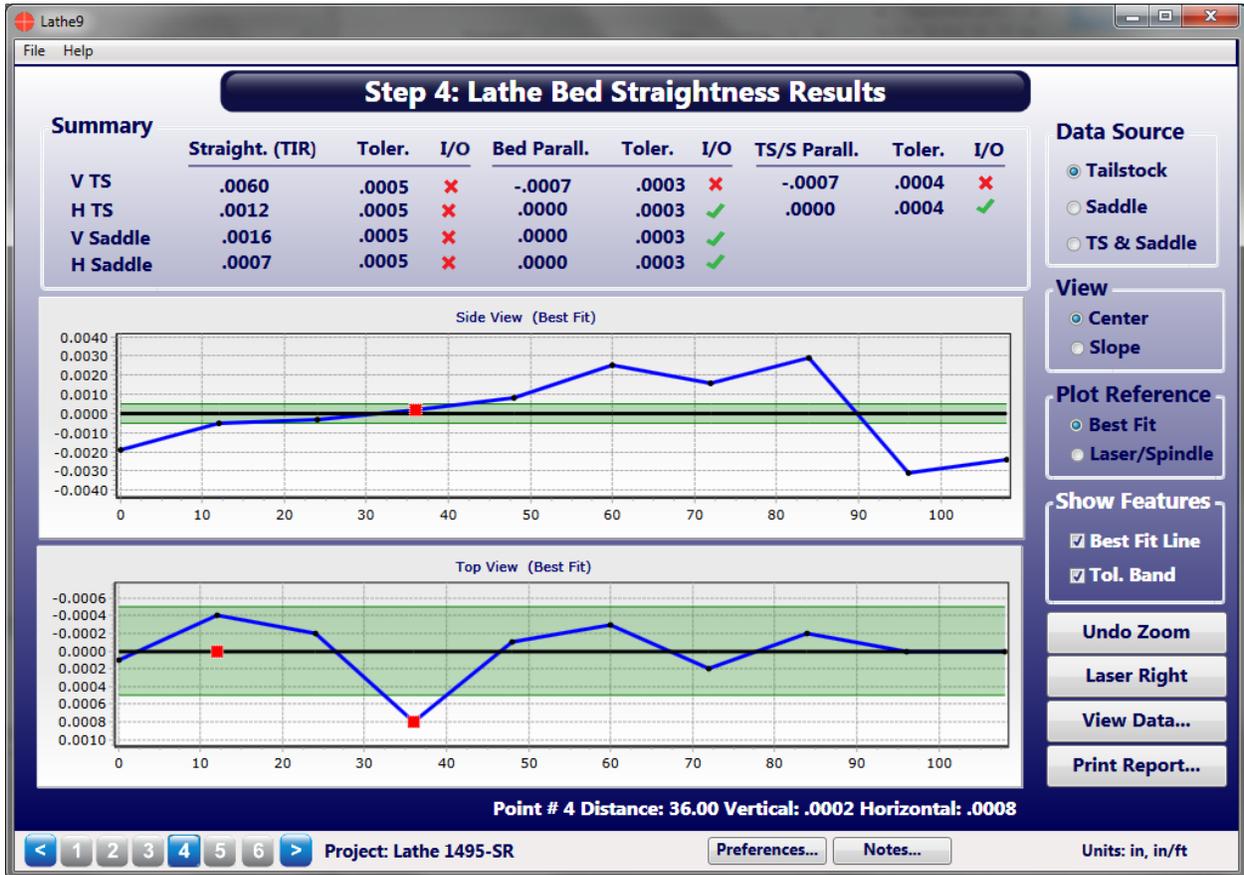


The Vertical shim value is locked by default. To update the shim in real time, click on the lock icon to unlock it. The Horizontal move is unlocked by default but can also be locked by clicking on the lock icon for the H axis.



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 TS* – Vertical axis of the Tailstock guideways.
- *H TS*– Horizontal axis of the Tailstock guideways.
- *V Saddle*– Vertical axis of the Saddle (Turret or Subspindle) guideways.
- *H Saddle*– Horizontal axis 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 tailstock guideways. This also equals the slope of the best fit line. Expressed in in/ft or mm/m or mm/100 mm.
- *TS/S 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 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.

Summary	Straight. (TIR)	Toler.	I/O	Bed Parall.	Toler.	I/O	TS/S Parall.	Toler.	I/O
V TS	.0060	.0005	X	-.0007	.0003	X	-.0007	.0004	X
H TS	.0012	.0005	X	.0000	.0003	√	.0000	.0004	√
V Saddle	.0016	.0005	X	.0000	.0003	√			
H Saddle	.0007	.0005	X	.0000	.0003	√			

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.

View

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

Data Source

- Tailstock
- Saddle
- TS & Saddle

View

- Center
- Slope

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 \pm band around zero. In the **Summary**, a green \checkmark 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, Lathe9 will look at the absolute 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. 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.

Plot Reference

- Best Fit
- Laser/Spindle

Show Features

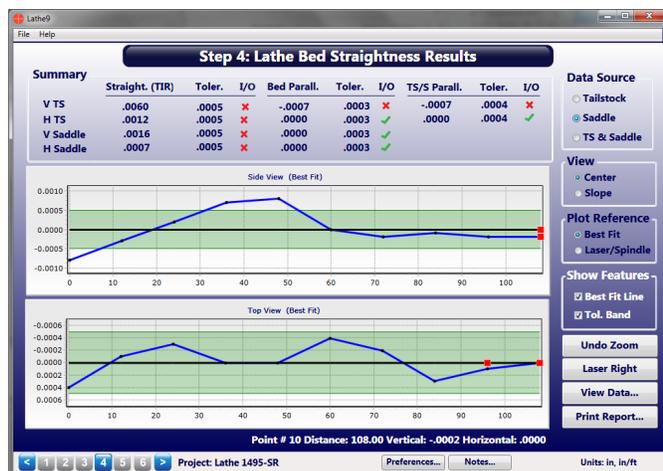
- Best Fit Line
- Tol. Band

Undo Zoom

Laser Right

View Data...

Print Report...



- 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

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**.

Plot Reference

- Best Fit
- Laser/Spindle

Show Features

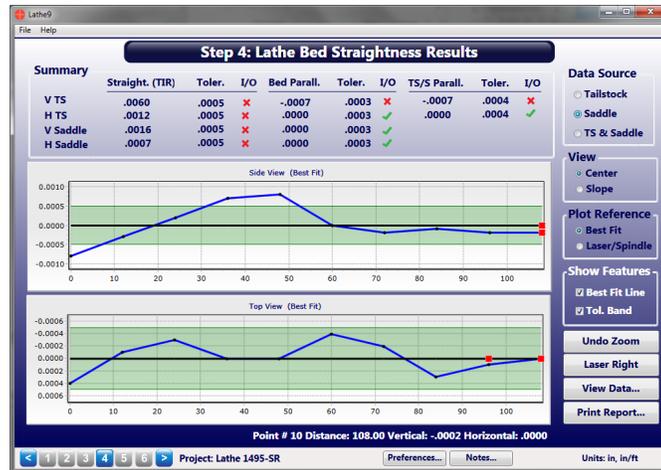
- Best Fit Line
- Tol. Band

Undo Zoom

Laser Right

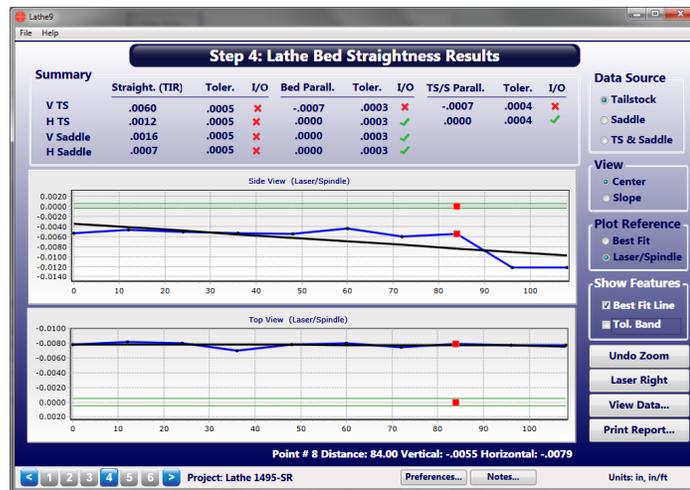
View Data...

Print Report...



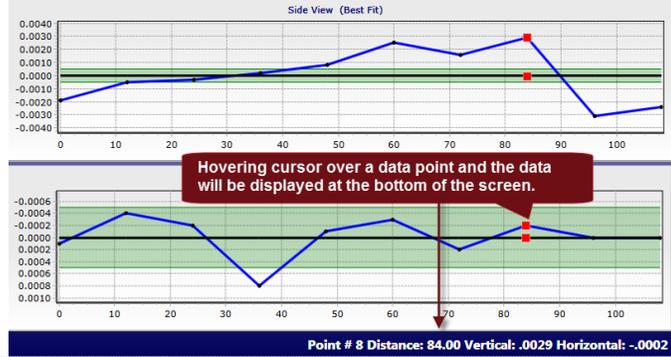
Graph Using Laser/Spindle as the Plot Reference

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.
- **Laser Right** - Flips the graph so the data starts from the right and flows to the left.
- **View Data** – Brings up a data table for the data being plotted in the graph.
- **Print Report** - Opens the **Print Report** screen to make selections and print the report. You can also print from **Step 5**. See Page 54 for more details on Printing the Report.



Data Point	Distance	Tailstock VC	Tailstock HC	Tailstock VS	Tailstock HS	Saddle VC	Saddle HC	Saddle VS	Saddle HS
1	0.00	-.0054	-.0078	.0257	.0036	-.0061	-.0075	.0369	-.0052
2	12.00	-.0047	-.0082	.0121	.0176	-.0056	-.0080	.0284	.0079
3	24.00	-.0051	-.0080	.0203	.0138	-.0050	-.0082	.0197	.0178
4	36.00	-.0054	-.0070	.0245	-.0114	-.0046	-.0079	.0107	.0133
5	48.00	-.0055	-.0078	.0254	.0086	-.0044	-.0079	.0085	.0139
6	60.00	-.0045	-.0080	.0097	.0152	-.0052	-.0083	.0207	.0181
7	72.00	-.0061	-.0075	.0370	-.0002	-.0054	-.0081	.0247	.0109
8	84.00	-.0055	-.0079	.0285	.0062	-.0053	-.0076	.0238	-.0017
9	96.00	-.0122	-.0077	.0230	-.0039	-.0054	-.0078	.0240	.0000
10	108.00	-.0122	-.0077	.0230	-.0039	-.0054	-.0079	.0241	.0052

Step 5: Record Tailstock/Subspindle Axis Data

In **Step 5: Record Tailstock/Subspindle Axis Data**, we will be checking the coincidence (in four 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 four 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, three 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 take the data.

Step 5: Record Tailstock/Subspindle Axis Data

V Center: **-0.0124** V Slope: **.0231**
H Center: **-0.0078** H Slope: **-0.0040**

Offset:

Record Clear Data Procedure Print Report... Averaging:

Laser Position	V Center	H Center	V Slope	H Slope
Laser Inverted/Target Normal				
Normal Laser/Target Inverted				
Laser Normal/Target Normal				
Calculated Mounting Errors	N/A	N/A	N/A	N/A

Alignment Results - Tailstock/Subspindle Axis

Side View				Top View			
V. Center	I/O	V. Slope	I/O	H. Center	I/O	H. Slope	I/O
.0000		.0000		.0000		.0000	

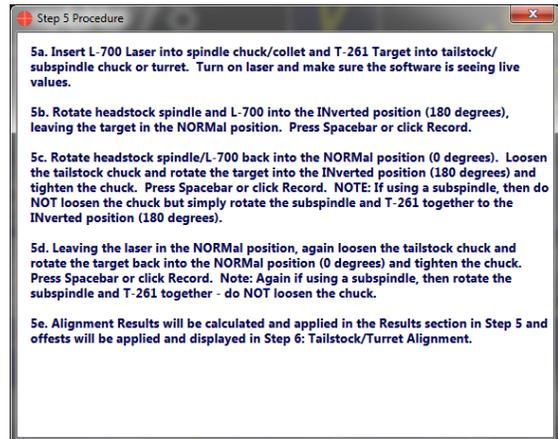
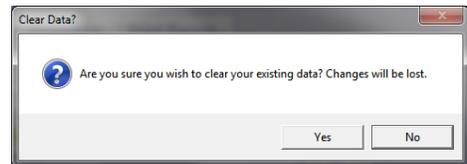
Orientation

Side View **Top View**

< 1 2 3 4 5 6 > Project: Lathe 1495-SR Preferences... Notes... Units: in, in/ft

What the Buttons Do

- **Record** – Records the four 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 to see a summary of the data-taking procedure.
- **Print Report** – Click to print the report. You can also print from **Step 4**. See Page 54 for more details on Printing the Report.



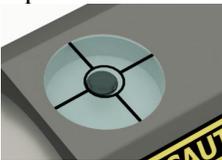
Taking Data

A simple 3-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. For the tailstock chuck or turret fixturing, loosen the chuck or the fixture to rotate the target. 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 lathe. 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.*

Procedure

1. Inverts the L-700 Laser/spindle, keeping the T-261 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 target and laser for taking the data on the *next* point.

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

Step 5: Record Tailstock/Subspindle Axis Data

V **-.0033** V **.0333**
H **-.0002** H **.0176**

Center Slope Offset OFF

Record Clear Data Procedure Print Report... Averaging 10

Laser Position	V Center	H Center	V Slope	H Slope
Laser Inverted/Target Normal	-.0033	-.0002	.0333	.0176
Normal Laser/Target Inverted				
Laser Normal/Target Normal				
Calculated Mounting Errors	N/A	N/A	N/A	N/A

Alignment Results - Tailstock/Subspindle Axis

Side View		Top View	
V. Center I/O	V. Slope I/O	H. Center I/O	H. Slope I/O
.0000	.0000	.0000	.0000

Orientation

Side View Top View

Project: Lathe 1495-SR Units: in, in/ft

Record Clear Data Procedure Print Report...

Laser Position	V Center	H Center	V Slope	H Slope
Laser Inverted/Target Normal				
Normal Laser/Target Inverted				
Laser Normal/Target Normal				
Calculated Mounting Errors	N/A	N/A	N/A	N/A

Orientation

Laser Inverted Target Normal

2. Rotate the L-700 Laser/Spindle back to the NORMAl position. For the tailstock, loosen the chuck, rotate the T-261 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-261 in it. Wait 10 seconds or so before clicking **Record**.

Laser Position	V Center	H Center	V Slope	H Slope
Laser Inverted/Target Normal	-.0033	-.0002	.0333	.0176
Normal Laser/Target Inverted				
Laser Normal/Target Normal				
Calculated Mounting Errors	N/A	N/A	N/A	N/A

Orientation

Laser Normal Target Inverted

3. Leaving the laser in place, loosen the tailstock chuck, rotate the T-261 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-261 in it back to the NORMAl position. Wait 10 seconds or so before clicking **Record**.

Laser Position	V Center	H Center	V Slope	H Slope
Laser Inverted/Target Normal	-.0033	-.0002	.0333	.0176
Normal Laser/Target Inverted	-.0124	.0071	-.0183	-.0003
Laser Normal/Target Normal				
Calculated Mounting Errors	N/A	N/A	N/A	N/A

Orientation

Laser Normal Target Normal

Interpreting the Results

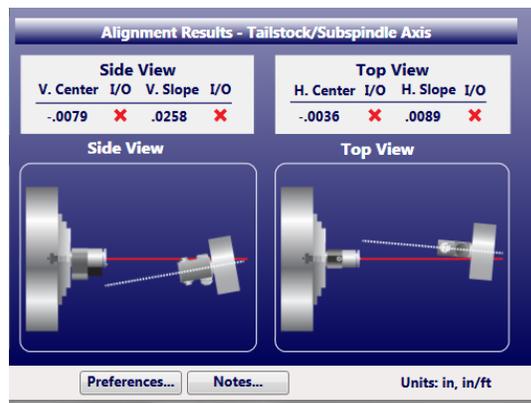
After recording the third point, Lathe9 calculates the mounting errors of the laser and target and subtracts them from the raw data, applying display offsets to the four real-time data displays. These values are the actual alignment values of the tailstock chuck centerline, the turret tool holder centerline 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.

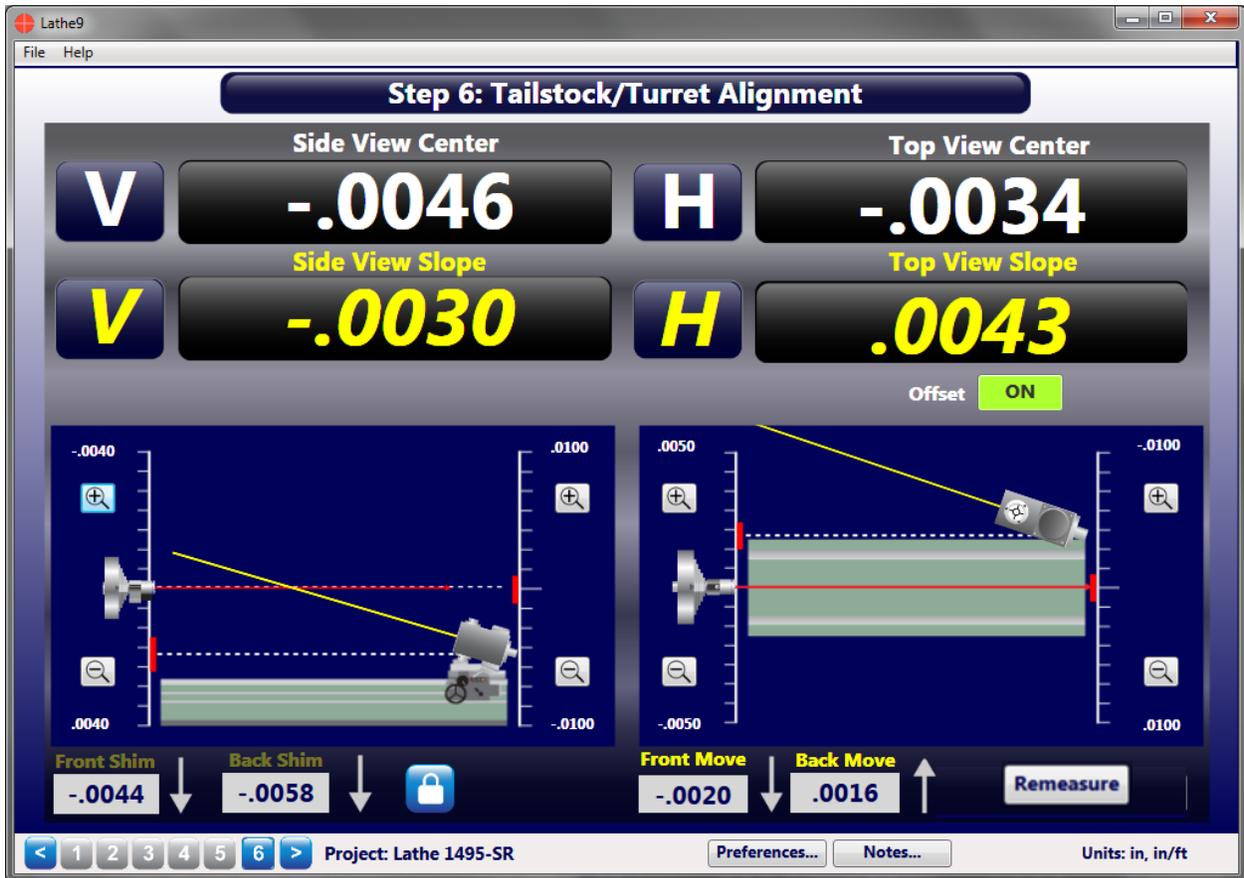


Out of Tolerance

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

Step 6: Tailstock/Turret Alignment

Step 6 provides a real-time, 4-axis display of the four alignment values. A T-261 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.



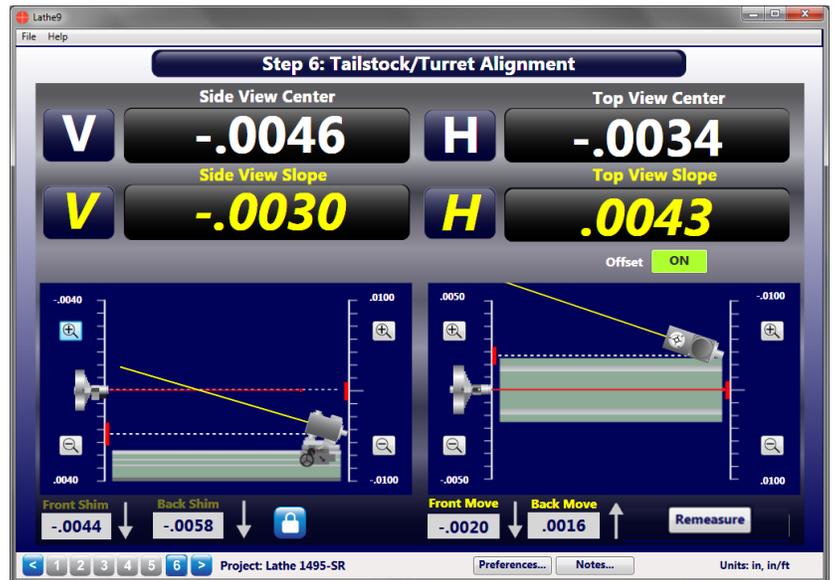
What the Buttons Do

- **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.

Offset **ON**

- **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 graphic 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 graphic 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.

Horizontal Axis

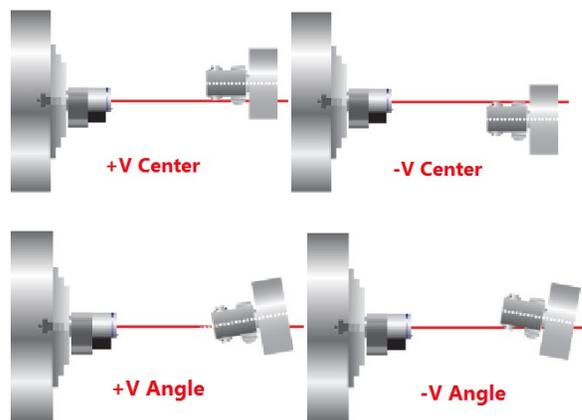
A **+H center** value indicates the target is to the right of the laser beam when looking from the laser *into* the T-261 target.

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.

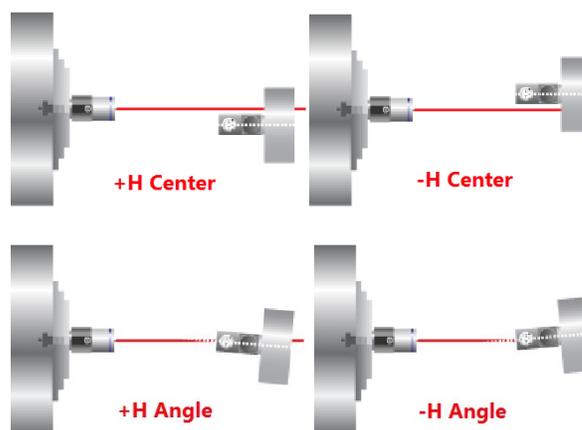
A **-H center** value indicates the target is to the *left* of the laser beam when looking from the laser *into* the T-261 target.

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.

Side View



Top View



Shim Values

Lathe9 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**.

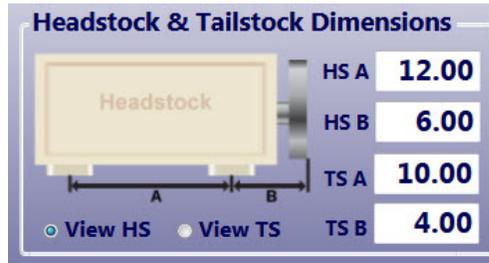
The *Shim* values are locked while the *Move* values update with changes in the H axis alignment values.



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

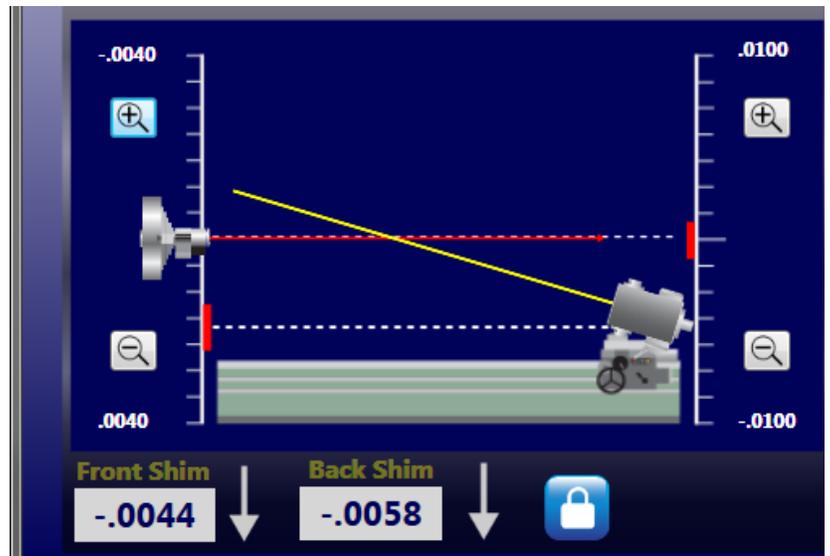
Display offsets are applied to the raw target values to remove the mounting errors. This displays the actual alignment, so the display values shown in **Step 6** are the *actual* alignment values of the tailstock or subspindle relative to the headstock AOR. The display values and the graphics update in real time.

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.

The yellow line attached to the T-261 Target graphic shows which way the tailstock/subspindle axis is tilted relative to the headstock AOR, which is represented by the red laser line.

The white dotted line represents the centerline of the tailstock chuck or subspindle rotation axis and whether it is above/below or left/right relative to the headstock AOR.

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.



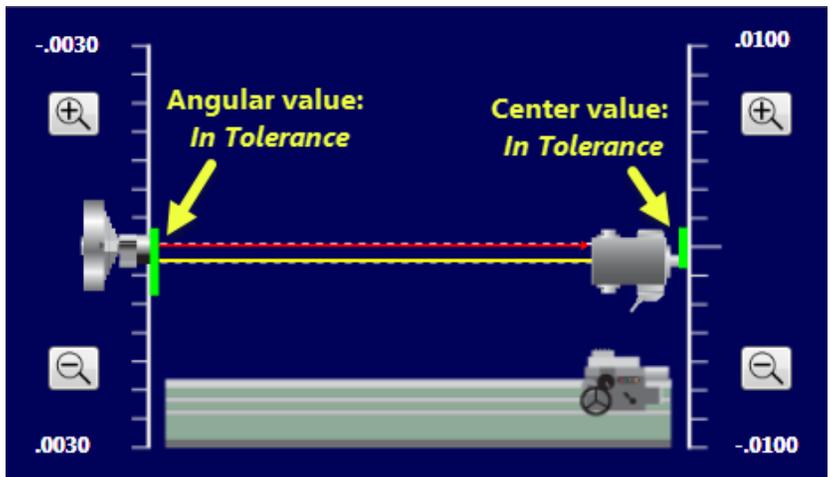
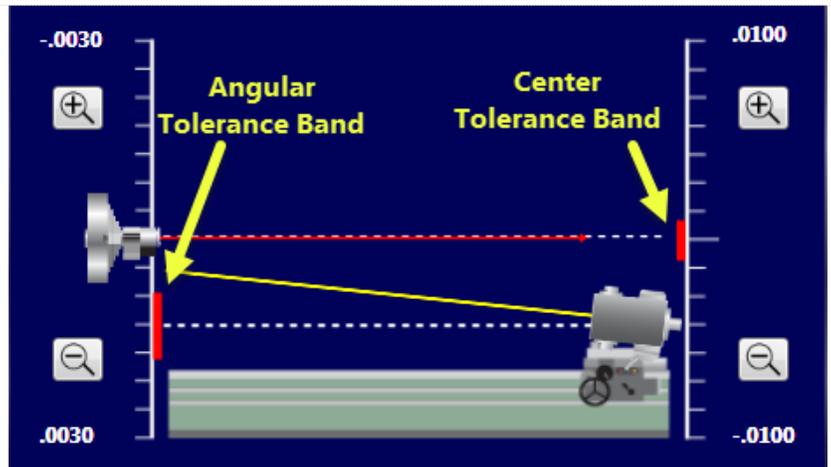
Tolerance Bands

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

Note: *The Angular Tolerance Band moves up and down the screen following the target icon's white dotted centerline, which represents the tailstock center value.*

Red indicates it is out of tolerance

Green indicates the values are in tolerance.



Aligning the Tailstock/Subspindle (continued)

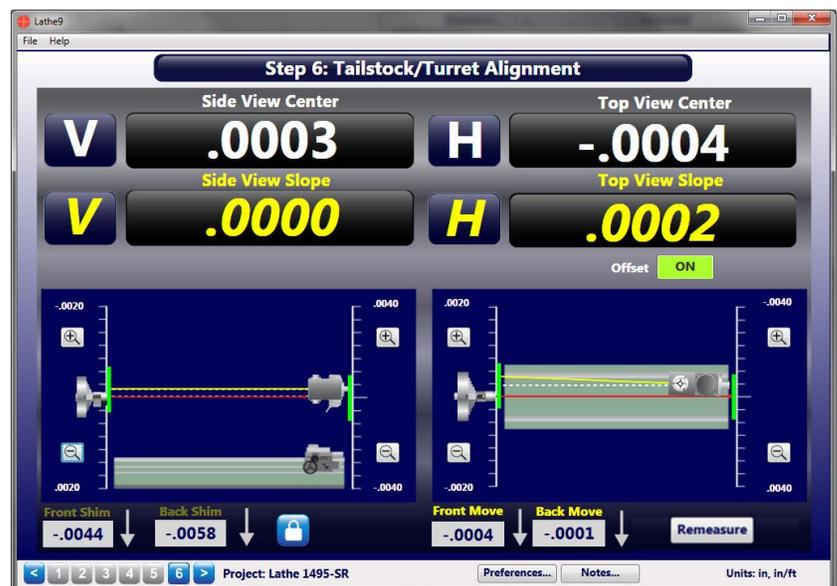
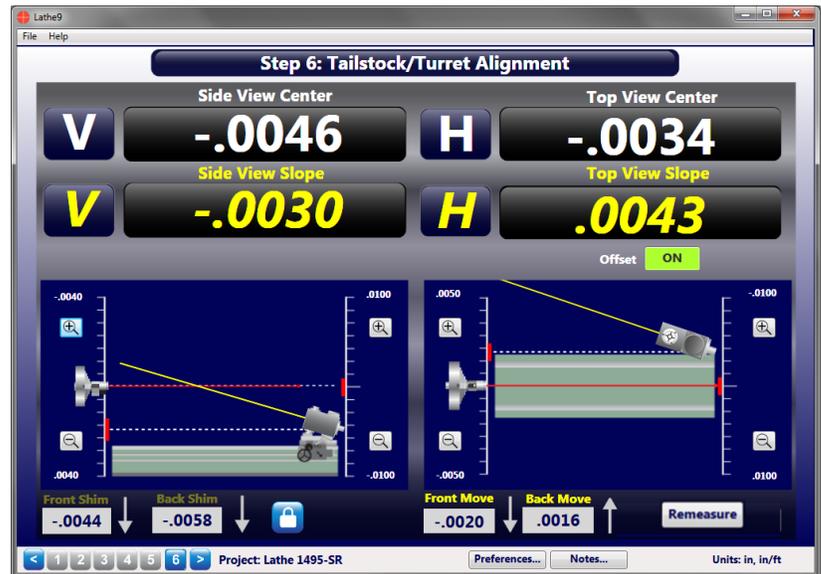
In the screen to the right, all values are out of tolerance (the tolerance bands are all red) so the tailstock is *not* aligned.

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

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

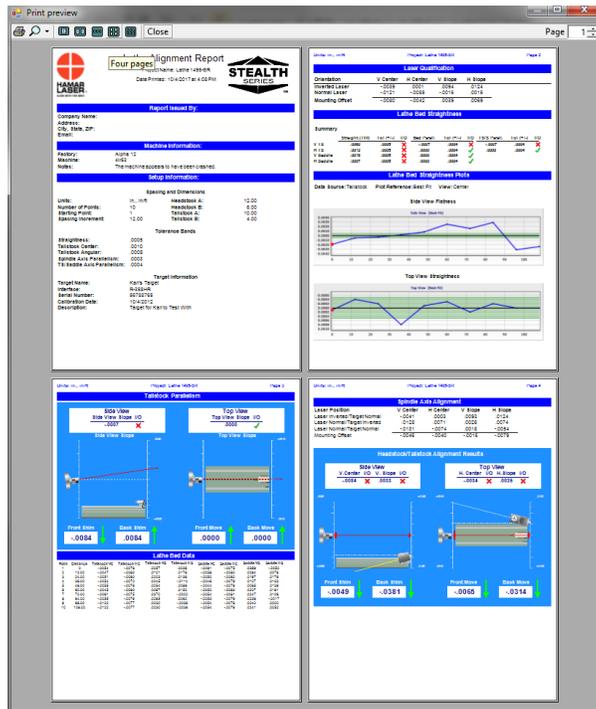
In the screen to the right, all the values are within the specified tolerances from **Step 1**, as shown by the green tolerance bands, so the tailstock is now aligned.

To verify the alignment, click **Remeasure** to return to **Step 5** and re-take the alignment data.



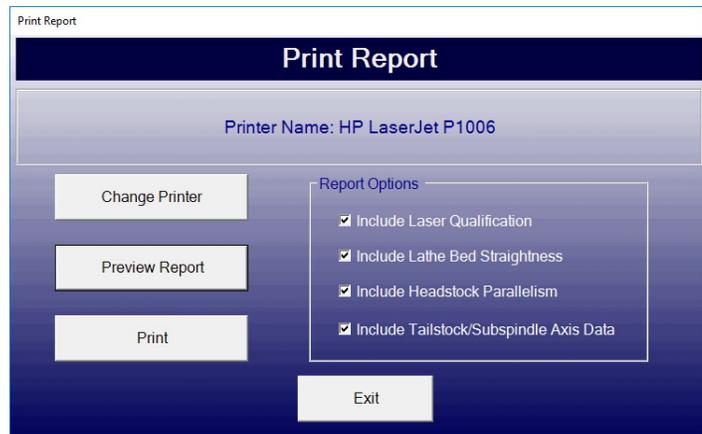
Printing Reports

You can print a report from **Step 3, 4 or 5** by clicking **Print Report**. You can also print a report from the **File Menu**.



Printing a Report

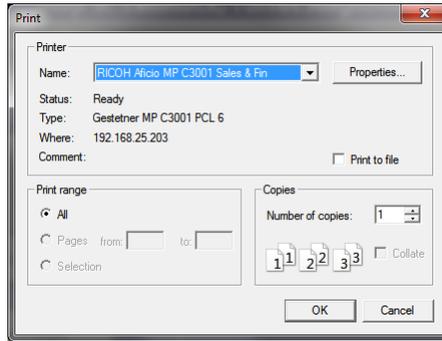
To print a report, click **Print Report** or **Report** in **Steps 3, 4 or 5**. This opens the **Print Report** dialog box, where you can select a printer, preview the report, hide certain sections of the report and print the report.



What the Buttons Do

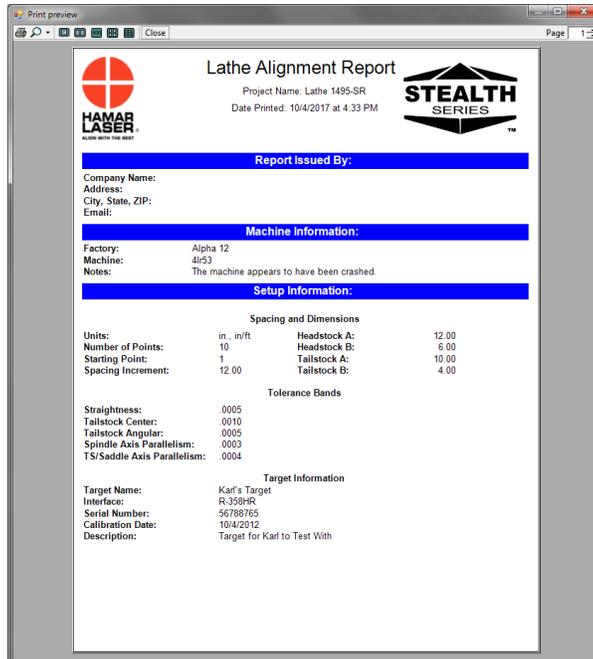
- **Change Printer** – This opens the Windows printer dialog box where you can select either your printer or print the report to a .pdf file for emailing.

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

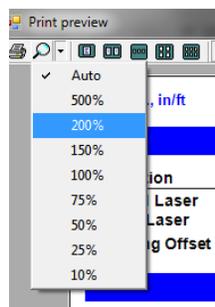


- **Preview Report** – Click to open a preview window of the report. The preview window default shows one page at a time.

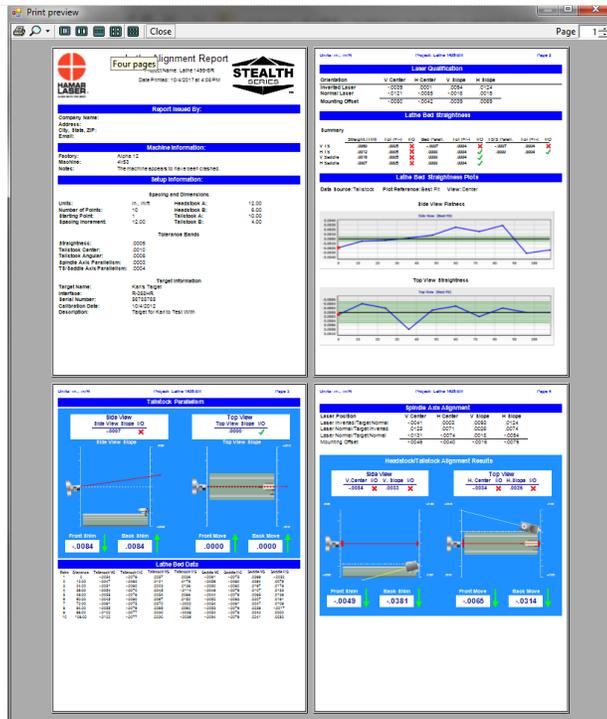
You can show multiple pages at a time by clicking the buttons at the top of the screen.



Clicking the magnifying glass will zoom in on the pages.



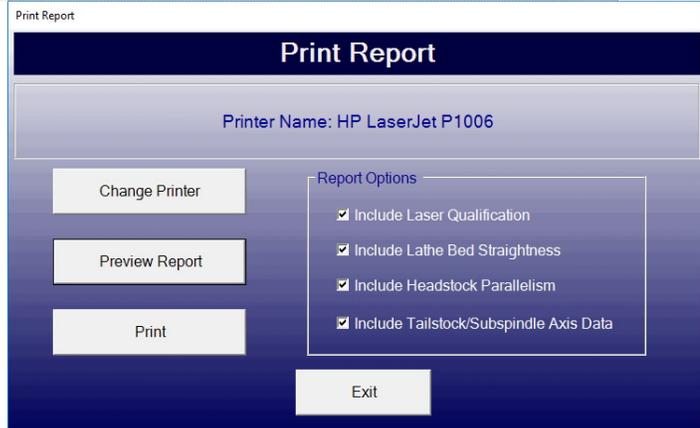
- **Print** – Skips the preview and prints the report to the previously selected printer.
- **Exit** – Closes the popup and returns to the Lathe9 screen.



Excluding Sections on the Report

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

- **Include Laser Qualification** –hides the data from **Step 2: Laser Qualification**.
- **Include Lathe Bed Straightness** –hides the **Step 3: Bed Straightness** data table and the **Step 4: Straightness Graphs**.
- **Include Headstock Parallelism** –hides the summary of the alignment data from **Step 4: Straightness Graphs**, and the headstock parallelism graphics.
- **Include Tailstock/Subspindle Axis Data** – 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 four 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 two sets of readings cancel out centering errors and provide a very accurate result.

There are three 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 12.

Two relationships can be calculated from these three centers and two 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.

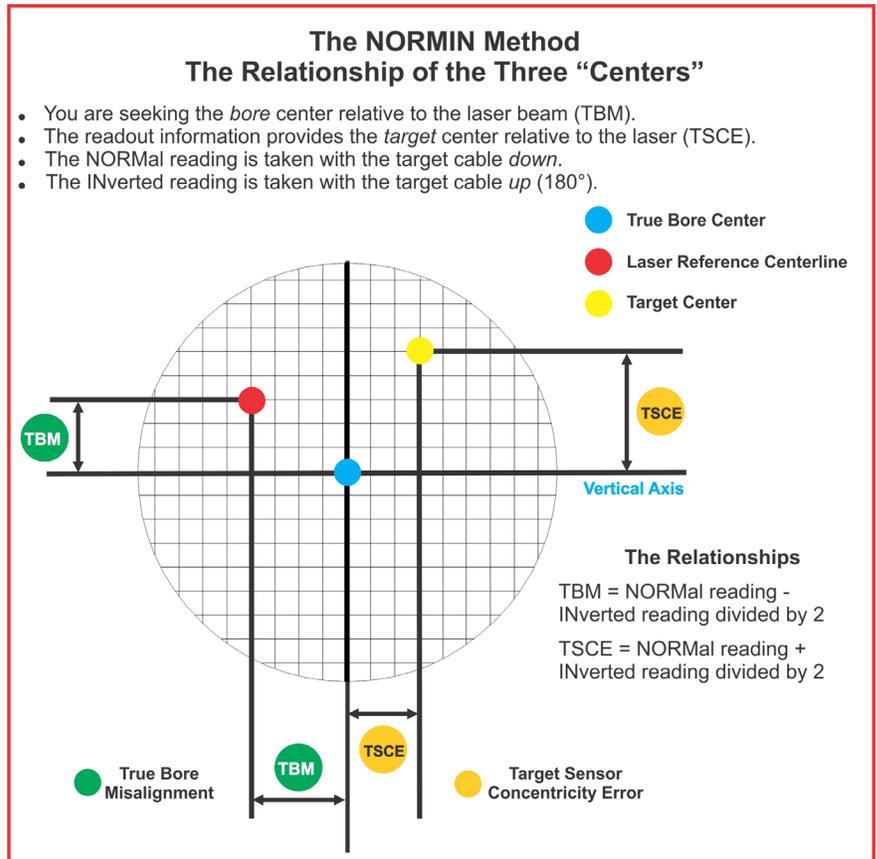


Figure 12 – Three centers of bore alignment

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 13 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.).

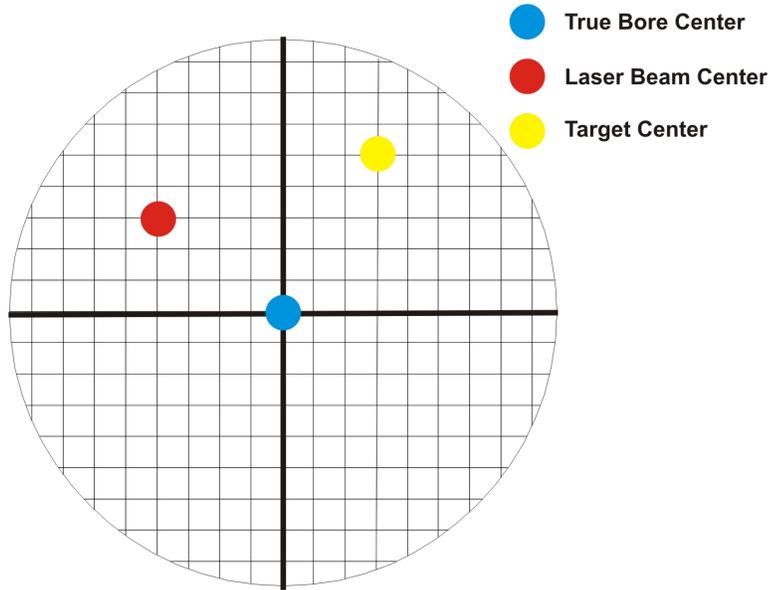


Figure 13 – Target in the **NORMAL** position

Figure 14 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 Figure 14, 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.

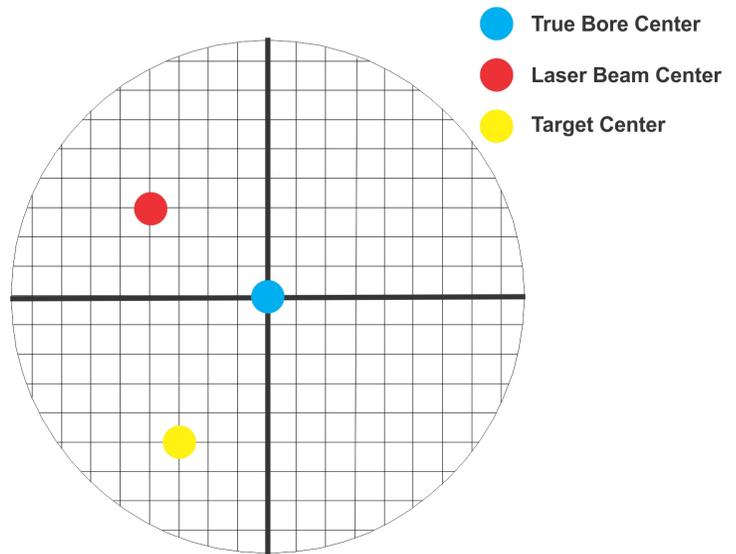


Figure 14 – Target in the **INVERTED** position

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

NORMAL Vertical Reading	+0.002 in.	NORMAL Horizontal Reading	+0.007 in.
INVERTED Vertical Reading	+0.008 in.	INVERTED Horizontal Reading	-0.001 in.
Total	+0.010 in.	Total	+0.006 in.
Divide by 2 = Vertical TSCE	+0.005 in.	Divide by 2 = Horizontal TSCE	+0.003 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 +0.005 in. and Horizontal +0.003 in.

Appendix B – Qualifying the Laser

Lasers must be qualified; that is, the beam must be centered and made parallel 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.

All Hamar lasers are factory qualified to the mounting stud axis. Sometimes, due to slight mounting errors, it is desirable to adjust a laser so that it is aligned to the spindle axis of rotation rather than to its own. A laser that has been qualified for a particular application may need to be re-adjusted for another. The following procedure is used to qualify the L-700 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 recorded. Then the target fixture is rotated 180 degrees to the INverted (cable up) position and a second set of readings 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 57.

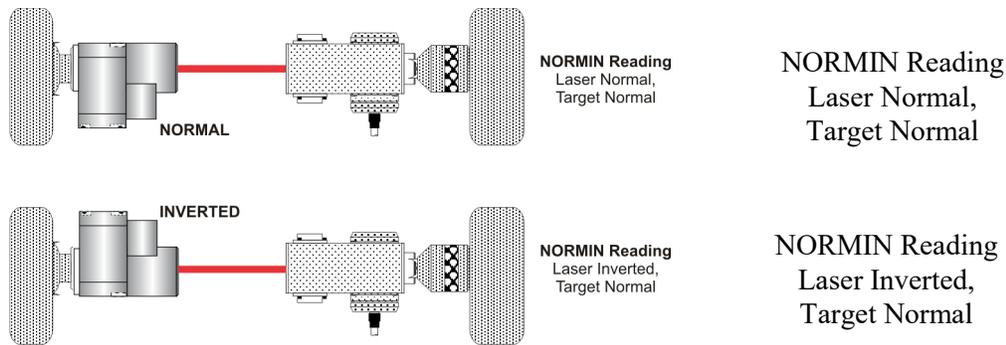


Figure 15 – Taking NORMIN Readings

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/Software-Assisted Qualification

To qualify a laser, error correction readings are taken to cancel out mounting and other errors and 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.

Manual 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 READ8, 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.

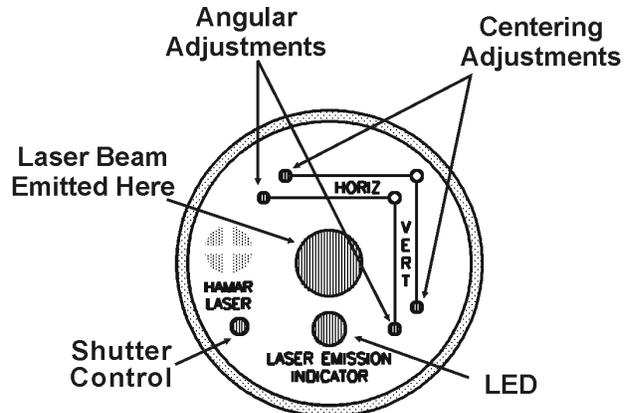


Figure 16 – Laser Adjustment Screws

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 two-axis target with an angle module (the T-212) or a four-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 Lathe9, Spindle8 or Read8 software.

Manual Qualifying Procedure

The following procedure explains how to qualify the laser with a four-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:

$$(\text{NORMal reading} + \text{INverted reading}) / 2 = \text{Set Point}$$

**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 two 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:

$$(\text{NORMal reading} + \text{INverted reading}) / 2 = \text{Set Point}$$

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 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

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.

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 two-axis target. A four-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.

Calibration Setup

1. Mount the laser and target.

Note: Figure 17 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 18).

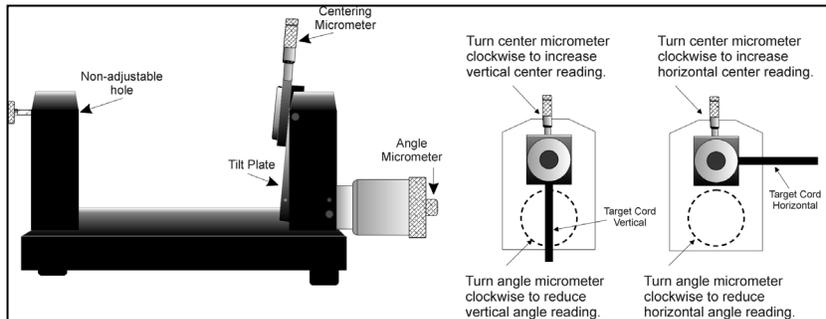


Figure 17 – Model A-807 Calibration Mounting Fixture

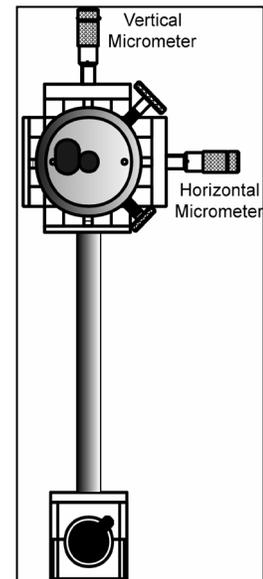


Figure 18 – T-230 Target Stand

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 19).

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.

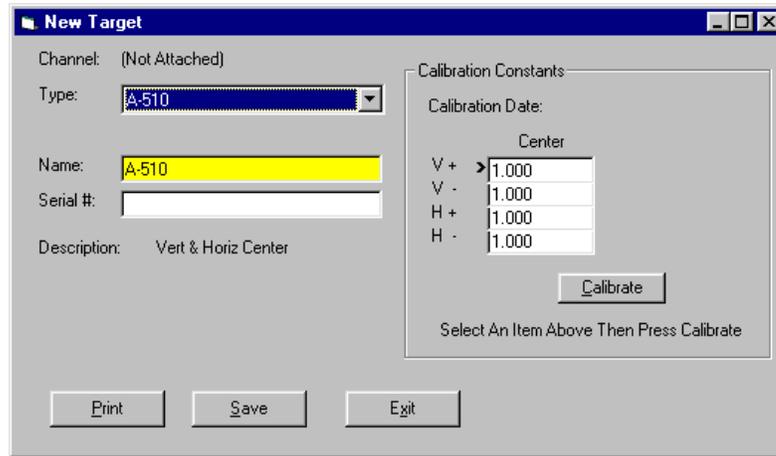


Figure 19 – New Target Screen – 2-axis Target

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 (see Figure 17). If working with a fixture that has a horizontal micrometer, there is no need to rotate the target (see Figure 18).

The Select Channel/Port for Target menu displays (see Figure 20). 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 21).

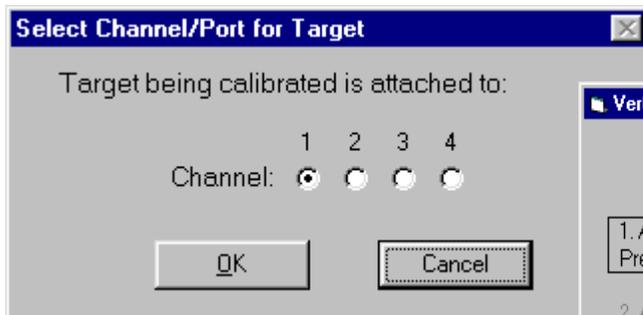


Figure 20 – Channel/Port Selection Screen

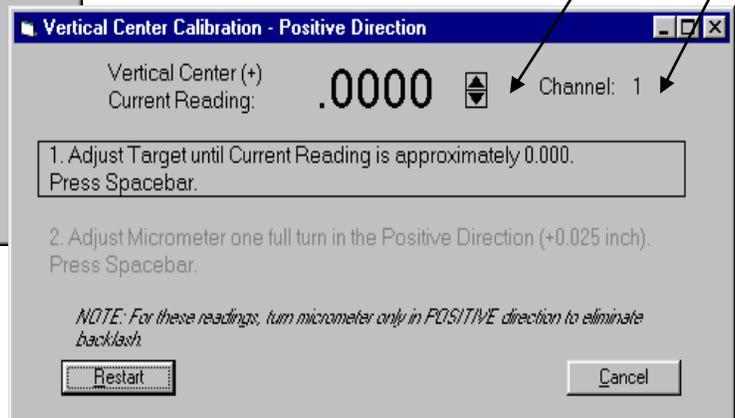


Figure 21 – Calibration Screen

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 Figure 21).*
- *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 21).**

The display should read close to 0.000 (within ± 0.005 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 17) 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 17). 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 22). 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 Figure 21).**
The display should read close to 0.000 (within ± 0.005 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 17) 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 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.

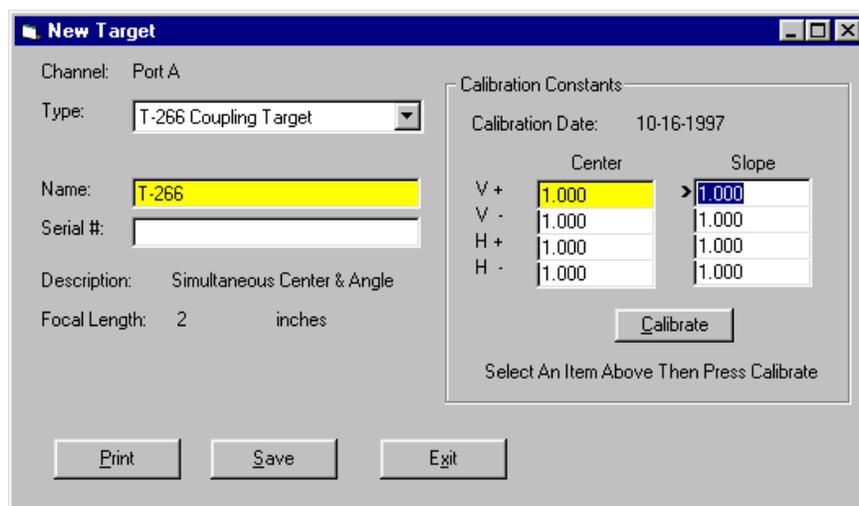


Figure 22 – New Target Screen – 4-axis Target

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.

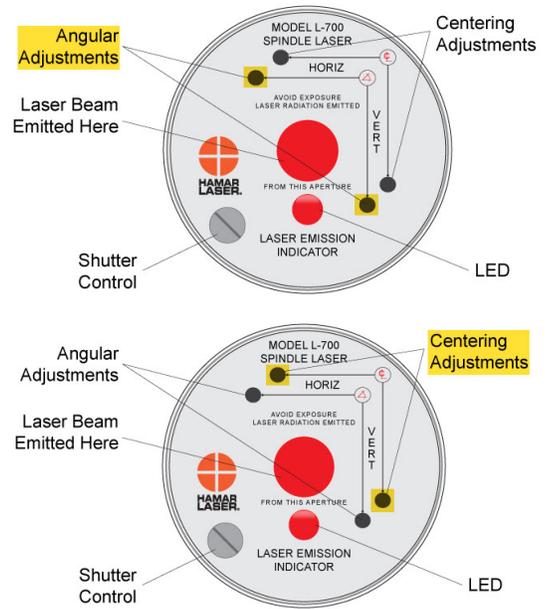
1. Adjust the angle using the Angular controls on the laser faceplate until the Angular readout displays the calculated V & H Angular Set Points.
2. Adjust the L-700 Vertical and Horizontal Center controls on the laser faceplate until the Center readout displays the calculated V&H Center Set Points.

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.

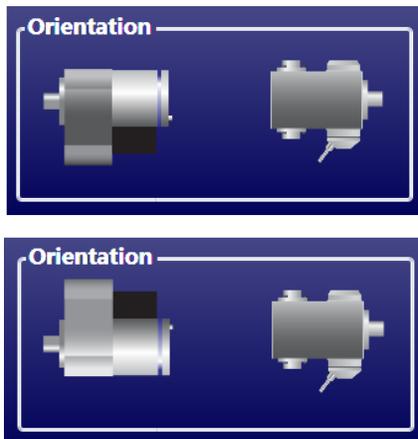
The following procedure is used to qualify the L-700 laser to its mounting stud.

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 recorded. Then the target fixture is rotated 180 degrees to the INverted (cable or switch up) position and a second set of readings 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 57.



NORMIN Reading
Laser NORMAl,
Target NORMAl

NORMIN Reading
Laser INverted,
Target NORMAl

Figure 23– 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.

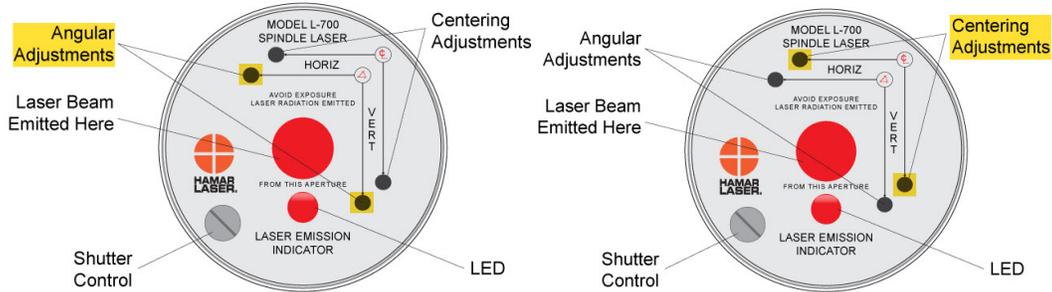


Figure 24– Laser Adjustment Screws

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 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.

Lathe9 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 recommend 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 Lathe9, Spindle8 or Read8 software.



Figure 25 - A-801 Alignment Fixture

If using the manual procedure, then you will need two R-1307 readouts, one for the *center* readings and one for the *angular* readings. See Appendix B beginning on Page 59 for the manual procedure.

Qualifying Procedure Using Lathe9 Software

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 8 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: \pm -.001 in. (0.025 mm)

Angle: \pm -.0002 in/ft (0.017 mm/m)

4. Open Lathe9

Open Lathe9 using either a saved file or enter a new file name.

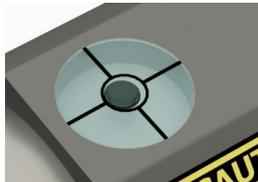
5. Go to Step 2: Qualify Laser

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



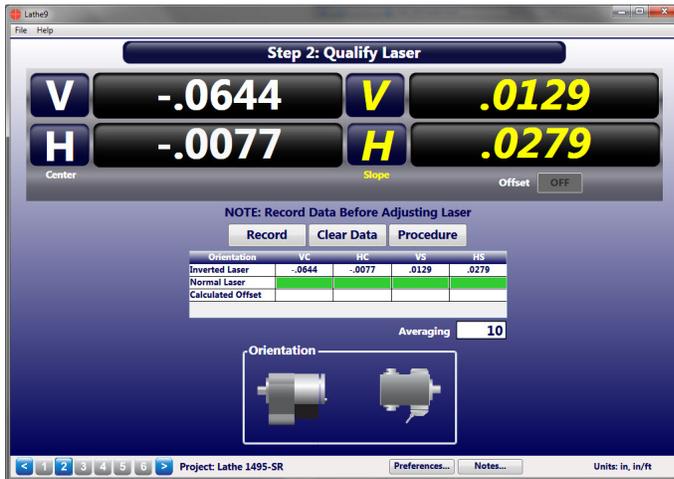
6. Invert the L-700 with the T-261 in the NORMAL position.

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.



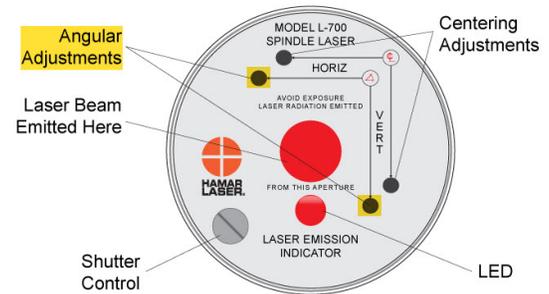
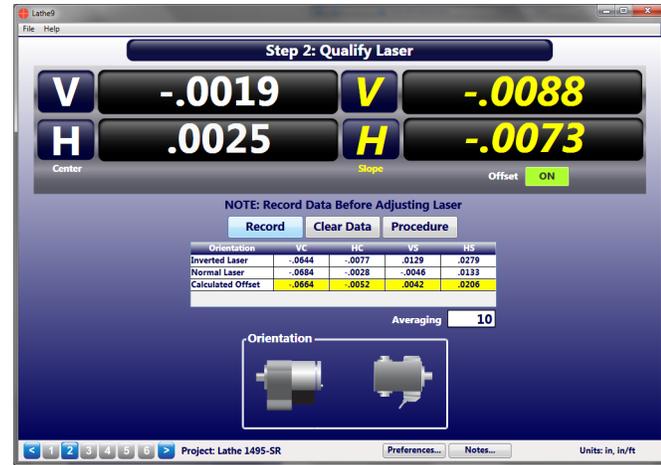
9. Click RECORD.

Click or press *Record* to record the NORMAL value. Lathe9 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.

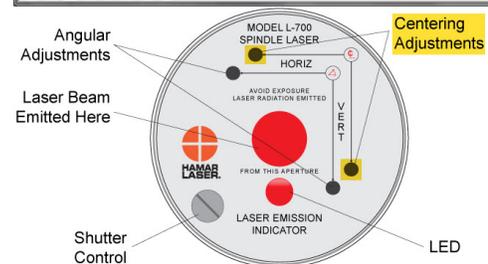
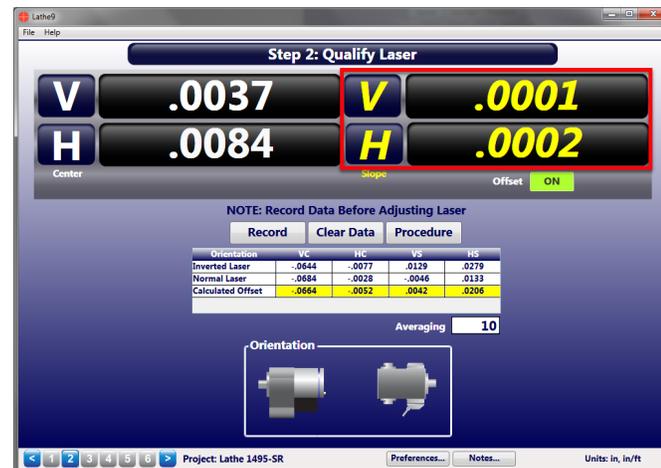
10. Adjust the V and H Angular (slope) adjustment on the L-700 until the Slope values in the Step 2 display are within ± 0.0002 in/ft (0.015 mm/m) of zero.

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 ± 0.001 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.

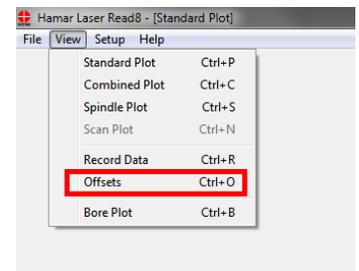
12. Repeat Steps 5-9 to verify the laser is aligned to the L-700 mounting stud.

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.

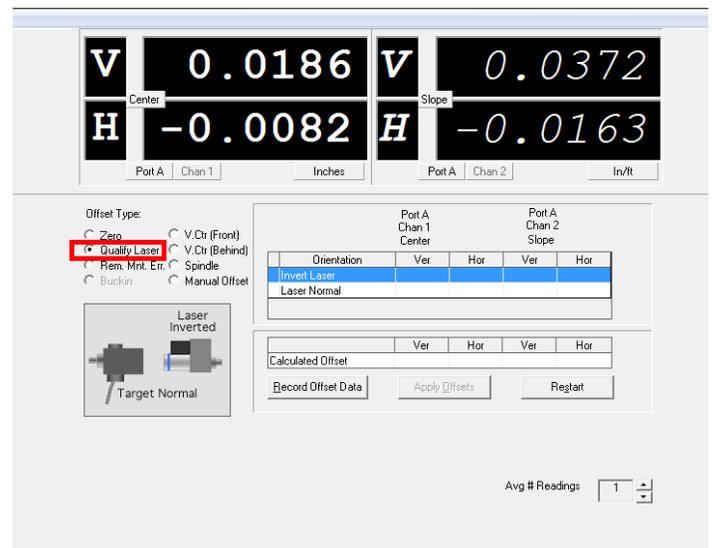


Note on Using Read8 for this procedure.

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**.



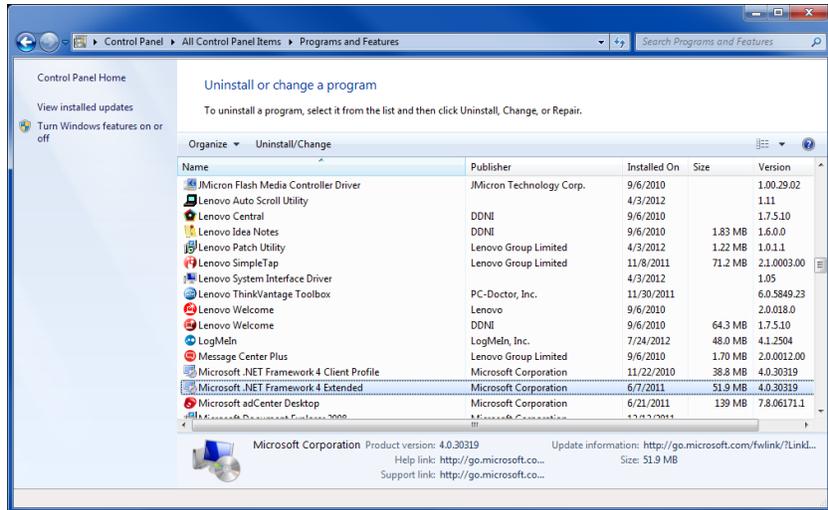
In the **Offsets** screen, click **Qualify Laser** and you will see a similar screen to **Step 2: Qualify Laser**. The instructions are nearly identical so use Steps 5-12 to align the L-700 laser to its mounting stud.



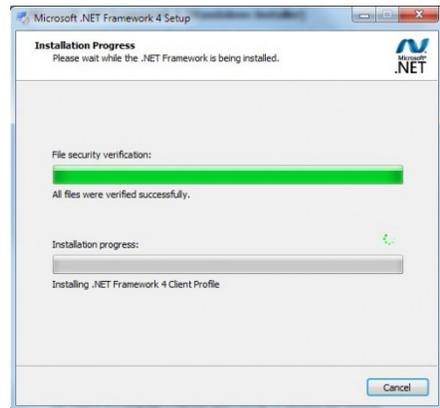
Appendix F – Installing Additional Microsoft Software

Installing Microsoft .NET Framework 4

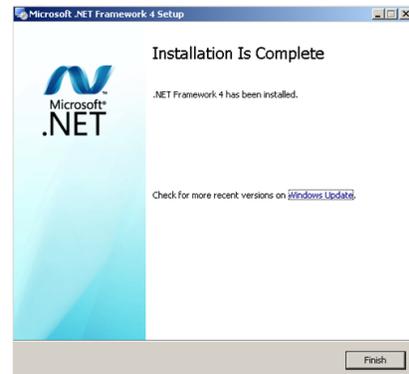
You must have Microsoft .NET Framework installed before installing the Lathe9 software. If you are unsure about whether you have Microsoft .NET Framework 4 installed on your computer, open the Control Panel. For Windows XP users, select **Add/Remove Programs**; for Windows 7 users, select **Programs 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 Lathe9 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.



Installing Microsoft Access Database Engine

The Microsoft Access Database Engine must be installed on your computer before installing the Lathe9 software. This file is usually present if you have a full version of Microsoft Office installed. If not, do the following:

1. Open the folder on the Lathe9 installation USB drive called **MSAccessDatabaseEngine**. Double-click the file **AccessDatabaseEngine** to begin the installation.
2. When prompted, check the box to accept the terms in the License Agreement and select **Next** to continue.
3. Choose the location to install Microsoft Office Access Database (the default location is automatically selected). To change the installation location, select **Browse** and specify a folder. Select **Install** to continue.
4. When installation is complete, click **Finish**.

