

*L-702SP Spindle and MultiTurn
5-Axis Alignment System*

Operations Manual

December 2021



**HAMAR
LASER**®
ALIGN WITH THE BEST

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L-702SP Spindle and Multi-Turn Alignment System

The L-702SP 4-Axis Spindle & Multi-Turn Machine Alignment System is a complete alignment system for aligning spindles on lathes, turning centers and multi-turn machines. It has an automatically rotating turret optic that sweeps a laser scan plane that is perpendicular to the spindle laser, which allows the capability to check squareness of cross slides or machining axes on lathes and multi-turn machines. With an added magnetic leveling base accessory, the L-702SP can also be used to check machine leveling, alignment and axis squareness.

System Features

- **Fast:** Easy setups let you do a quick alignment check in 20 minutes and get full alignment data in 30-40 minutes on most machines.
- **Easy:** Laser and target mount directly into the spindle and tailstock, respectively, allowing the entire length of even the largest lathes or multiturns to be quickly and easily aligned without changing setups, replacing cumbersome and impractical alignment test bars. With built-in squareness capability, checking cross-slide squareness is a 5- minute operation
- **Accurate:** Ultra-high resolution of up to .00001 in. (0.00025 mm) combined with software to correct mounting errors produces a very accurate alignment, less than .0001 in. (0.0025 mm) and .0001 in/ft (0.0083 mm/m) under good environmental conditions.
- **Lathe9 Software:** Large, easy-to-read alignment displays, live alignment data and spindle graphics, and a six-step procedure that guides users through the alignment with on-screen help instructions.
- **MultiTurn10 Software:** Designed mainly to take data for multiturns and lathes, it has a 6 step process that guides you through the alignment process. It records the straightness of each axis and the parallelism or squareness between them.

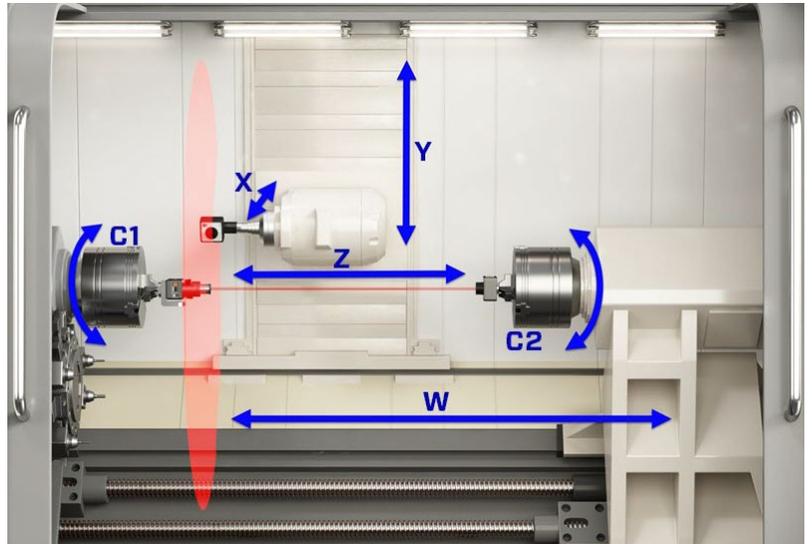


Figure 1 - L-702SP 4-Axis Spindle & Multi-Turn Machine

Model L-702SP Spindle & Scan Laser

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

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

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

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

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

Applications include:

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



Figure 2 – L-702SP Spindle Laser and Scan Plane

Laser Control Panel and Functions

The Status LEDs

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

The On/Off Button

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

Laser Modes

There are 3 laser modes:

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

To change the mode, press the **I/O** power button once.

L-702SP Scan button

To switch the L-702SP to *Scan Mode* (laser plane), you must first put the laser into *Beam Mode*. Then the pentaprism optic in the turret needs to be rotated into place to create the scan plane by turning the set screw (see Switching L-702SP Turret into Scan Mode on Page 4 for instructions). Then press the **SCAN** button to turn on the turret laser rotation and create a scan plane. Press the **SCAN** button again to turn it off.

A/C Connector

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



L-702 A/C Adapter Connector

Pitch/Roll Adjustment Knob

The adjustment knobs use *differential* micrometers, allowing both coarse and fine functions.

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

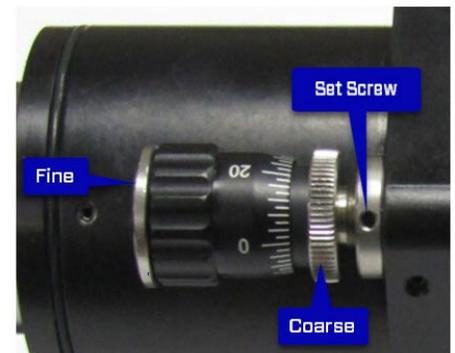


Figure 4– Differential Micrometer



Figure 3– L-702SP Control Panel

Switching L-702SP Turret to Scan Mode

Warning - Do not stare into the beam.

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

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



Figure 5 - L-702SP flip mechanism for Scan Mode

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

L-702SP Laser Dimensions

L-702SP Spindle Laser with Scan Plane

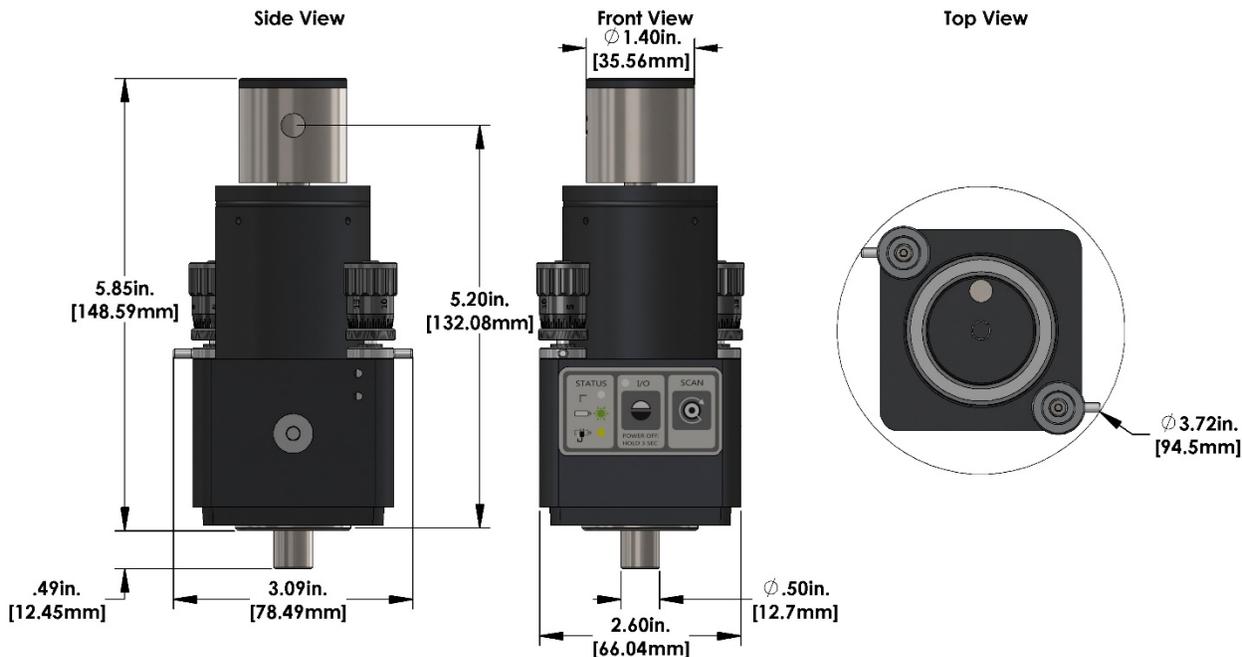


Figure 6 - L-702SP Spindle laser dimensions

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

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

- Offers 3 measurement modes:
 - ❖ *Center Mode* - 2-axis center measurement for use with the L-702SP's through-beam.
 - ❖ *Angular Mode* - 2-axis angular measurement for use with the L-702SP's through-beam.
 - ❖ *Flatness (Scan) Mode* - single-axis flatness measurement for use with the L-702SP's auto-rotating laser plane in Scan Mode.
- PSD (Position Sensing Detector) Size:
 - ❖ T-1295: 1.3 x .51 in. (33x13 mm) PSD
 - ❖ T-1296: .39 x .39 in. (10x10 mm) PSD
- Resolution:
 - ❖ *Center* (2 axis & 1 axis):
 - T-1295: .00002 in. (0.0005 mm)
 - T-1296: .00001 in. (0.00025 mm)
 - ❖ *Angular* (2 axis) – Standard 3 in. Lens:
 - T-1295: .00008 in/ft. (0.007 mm/m)
 - T-1296: .00004 in/ft. (0.0035 mm/m)
 - ❖ *Angular* (2 axis) – High-Res 6 in. Lens:
 - T-1295: .00004 in/ft. (0.0035 mm/m)
 - T-1296: .00002 in/ft. (0.0018 mm/m)
- Wireless communication via Bluetooth Class 1 radio with 100 ft. (30 m) of communication range.
- Accuracy is < 1.0% of the measurement.
- PSD concentric to the mounting stud to < .0005 in. (0.012 mm).
- The T-1295/T-1296 are designed so the measuring plane of the target is right at the face plate of mounting stud giving better accuracy on spindle alignments.
- Accelerometer rotation axis (6th axis) helps to orient the PSD sensor axes to the alignment axes of the spindle.
- Lithium polymer rechargeable battery with 14 hours battery life.



Figure 7– T-1295/T-1296 5-Axis Wireless Spindle & Scan Target

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

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

Below are descriptions of the target LED's and their functions:



Center Mode

This is the default mode when the target is turned on. It is recommended to use the light/dust shield while using the target in center mode, which is held in place with magnets. While in this mode, the values shown in MultiTurn10 Software displays show the center (offset) values of the target relative to the laser beam. It follows the same sign convention as shown page 12, *Interpreting the + and - Signs*.

Angular Mode

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

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

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

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



Figure 8– T-1295/T-1296 Target with light shield installed



Figure 9– T-1295/T-1296 Target with T-1295-AO-3 Lens installed correctly

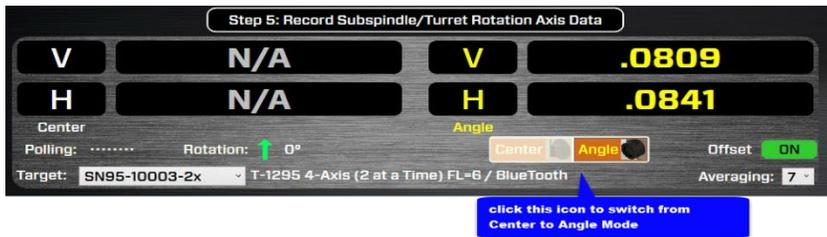


Figure 10– MultiTurn10 Step 5 – showing Angle Mode turned on

Scanning Laser Mode

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

Note: You must also put Multi-Turn10 into Scan Mode using the dropdown list in Step 3.

T-1295/T-1296 ON-TGT LED

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

Continuous Green – means the target is detecting the laser beam properly.

Continuous Red – means the target is not detecting the laser beam.

Blinking Green – means the target is detecting the laser scan plane (Scan Mode) properly.

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



Figure 11 - T-1296/1296 Control Panel

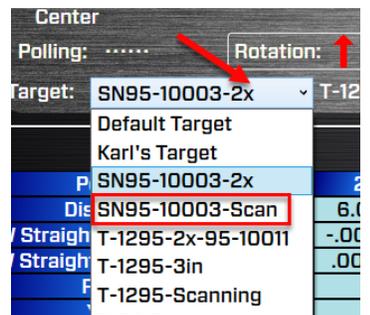
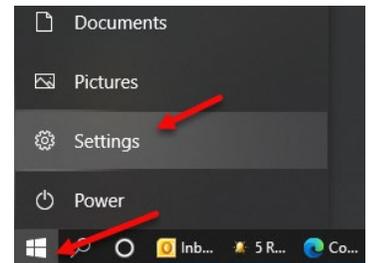


Figure 12 - Target Scan Mode selection Step 3

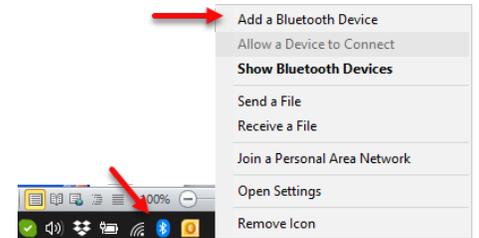
How to Pair the T-1295/T-1296 Target's Bluetooth to a PC

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

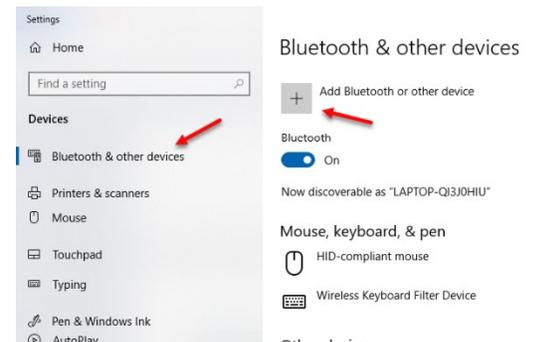
1. Tap on **Start** (the Microsoft Logo) > **Settings**.
2. Navigate to **Devices** and go to **Bluetooth**



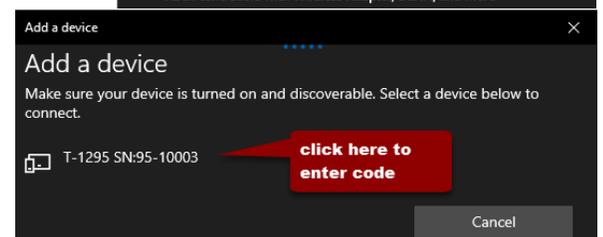
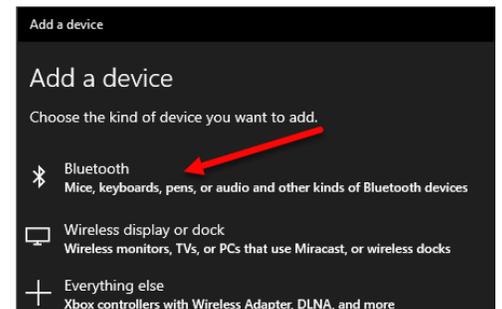
Or click on the **Bluetooth** icon in the system tray and click on **Add a Bluetooth Device**.



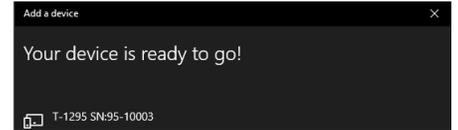
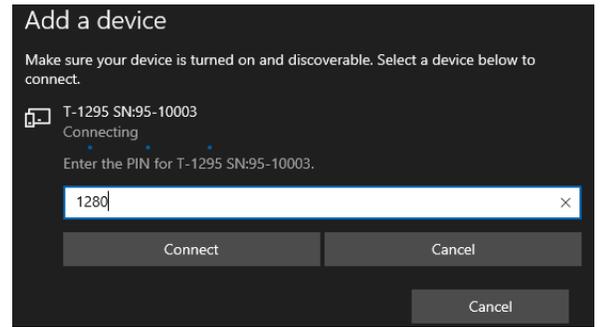
3. Make sure the Bluetooth toggle is in the **On** position. (You'll know it is working because you'll notice the message that reads "Your PC is searching for and can be discovered by Bluetooth devices.")
4. Click on **Add Bluetooth or other device**



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



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



The T-261A 4-Axis Target

The T-261 4-Axis Target reads both center and angle (pitch and yaw) simultaneously, allowing a real-time display of misalignment. The target data has a resolution with the R-358 of .00001 in./ft. (0.0008 mm/m) in angle mode and .00001 in. (0.0005) in in centering mode. Two bubble levels on the top and bottom make it easy to position when inverting for NORMIN procedure (see Appendix A, beginning on Page 53).

When the target is purchased as part of a system, it is calibrated at the factory before shipping. If the target is purchased separately, then the user must calibrate it, or enter the HLI-supplied calibration factors into Lathe 9, before use. An alignment/calibration fixture and a target stand, available from Hamar Laser, are required for calibration. The procedure is outlined in Appendix C, beginning on Page 58.



Figure 13—T-261 4-Axis Target

The R-358 Computer Interface

The R-358 Computer Interface provides high accuracy (resolution is .00001 in. or 0.0005 mm) for downloading live target data into a computer. It attaches to the computer with a cable and is powered by a lithium-ion battery for up to 8 hours of life. The battery automatically turns on when the target starts taking measurements and turns off when the program is closed down. An AC adapter/charger is provided, and the unit features "charging" and "power" LED indicators.

Installing the (RS-232) USB to Serial Converter Cable Driver for R-358 Interface

For use with the T-261 Target only. This driver is required for the R-358 Transceiver and to communicate with targets via the computer USB port. The driver creates a virtual COM Port that is recognized by the applications as a standard serial port.

Important Windows 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.

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.

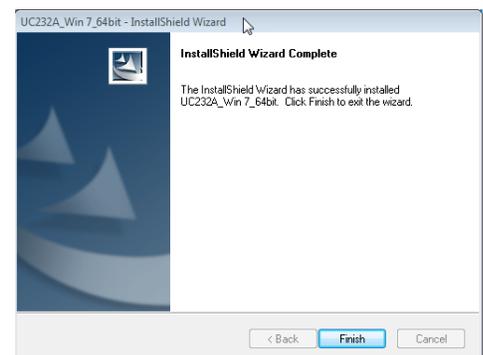
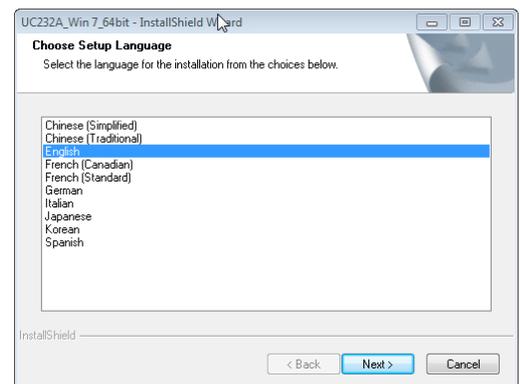


Figure 14 - R-358 USB to Serial adapter driver installer

Connecting to the R-358 Computer Interface

The R-358 Computer Interface connects the T-261 Target to a computer for automatic downloading of the target data into Lathe9 or other HLI software. This enables the software to offer real-time data displays, perform calculations, and plot results. The R-358 attaches to the computer with an USB/RS-232 (supplied with the R-358) converter cable and is powered by a lithium-ion battery or an AC adapter.

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

1. Connect the T-261 target to the INPUT connector on the FRONT of the R-358 Interface.

The interface can support one 4-axis target. It can also support two 2-axis targets with the use of an optional splitter cable. Make sure to screw in the flat-head screws to securely hold the connector in place.

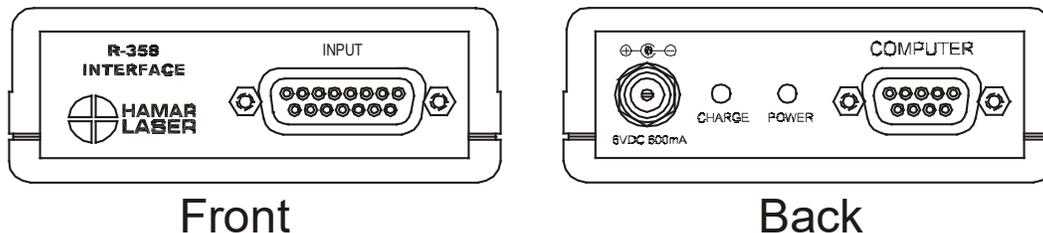


Figure 15—R-358 Interface Connection

Note: The R-358 power is turned on by the software when you click any of the Lathe9 steps that have live data displays. When turned on, the green **POWER** LED on the R-358 lights.

2. Connect the R-358 Interface to the computer.

After installing the USB converter cable drivers on your laptop, connect the RS-232 extension cable provided to the back of the R-358 (labeled COMPUTER) and screw in the plastic thumb screws. Then connect the USB/RS-232 Converter cable to the RS-232 extension cable and plug it into the computer's USB port.



Figure 16 – USB to Serial Converter Cable

Software Programs used with the L-702SP

Lathe9 Alignment Software

Hamar Laser provides alignment software as standalone programs. The latest software for lathe alignment is Lathe9. For aligning transfer-line spindles, we offer Spindle8 Software.

Lathe9 offers a user-guided, six-step process to check the alignment of lathes, turning centers, multi-turn machines and spindles in other machines.

Applications include:

- Lathes
- OD/ID Grinders
- Turning Centers

Supports the following equipment:

- L-700 and L-702SP lasers and T-261 Target.



Figure 17– Lathe9, Step 6 – Tailstock/Turret Alignment

MultiTurn10 Alignment Software

MultiTurn10 alignment software is a powerful tool for aligning the complex multiturn machine tools and was written to support our L-702SP 5-Axis Machine Tool & Spindle Alignment system. This comprehensive and easy-to-use program records data for all the machining axes of most types of multiturn type machine tools. It also checks the main spindle parallelism to the guideways and 4-axis alignment of the main spindle rotation axis to the sub-spindle axis.

Applications include:

- Machining Centers
- Multiturn Machines
- OD/ID Grinders
- Turning Centers

Supports the following equipment:

L-700 and L-702SP lasers and T-261 Target, A-1519-2.4BT and T-1295/T-1296 Targets.

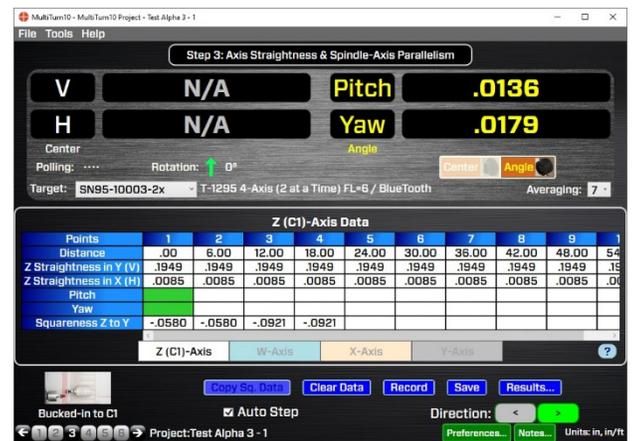


Figure 18– MultiTurn10 Alignment Software
Step 3: Axis Straightness & Spindle-Axis Parallelism

Interpreting the Plus and Minus Signs in Software Live Displays

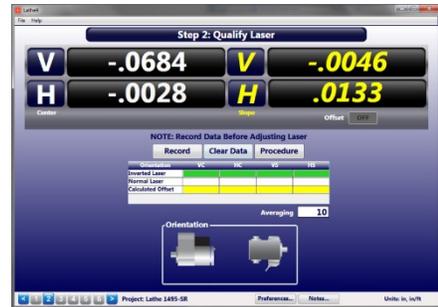
The signs of the data displays indicate the position (high/low or left/right) of the target is relative to the laser beam when “standing” *behind* the laser and looking *into* the target. See the interpretation below.

Note the T-261 provide 4 simultaneous axes:

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

The T-1295/T-1296 provides 4 axes but 2 at a time.

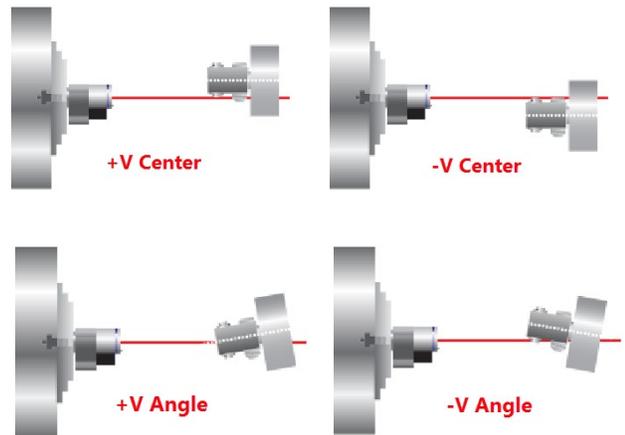
- Vertical Center
- Horizontal Center
- Vertical Angle
- Horizontal Angle



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.

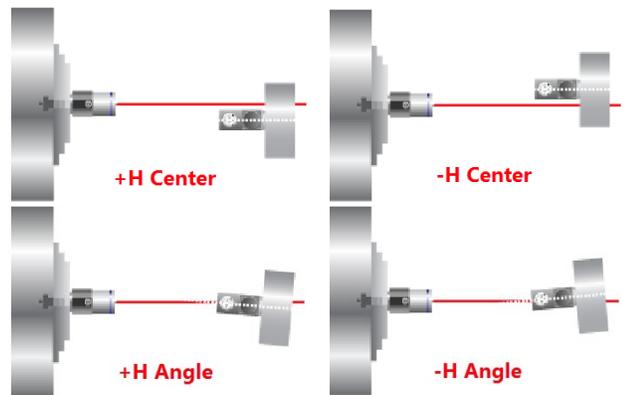
A -**V** *center* value indicates the target is lower than the laser beam.
 A -**V** *angular* value indicates the back of the target is *lower* than the front of the target.



Horizontal Axis

A +**H** *center* value indicates the target is to the right of the laser beam.
 A +**H** *angular* value indicates the back of the target is to the *right* of the front of the target.

A -**H** *center* value indicates the target is to the *left* of the laser beam.
 A -**H** *angular* value means the back of the target is to the *left* of the front of the target.



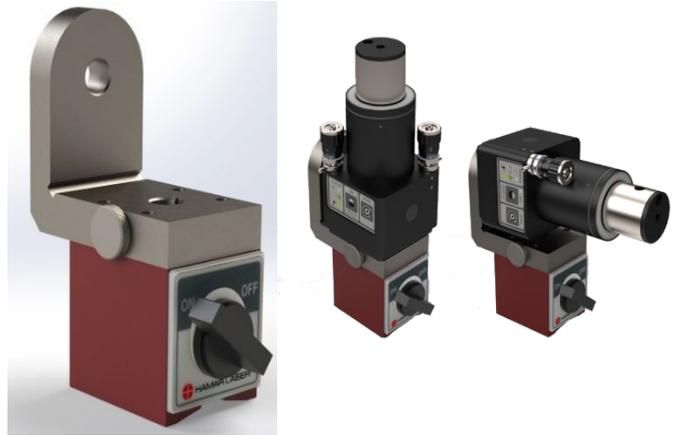
L-702SP Mounting Accessories

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

L-702MB Laser Mounting Mag Base

- Used to mount the L-702SP on flat surfaces for: Flatness measurements of surfaces.
- Flatness, straightness & squareness measurements of machine tool axes.

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



L-702MB Laser Mounting Base

Figure 19 - L-702MB laser mounting mag base

L-702RA – Right Angle Spindle Mounting Fixture

Used to mount the L-702SP Laser and T-1295 Target at right angles to the spindle axis for use on:

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

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



L-702RA Right-Angle Spindle Mount



Figure 20 - L-702RA right angle spindle mounting fixture

T-242 Target Straightness Measuring Base

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

T-243 Target Flatness Measuring Base

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



Figure 21 - T-243 Target Flatness Measuring Base



Figure 21a - T-242 Target Straightness Measuring Base

Preparing for an Alignment

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

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

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

If the headstock rotation axis (AOR) is parallel (aligned) to the guideways, only then can the tailstock center or a sub-spindle AOR be checked for alignment to the headstock AOR. The T-261 offers a live four-axis display of the tailstock, sub-spindle or turret centers or AOR relative to the laser beam (headstock AOR).

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

Hardware Mounting

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

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



Figure 22—L-702SP Mounting Stud

Maintenance and Cleaning

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

Tools and Equipment

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

Other Considerations

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

Target Calibration

The T-1295/T-1296 and T-261 Targets must also be calibrated. When purchased as part of a system, target calibration factors are provided. If the target is purchased separately, it should be calibrated before use. This can be done at the factory or on site using the A-807 Calibration Fixture and Read8, available for purchase from Hamar Laser. The procedure is included in Appendix C, *Target Calibration*, beginning on Page 58.

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.

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

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

To return the angular adjustments to the middle of their adjustment range, adjust the *Pitch* and *Roll* COARSE adjustment axes so that the bottom of the L-702SP base cover is aligned to the white line on the mounting base (see Figure 23).



Figure 23 - L-702SP angular adjustment

Qualifying the L-702SP Laser Beam to a Spindle AOR

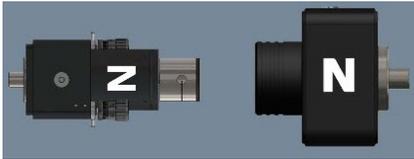
In spindle alignments on lathes and turning centers, it is important to ensure that the L-702SP laser beam is aligned, or qualified (bucked-in), to the axis of rotation (AOR) of the spindle. This is so the alignment of the headstock to the machine's guideways can be checked.

This procedure describes how to align the L-702SP to the spindles AOR.

The NORMIN Method

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

To take NORMIN readings, the laser and target fixtures are set in the NORMAl position (cable down or switch panel facing toward you) and the readings recorded. Then the laser or target fixture is rotated 180 degrees to the INverted (cable up or switch panel facing away from you) 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 53.



NORMIN Reading
Laser NORMAl,
Target NORMAl



NORMIN Reading
Laser INverted,
Target INverted

Figure 24 - Taking NORMIN Readings

To qualify or buck-in a laser, error correction readings are taken to cancel out mounting and other errors, and MultiTurn10 and Lathe9 calculate *Set Points*. The laser beam is then adjusted to the *Set Points*, making it parallel to/coincident with the desired axis of rotation.

Operation of Differential Pitch/Yaw Adjustments

Warning - Do not stare into the laser beam.

The adjustment knobs are used to adjust the *pitch* and *yaw* angles of the laser *beam* when used in a spindle and the *pitch* and *roll* angles of the laser *plane* when used for flatness. They use *differential* micrometers. This means the micrometers have a coarse and fine function.

- **Coarse Adjustment** – loosen the set screw to enable the coarse adjustment (see figure 26).
- **Fine Adjustment** – tighten the set screw (with the provided Allen wrench) to enable the fine adjustment, which is 12-times finer adjustment resolution. *Note: you do not need to tighten the set screw very much to disable the coarse adjustment.*

Hardware Requirements

To qualify the L-702SP to the spindle's AOR you will also need the L-702SP Laser, T-1295/T-1296 Targets and MultiTurn10, or the L-102SP, T-261 4-Axis Target, the R-358 Computer Interface and Lathe9 or MultiTurn10.

If using the manual procedure, then you will need 2 R-1307 readouts, one for the *center* readings and one for the *angular* readings. (See Appendix B beginning on Page 54 for the manual procedure.)



Figure 25– L-702SP Pitch and Roll Adjustments

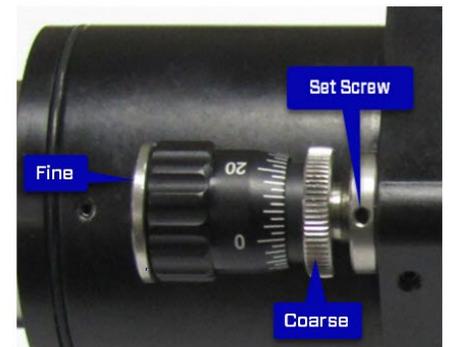
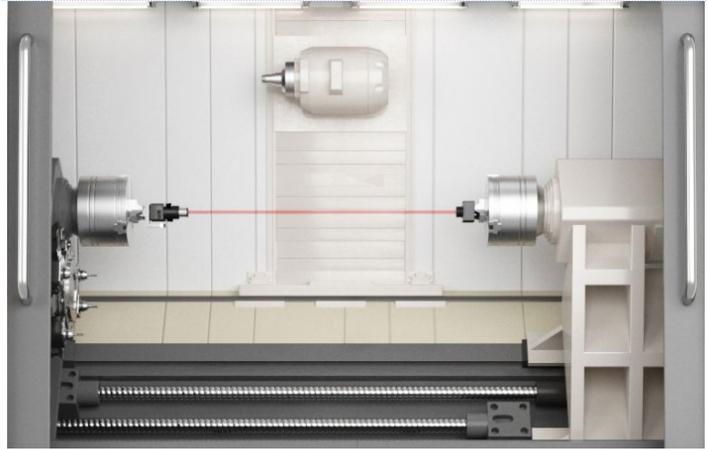


Figure 26 - Differential Micrometer

Procedure for Qualifying the Laser to a Spindle's Rotation Axis T-1295/T-1296 and MultiTurn10

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

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



L-702 Switch Panel



L-702 A/C Adapter Connector

- 2. Alignment Tolerance**

The goal is to align the laser to the spindle's AOR to $\pm .0001$ in/ft (0.012 mm/m) in angle.

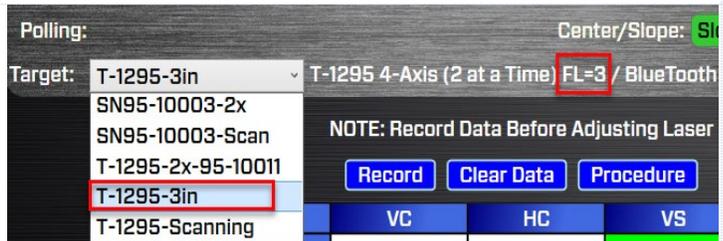
- 3. Open MultiTurn10**

Open MultiTurn10 using either a saved file or enter a new file name.

See the *MultiTurn10 Software Manual* for details on how to set up the T-1295/T-1296 Targets.

- 4. Go to Step 2: Qualify Laser**

Go to Step 2: Qualify Laser and ensure you are getting readings in the **Angle** displays. Make sure to install the T-1295-A-3 (or A-6) Lens and ensure that the target description has a matching focal length. **FL=3** should be selected for the T-1295-A-3 lens and **FL=6** should be selected for the T-1295-A-6 lens. See the MultiTurn10 Manual for instructions on how to setup a new target.

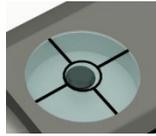


Note: for the L-702SP/T-1295 Target there is no centering adjustment, so you will only be adjusting the V & H angular axes.

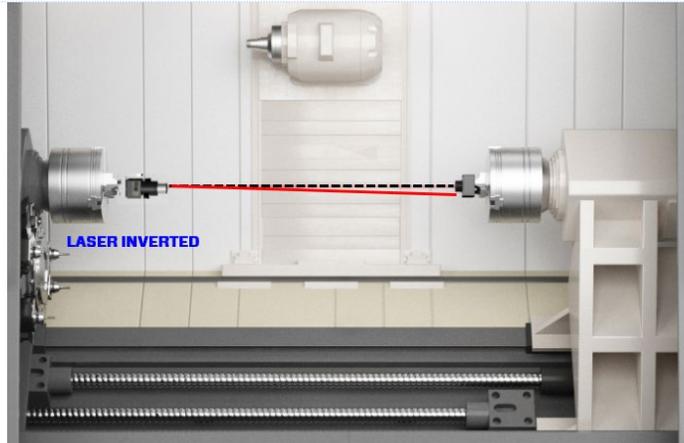


5. Rotate the spindle/L-702SP to the INverted Position.

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



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



6. Click RECORD.

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

Step 2: Qualify Laser

V N/A V **-.1522**

H N/A H **.0069**

Center

Rotation: 0°

Target: SNS5-10003-2x T-1295 4-Axis (2 at a Time) FL-6 / BlueTooth Averaging: 7

NOTE: Record Data Before Adjusting Laser

Record Clear Data Procedure

Orientation	VC	HC	VS	HS
Inverted Laser	N/A	N/A	-.0581	.0034
Normal Laser	N/A	N/A		
Calculated Offset	N/A	N/A		

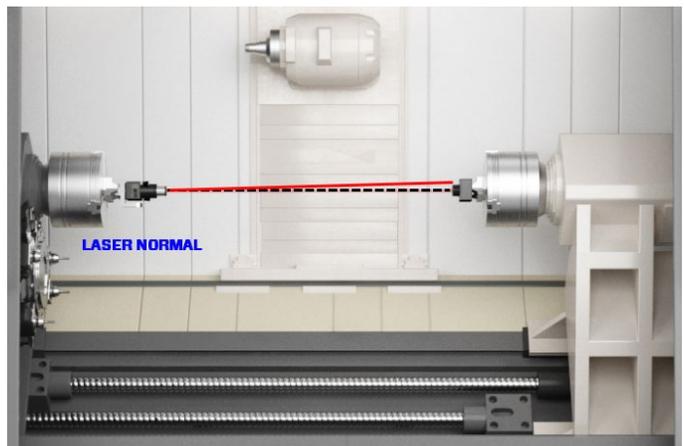
Orientation

Project: Test Alpha 3 - 1

Preferences... Notes... Units: in, in/ft

7. Rotate the spindle/laser to the NORMAL position.

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

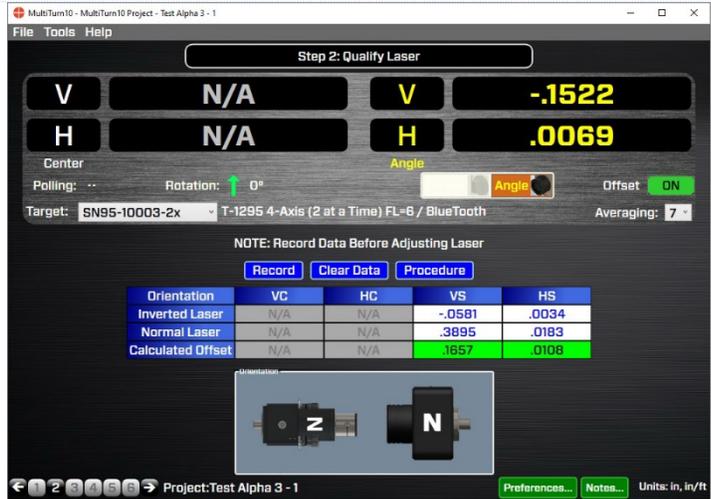


8. Click RECORD.

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

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

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



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

Turn the Pitch and Roll adjustment knobs until the Angle values in the Step 2 display are within $\pm .0001$ in/ft (0.012 mm/m) of zero. Use the coarse adjustments first and then the fine adjustments when the coarse adjustments can't get the value to the recommended tolerance.

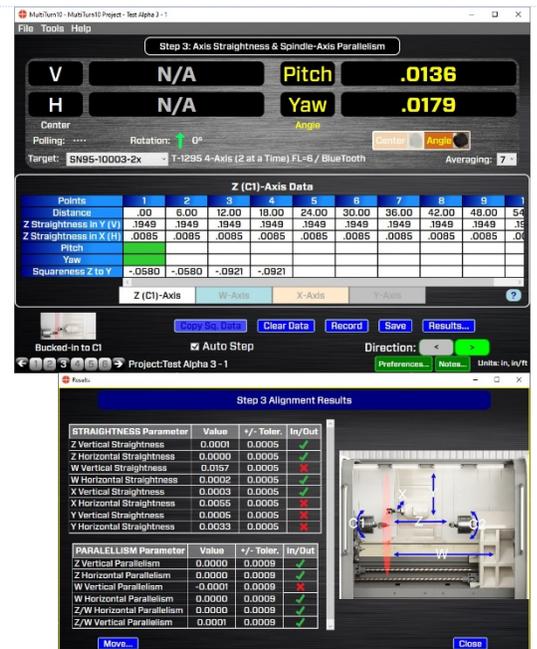
In the image here are the L-702SP V and H Angular (Slope) values in or close to tolerance.

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



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

11. The laser is now bucked into the C1 axis and the straightness for the Z and W axes can be recorded in Step 3. See the MultiTurn10 Manual for more information.



Procedure for Qualifying the Laser to a Spindle's Rotation Axis T-261 and Lathe9 Software

The following procedure explains how to qualify (buck-in or align) the L-702SP laser to the spindle's rotation axis using the T-261 4-axis Target and Lathe9 software.

Setup

1. Connect the T-261 Target to the R-358 Computer Interface.

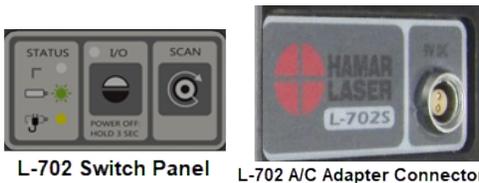
Connect the T-261 to the R-358 and use the mounting screws to hold the target connector in place. Connect the serial cable to the USB/Serial adapter cable and plug it into the laptop or desktop computer.



Note: You must install the software driver for the USB cable **BEFORE** plugging in the USB cable into your computer. Please see Page 15 for details on how to install the driver.

2. Install the L-702/T-261 into the headstock and tailstock spindles.

Mount the laser in the headstock spindle and the target in the tailstock or the T-230 Target Stand. Both the laser and target should be in the *NORMAL* position. The *NORMAL* position for the laser is with the switch panel facing toward you.



L-702 Switch Panel

L-702 A/C Adapter Connector

3. Alignment Tolerance

The goal is to align the laser to the spindle's AOR to $\pm .0001$ in/ft (0.012 mm/m)

4. Open Lathe9

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

See the *Lathe9 Software Manual* for details on how to set up the T-261 Target and R-358 Computer Interface.

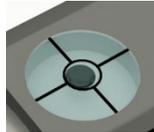
5. Go to Step 2: Qualify Laser

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

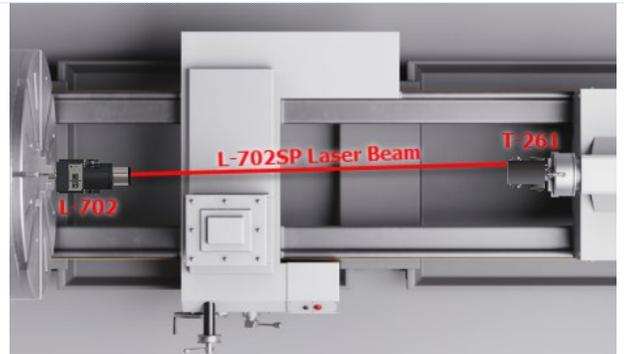


6. Rotate the spindle/L-702SP to the INverted Position.

Rotate the spindle/L-702SP to the *INverted* position (A/C connector panel is facing *toward* you), with the target in the *NORMAL* (cable down) position and ensure the bubble level is in the center of the circle. Wait for the readings to stabilize (approximately 5 seconds).



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



7. Click RECORD.

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



8. Rotate the spindle/laser to the NORMAL position.

Rotate the spindle/L-702SP to the *NORMAL* position (switch panel facing *toward* you with the level vial leveled), with the target in the *NORMAL* position (cable down) and ensure the bubble level is in the *center* of the circle. Wait for the readings to stabilize (approximately 5 seconds).



9. Click RECORD.

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

Lathe9 automatically calculates display offsets so you can adjust the two *angular* adjustment axes to zero instead of the calculated Set Point.

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

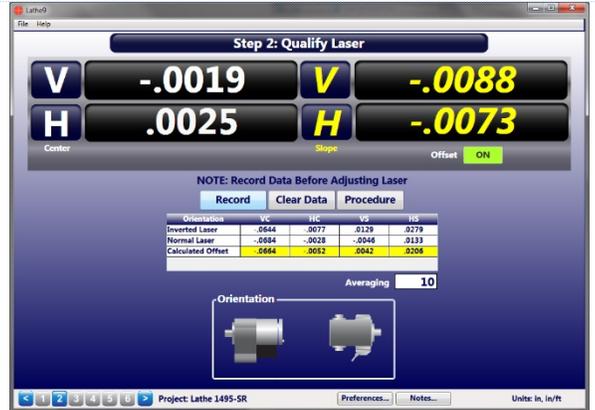


10. Adjust the V and H Angular (slope) adjustments

Turn the Pitch and Roll adjustment knobs until the Slope values in the Step 2 display are within ± 0.0001 in/ft (0.012 mm/m) of zero.

Here are the L-702SP V and H *Angular (Slope)* values in or close to tolerance.

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



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

12. See the Lathe9 Manual for information on how to check straightness of the lathe bed guideways and parallelism of the headstock to the guideways.

The screenshot displays the Lathe9 software interface. The main window is titled "Step 3: Spindle Axis Parallelism" and shows four large digital readouts (DROs) for V and H straightness and parallelism. Below these are data tables for Tailstock and TS/Saddle Parallelism. A secondary window titled "Step 3 Alignment Results" is open on the right, showing a summary table of alignment data.

Step 3: Spindle Axis Parallelism DROs:

- V: .0031
- V: -.0052
- H: .0025
- H: .0064

Tailstock Data Table:

Item	Tailstock Data			Saddle Data		
	Value	Tolerance	In/Out	Value	Tolerance	In/Out
V Straightness	.0386	.0003	N	N/A		.0003
H Straightness	.0302	.0003	N	N/A		.0003
V Parallelism	-.0073	.0007	✓	N/A		.0007
H Parallelism	.0048	.0007		N/A		.0007

TS/Saddle Parallelism Table:

Item	Value	Tolerance	In/Out
V Parallelism	N/A	.0004	
H Parallelism	N/A	.0004	

Step 3 Alignment Results Table:

Item	Value	Tolerance	In/Out
V Parallelism	N/A	.0004	
H Parallelism	N/A	.0004	

Two-Point Buck-In Procedure for T-1295/T-1296 and MultiTurn10

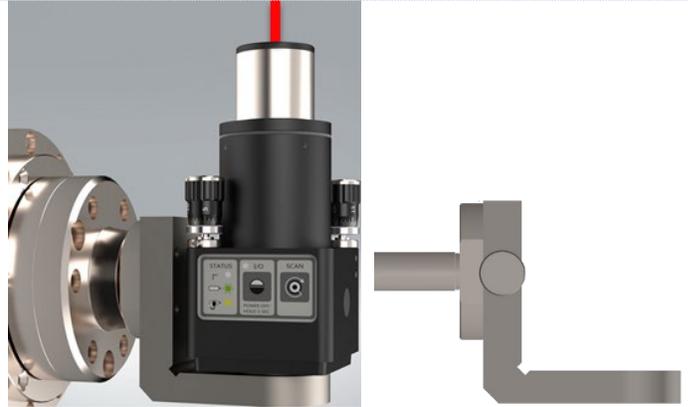
To measure the straightness of all the axes of a multiturn or machining center, it is necessary to do a 2-point buck-in to one of the axes, usually to the Y Axis. Here is a procedure for bucking-in to the Y Axis on a multiturn machine using the L-702RA Right-Angle Mounting Fixture.

1. Insert L-702SP into L-702RA Right-Angle Mounting Fixture.

Insert L-702SP into L-702RA Right-Angle Mounting Fixture and tighten the thumb screw very tight. Insert the mounting stud into the spindle and clamp with a chuck or collet.

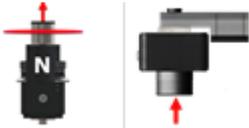
Rotate the spindle so the L-702SP is at the 12:00 position. Lock the spindle if possible.

Make sure the turret set screw is flipped so the beam is coming out the *top* of the turret.



2. Insert the T-1295 Target into another L-702RA and insert that into the machining head.

Insert the T-1295 Target into another L-702RA and insert that into the machining head, so the target is pointed down and the top of the target is pointed to the *left* (see the graphic below).



Note: you can also use the T-243 Target Stand to hold the target.

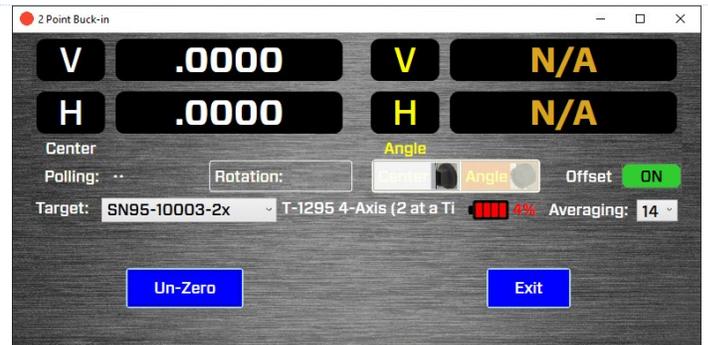
Remove the Angular Lens if it's installed and install the light shield.



3. Move the Machining Head Near the Laser and Zero the readout

Move the machining head down to be near the laser (*Near Position*). Go to **Step 2: Qualify Laser** and click on **2-Point Buck-In**. Make sure you are getting readings. If so, then click on **Zero** to zero out the reading.

To re-zero the value, click on the **Un-Zero** button and then click on **Zero** button again. If you just want to toggle the display offset on/off (keeping the recorded zero offset) then click on the **Offset On/Off** button.



4. Move Machining Head to the top of the travel

Move the machining head to the top of its travel (Far Position).



5. Adjust the Pitch/Yaw Axes on L-702SP

Adjust the Pitch/Yaw adjustment knobs until the displays read zero or within $\pm .001$ in. (0.025 mm) of zero.

Note: If you have a Remote Buck-in situation, then see the next page 26 for Remote Buck-In - Calculating a Set Point. We strongly recommend using this formula for L1/L2 ratios > 0.1.



6. Move back to close position and note the display values.

If the top and bottom values are close to .001 in. (0.025 mm), then the buck-in is done and you can hit Zero. If not, then repeat Steps 3-6 until the values are near .001 in. of each other.

Note: to measure the straightness of Y we recommend getting the top & bottom values to approximately .001 in. (0.025 mm) of each other. The last remaining slope in the laser beam will be removed by the MultiTurn10 when it analyzes the data.



Remote Buck-In – Calculating Set Points

Note: Use this formula if $L1/L2 > 0.1$ (see below for definitions)

As the distance between the laser and the near target increases with respect to the distance between the 2 targets, bucking in by the normal method becomes nearly impossible. A special **Remote Buck-In Procedure** has been developed for these situations. The Remote Buck-In uses simple geometry to make the laser beam parallel to the centerline of the 2 targets, and then centers the beam on that line. Figure xx9xx illustrates how the remote method works.

Unlike the normal *buck-in*, where the laser is pointed *to* zero on the far target, the *Remote Buck-In* procedure has the laser point (tilted) *through* zero to a point called the "Set Point". The set distance is the offset between the parallel laser beam and the target centerline.

The theory behind this is as follows:

The uncorrected laser beam, the offset parallel beam and the set distance form a triangle. The uncorrected laser beam, the target centerline and the distance between the far target center and the far reading form a second triangle. The two triangles have the same three angles and are therefore geometrically identical (see Figure 16xx).

A relationship between these two triangles can be stated in the formula, "The Set Point is to L1 as the far reading is to L2." Stated mathematically, the ratio is:

$$\text{Set Point}/L1 = \text{Far}/L2$$

If L1, L2, and the far reading are known, then the **Set Point Formula** can then be determined by the following formula:

$$\text{Set Point} = -1 * (\text{Far reading} * L1/L2)$$

(Note: This is a simplified formula for cases where the laser beam is zeroed on the near target).

In Remote Buck-Ins, steer/tilt the laser plane *through* zero until the display reading is equal to the Set Point. By doing this, the sign of the number (negative or positive) will be reversed. Figure illustrates this by taking sample readings and showing how the Set Point is derived. Notice the far reading is a negative number and the Set Point is positive as you go "through zero," resulting in a laser beam parallel to the target centerline but offset by the set distance.

An example:

Let say we have the following situation:

L1 = 8 in.

L2 = 30 in.

Far reading is +.012 in.

So the Set Point would be:

$$\begin{aligned} SP &= -1 * 8/30 * .012 \\ &= -1 * .2667 * .012 \\ &= -.0032 \end{aligned}$$

Notice the sign changed, so you would steer the laser beam using angular adjustment until the value is -.0032. Now if you move back to the Near Position, you should see the same value of -.0032. This means you are Bucked-in and ready to take data.

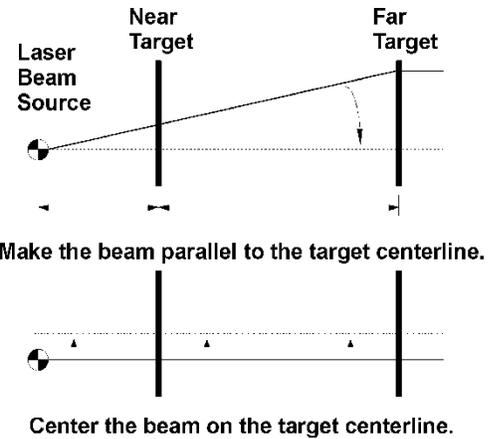
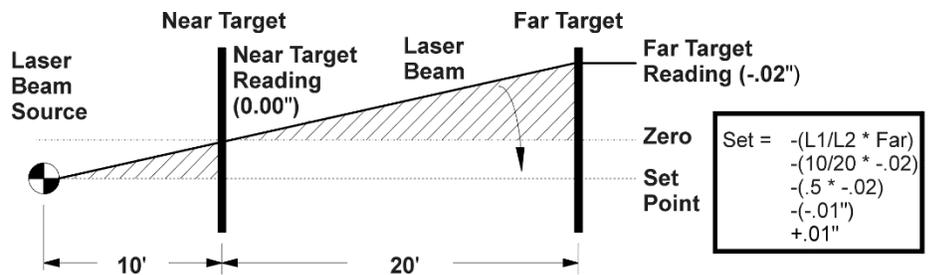
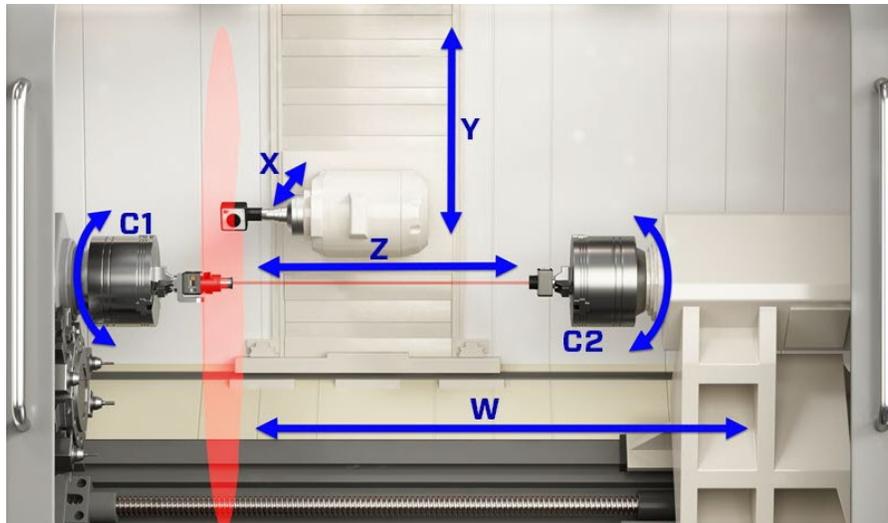


Figure xx9 – Remote Buck-in



Measuring Straightness - Identifying Axis and Parameter Names



We need to take a moment to talk about axis geometric parameter definitions. When taking geometric data for machine tools, it is important to identify what parameters you are measuring. This has always been somewhat complicated, especially on multiaxis machines. We try to make it easy but there is only so much we can do.

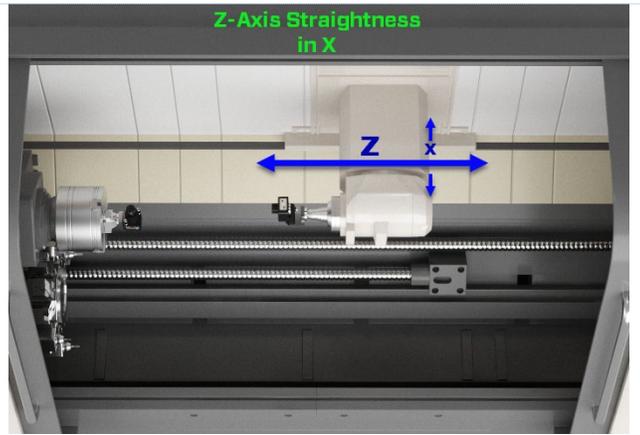
To try to make it easier to understand, the labels of the axes can be used to describe what direction the geometric parameter is varying. So in the example below, for the Z axis straightness (some might call this flatness), we say it's the straightness parameter of the Z Axis in the Y direction or put more succinctly: *Straightness of Z in Y* or *Z-Axis Straightness in Y*. In other words, viewing from the front of the machine, this Z straightness error is the movement of the axis up/down (in the direction of Y) as Z traverses along its axis (left/right).



See more examples below.

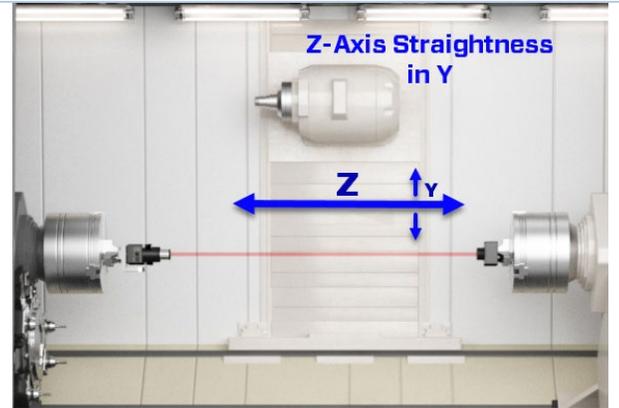
Z-Axis Straightness in X

This is what some might call “horizontal straightness”. It is the straightness error of the *Z axis* in the direction of the *X axis*.



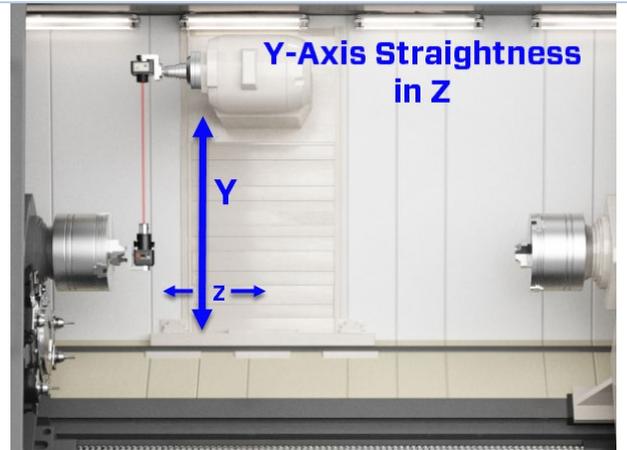
Z-Axis Straightness in Y

This is what some might call “vertical straightness” or “flatness”. It is the straightness error of the *Z axis* in the direction of the *Y axis*.



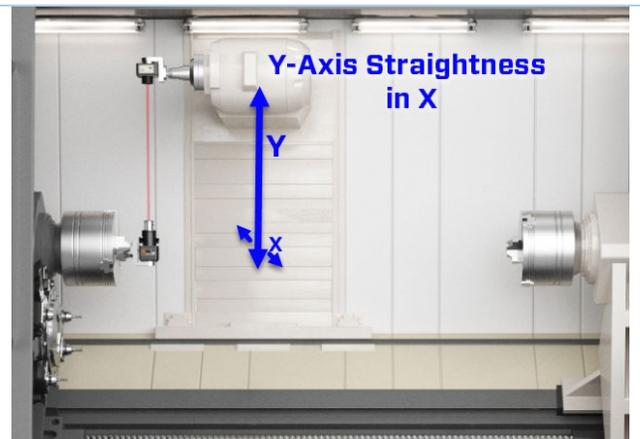
Y-Axis Straightness in Z

This is what some might call “horizontal straightness”. It is the straightness error of the *Y axis* in the direction of the *Z axis*.



Y-Axis Straightness in X

This is what some might call “vertical straightness” or “flatness”. It is the straightness error of the *Y axis* in the direction of the *X axis*.



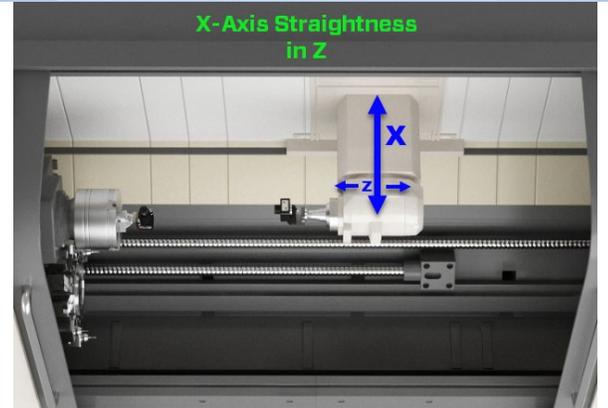
X-Axis Straightness in Y

This is what some might call “vertical straightness” or “flatness”. It is the straightness error of the X axis in the direction of the Y axis.



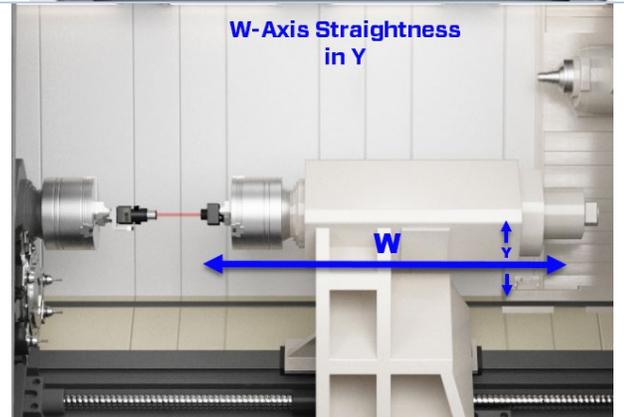
X-Axis Straightness in Z

This is what some might call “horizontal straightness”. It is the straightness error of the X axis in the direction of the Z axis.



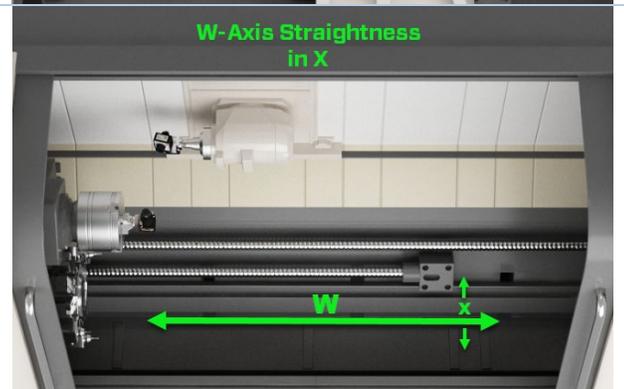
W-Axis Straightness in Y

This is what some might call “vertical straightness” or “flatness”. It is the straightness error of the W axis in the direction of the Y axis.



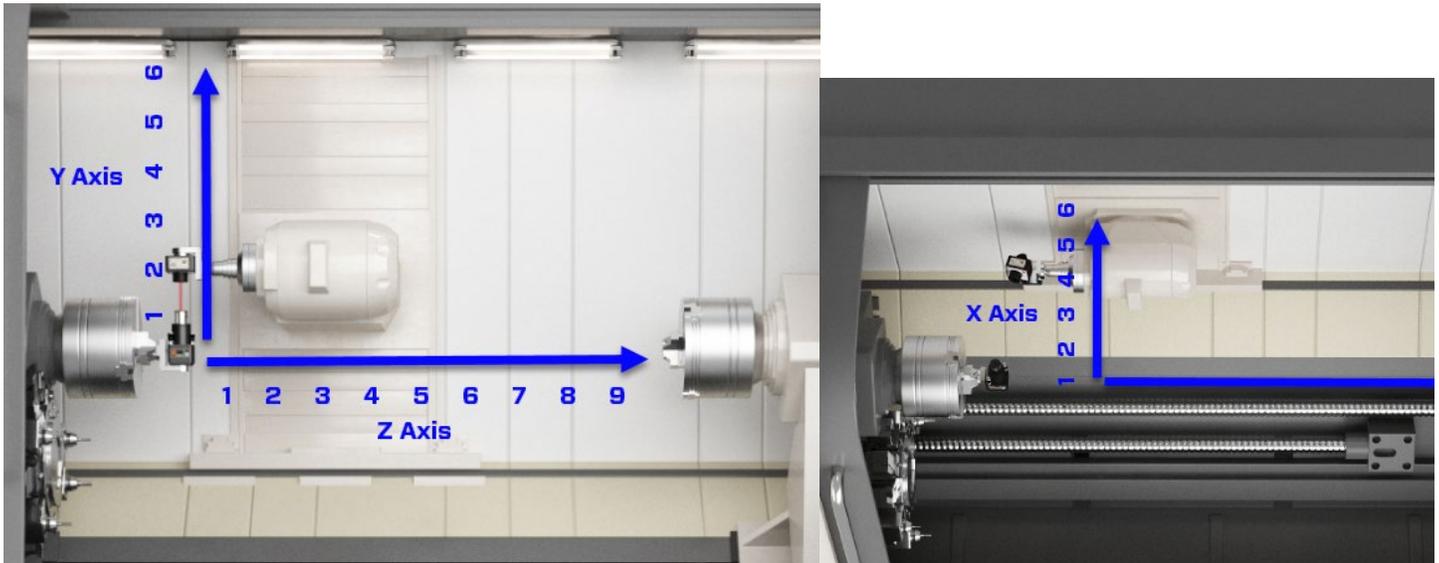
W-Axis Straightness in X

This is what some might call “horizontal straightness”. It is the straightness error of the W axis in the direction of the X axis.



Procedure to Measure MultiTurn Machines for Straightness and Squareness

Please note that MultiTurn10's measurement of the axes for straightness assumes that the first point of any axis is that one that is closest to the laser. It is important to follow this data taking rule so that the direction of the tilt of the squareness and parallelism errors will be correct. If this is not followed, then the squareness/parallelism values will be correct but the interpretation of which direction the axis is tilted will be wrong. See below for examples of how the data points should be taken.



MultiTurn10 Axis Setup

1. MultiTurn10 Step 1 - Project Setup

Select which axes you want to measure, the number of points and the distance between the points. Also choose the tolerances and laser setup.

*Note: if you do not click the "Include *" Axis checkbox, then that data-taking tab will not appear in Step 3.*

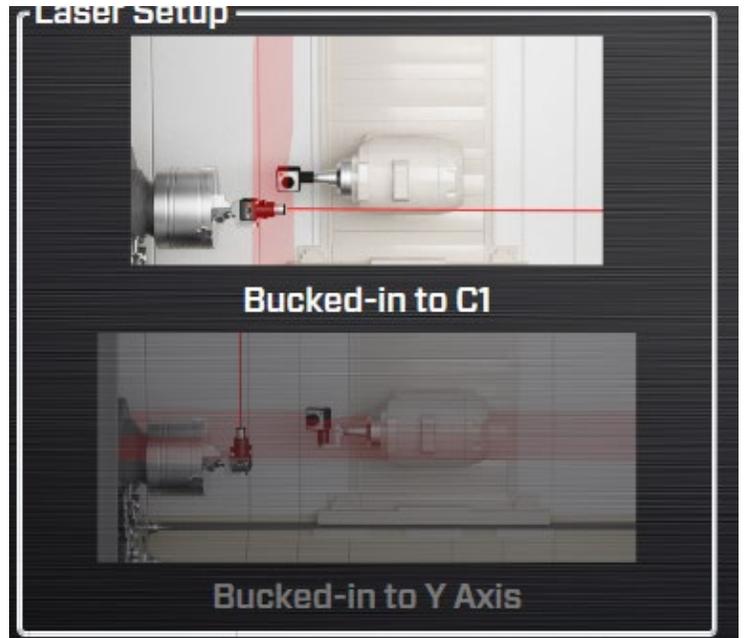


2. Choose the Laser Setup

Choose the laser setup you are going to use. Selecting one of the 2 setup images will change that image in Step 3 as a reminder of the laser setup needed for these parameters. There are 2 for a multiturn machine:

- a. *Laser bucked-in to C1* (main spindle rotation axis) - use this to measure:
 - i. Z & W straightness (in X & Y),
 - ii. X squareness to Z
 - iii. Y squareness to Z
 - iv. X straightness in Z
 - v. Parallelism of Z to W
 - vi. Parallelism of C1 to Z
- b. *Laser bucked-in to Y axis* - use this to measure:
 - i. Y axis straightness (in X & Z)
 - ii. X Axis straightness in Y.
 - iii. X squareness to Y.

Note: this is only for information. Selecting the wrong setup will not affect any results.



X, W & Z Axis Straightness Data – Laser Setup #1

3. MultiTurn10 Step 2 - Align L-702SP Beam to Spindle Rotation Axis.

As shown in Qualifying L-702SP Laser on Page 8, align the L-702SP laser beam to the spindle rotation axis. Make sure to put the T-1295/1296 target into the machining axis spindle for the setup and also that it is mounted in the NORMAL position.



Step 2: Qualify Laser

V N/A V .0000
H N/A H .0001

Center
Polling: .. Rotation: 0° Angle
Target: SN95-10003-2x T-1295 4-Axis (2 at a Time) FL-6 / BlueTooth Averaging: 7

NOTE: Record Data Before Adjusting Laser

Record Clear Data Procedure

Orientation	VC	HC	VS	HS
Inverted Laser	N/A	N/A	-.0581	.0034
Normal Laser	N/A	N/A	.3895	.0183
Calculated Offset	N/A	N/A	.1657	.0108

Orientation: Z N



4. MultiTurn10 Step 3 - Measuring Axis Straightness

Go to **Step 3: Measure Axis Straightness**. Click On “Center” to switch the display mode to Center values. **Important!** remove the lens from the T-1295/1296 and install the light shield.



MultiTurn10 - MultiTurn10 Project - test alpha 8 - 2

File Tools Help

Step 3: Axis Straightness & Spindle-Axis Parallelism

V **.0004** Pitch **N/A**

H **.0001** Yaw **N/A**

Center Angle

Rotation: ↑ 0.8°

Target: SN95-10003-2x T-1295 4-Axis (2 at a Time) FL-6 / BlueTooth 100% Averaging: 14

Z (C1)-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)								
Z Straightness in X (H)								
Pitch								
Yaw								
Squareness Z to X								

Z (C1)-Axis W-Axis X-Axis Y-Axis

Copy Sq. Data Clear Data Record Save Results...

Bucked-in to C1 Auto Step Direction: < >

Preferences... Notes... Units: in, in/ft

Z Axis Straightness Data

5. Select Z-Axis Tab and Record 1st Point

Select Z Axis Tab, move the Z axis to point #1 (nearest the laser) and hit **Record**. The data point will be recorded and the cursor “green boxes” will automatically move to the next point.

Move the axis to point #2 and click **Record** and continue until all the points are recorded. Hit **Save Data**.



Z (C1)-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008							
Z Straightness in X (H)	.0052							
Pitch								
Yaw								
Squareness Z to X								

Z (C1)-Axis W-Axis X-Axis Y-Axis

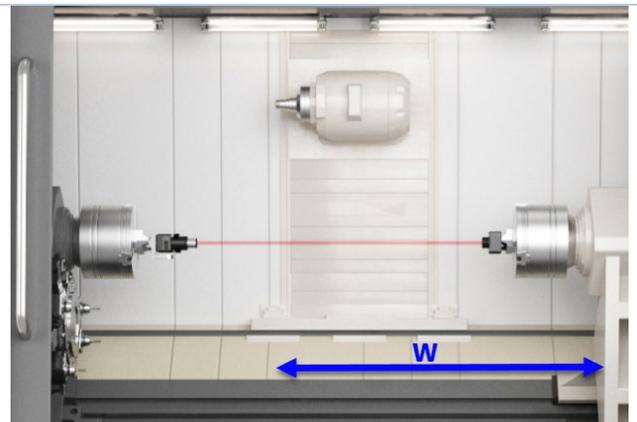
Z (C1)-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch								
Yaw								
Squareness Z to X								

Z (C1)-Axis W-Axis X-Axis Y-Axis

W Axis Straightness Data

6. Move T-1295/1296 Target to C2 Spindle

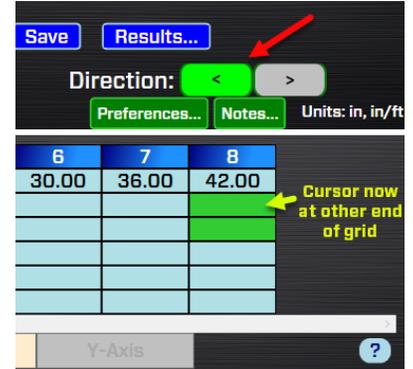
Move the T-1295 Target to the C2 spindle and chuck it up. Make sure the top of the target in the NORMal position (control panel is at 12:00).



7. Select W Axis Tab and Change Data Direction

Click on the **W-Axis Tab** to bring up the W-Axis grid and then click the *left Direction Arrow* to move the cursor to the other end of the grid, so you can start with the *W Axis* at the far *right* side of the machine. When you hit **Record**, the value is recorded and the cursor moves to the left.

Note – don't worry so much about the actual value of the target when you insert it into the W axis. While this value is an indication of the alignment it is incomplete and not the full picture of the C1 to C2 alignment. To see this alignment, go to Step 5: Record Sub-spindle/Turret Rotation Axis Data.



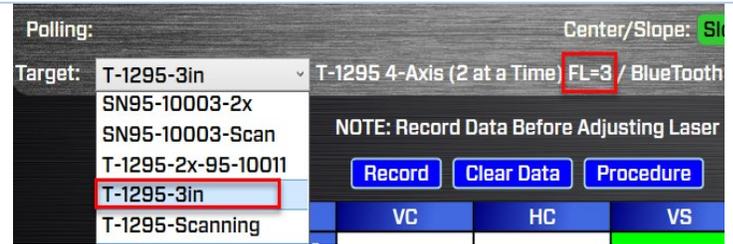
8. Record W Axis Data

Continue recording data for W Axis.

Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
W Straightness in Y (V)	-.0006	-.0008	-.0006	-.0007	-.0006	-.0005	-.0007	-.0032
W Straightness in X (H)	.0042	.0076	.0056	.0073	.0063	.0057	.0076	.0054
Pitch								
Yaw								

9. Record Z & W Axis Pitch/Yaw Data

Set Z axis at the same location as in Step 5. Insert the lens into the T-1295/1296 Target. Make sure the lens focal length (FL=?) matches the target type in the drop-down list in Step 3. There is an overlay on the lens identifying the focal length.



10. Change the display to Angle Mode

Change the display to the Angle Mode (you should see the numbers in yellow in the displays on the right).



11. Record Pitch/Yaw Data

Click on the direction you want to take the data - with the machine head on the left click the right arrow so the green cursor is on the left.

Then hit **Record**.

Move the axis to point #2 and click **Record** and continue until all the points are recorded. Hit Save Data.

Step 3: Axis Straightness & Spindle-Axis Parallelism

V N/A Pitch .0010
H N/A Yaw .0012

Center Angle
Polling: Center Angle

Target: SN95-10003-2x T-1295 4-Axis FL=6 / BlueTooth 100% Averaging: 12

Z (C1)-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch	.0010							
Yaw	.0012							
Squareness Z to X	.0036	.0046	.0034	.0023	.0018	.0019	.0024	.0030

Z (C1)-Axis W-Axis X-Axis Y-Axis

Copy Sq. Data Clear Data Record Save Results...

Bucked-in to C1 Auto Step Direction: < > Preferences... Notes... Units: in, in/ft

Z (C1)-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch	.0010	.0020	.0014	.0015	.0014	.0016	-.0002	.0011
Yaw	.0012	.0028	.0026	.0024	.0026	.0022	.0073	.0017
Squareness Z to X	.0036	.0046	.0034	.0023	.0018	.0019	.0024	.0030

Z (C1)-Axis W-Axis X-Axis Y-Axis

Z (C1)-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch	.0010	.0020	.0014	.0015	.0014	.0016	-.0002	.0011
Yaw	.0012	.0028	.0026	.0024	.0026	.0022	.0073	.0017
Squareness Z to Y	.0036	.0046	.0034	.0023	.0018	.0019	.0024	.0030

Z (C1)-Axis W-Axis X-Axis Y-Axis

12. Record the W Axis Pitch/Yaw Data

Select the W Axis tab and repeat the data collection with the lens installed as done in Step 11. See Step 7 for instructions on how to change the direction of the data taking.

X & Y Squareness to Z and Straightness of X-in-Z Data

1. Select Scan Mode in MultiTurn10

From the dropdown list in Step 3, select the Target serial number you are using with “-Scan”, which is Scan Mode. There will be a popup window that gives you instructions on how to change the laser and target to Scan Mode (or see below).

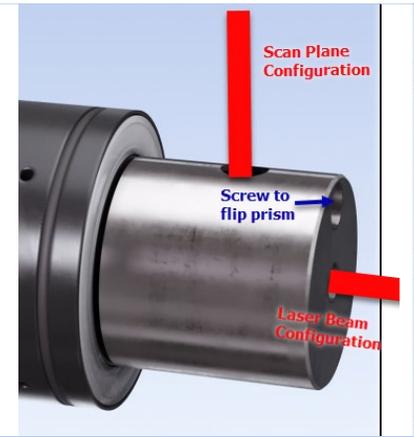
Center
Polling: Rotation: ↑

Target: SN95-10003-2x T-1295 4-Axis FL=6 / BlueTooth

- Default Target
- Karl's Target
- SN95-10003-2x
- SN95-10003-Scan
- T-1295-2x-95-10011
- T-1295-3in
- T-1295-Scanning
- T-261Test

2. Switch L-702SP & T-1295/1296 into Scan Mode to Record X and Y Squareness

First switch L-702SP into Scan Mode by pressing the power button until the **I/O** LED is always on. Flip the prism on the end of the L-702SP turret. Make sure the laser beam is coming out the side of the turret (see Page 4 or 26).



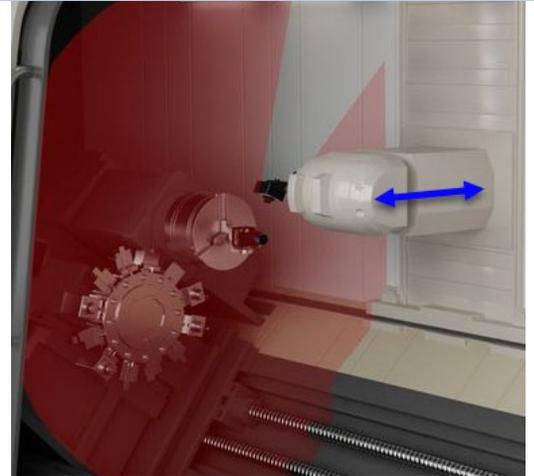
3. Attach the T-1295/1296 Target to the Machine Head

Attach the T-1295/1296 Target to the machine head spindle using custom fixturing or the magnetic base that comes with the target. Do NOT use the lens but the light shield.

Note: the top (Control Panel) of the target should be facing toward the C1 side of the machine. See image.

Adjust the height of the target so the laser plane is in the middle of the window. You can rotate the laser turret by hand to see where the laser beam is hitting the window to easily adjust the post in the fixture or magnetic base.

Bring the X Axis to the most extended (or most retracted) position in its travel.



4. Change T-1295/T-1296 Target to Scan Mode

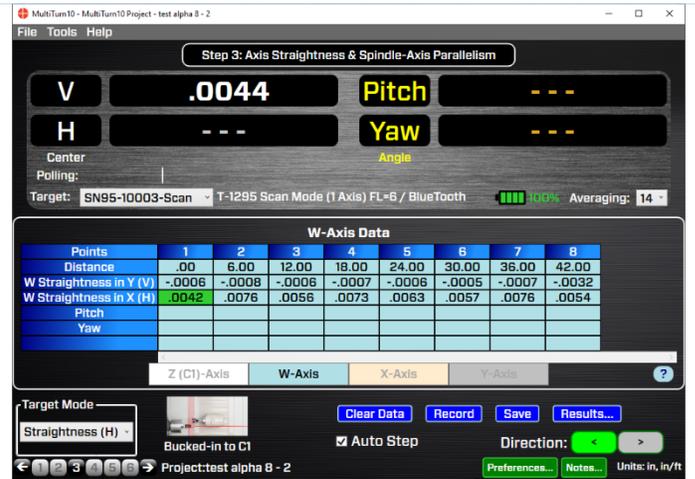
Change the target to Scan Mode by pressing and holding the power button until the **On TGT** LED starts blinking.

Note: Before switching to Scan Mode, make sure the L-702SP laser beam is either turned off or blocked from hitting the T-1295/1296 Target. The easiest way to do this is turn off the scan button.



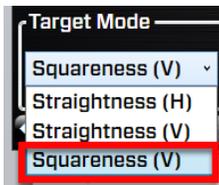
5. Turn on Scan Plane to Get Data & Adjust Target Height

Turn on the scan plane and you should see a value in the V Center display. Adjust the target height to get the raw value below ± 0.10 in. (0.25 mm).



6. Select Z-Axis Tab & Squareness (V) for Data Type

Select the **Z-Axis** tab and **Squareness (V)** from the lower left corner dropdown list. This will enable a row in the grid for X-to-Z Axis squareness and ready the program to record the data. You will see the green cursor in the *Squareness X to Z* row.



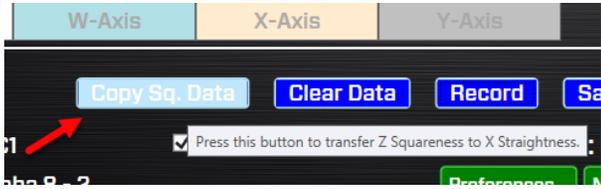
7. Take Measurements for the X Axis Squareness

Hit **Record** to record the first data point. Move the X Axis to the next point and hit **Record** and continue to record all the points. You may have to rotate the target on the post to point it toward the laser.

Note: Since the L-702SP scan plane is perpendicular to the laser beam, the laser is measuring the squareness of the X Axis to the Y Axis to within .00006 in/ft (0.005 mm/m). When analyzing the squareness data using the Least-Squares, Best-Fit algorithm, the straightness can also be calculated for the X Axis in the Z direction. All we have to do is transfer the data to the X Axis tab and MultiTurn10 will calculate the straightness of X in the Z direction.



Hit **Copy Data** button to transfer X-Axis Squareness data to *X Straightness in Z* row.



Z (C1)-Axis Data

Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch								
Yaw								
Squareness Z to X	-.0060	-.0070	-.0077	-.0079	-.0076	-.0074	-.0074	-.0073

Target Mode: **Squareness (V)** Bucked-in to C1 Auto Step Direction: < >

X-Axis Data

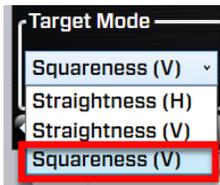
Points	1	2	3	4	5	6	7	8
Distance	.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00
X Straightness in Z (V)	-.0060	-.0070	-.0077	-.0079	-.0076	-.0074	-.0074	-.0073
X Straightness in Y (H)	-.0180	-.0180	-.0180	-.0187	-.0188	-.0191	-.0193	-.0195
Pitch	-.0125	-.0124	-.0129	-.0135	-.0135	-.0143	-.0142	-.0143
Yaw	.0031	.0038	.0036	.0024	.0031	.0030	.0038	.0029
Squareness X to Y	-.0180	-.0180	-.0180	-.0187	-.0188	-.0191	-.0193	-.0195

Target Mode: **Squareness (V)** Bucked-in to C1 Auto Step Direction: < >

Z-to-Y Squareness Data

8. Select Y-Axis Tab and Squareness (V)

Make sure the T-1295/1296 is still in Scan Mode and the L-702SP is, too. Then to measure squareness of Y to Z, select the Y-Axis tab, and using the dropdown, select Squareness (V) as above. You will see the green cursor in the Squareness Z to Y row.



MultiTurn10 - MultiTurn10 Project - test alpha 8 - 2

File Tools Help

Step 3: Axis Straightness & Spindle-Axis Parallelism

V .0031 **Pitch** N/A

H N/A **Yaw** N/A

Center Angle

Poling:

Target: SN95-10003-Scan T-1295 Scan Mode (1 Axis) FL-6 / BlueTooth 97% Averaging: 10

Y-Axis Data

Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Y Straightness in Z (V)								
Y Straightness in X (H)								
Pitch								
Yaw								
Squareness Z to Y	.0031							

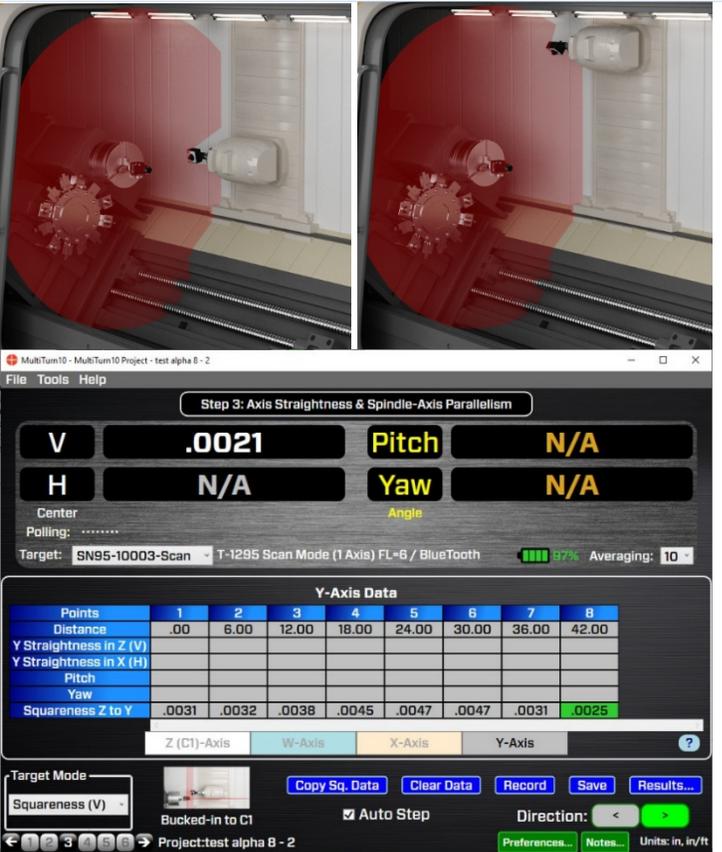
Target Mode: **Squareness (V)** Bucked-in to C1 Auto Step Direction: < >

Project: test alpha 8 - 2

Units: in, in/ft

9. Move the Y Axis to the Lowest Position

With the T-1295/1296 attached to the spindle as described above in Step 11, move the Y axis down to its lowest position. Hit **Record** to record point #1. Move Y up to the next position and hit **Record** again and continue until all the points are recorded.



The screenshot displays a CNC control interface. At the top, there are two side-by-side 3D CAD models of a machine's internal components, showing a red-colored part being scanned. Below the models is a software window titled "MultiTurn10 - MultiTurn10 Project - test alpha 8 - 2".

The main interface area is titled "Step 3: Axis Straightness & Spindle-Axis Parallelism". It features several data fields:

- V**: .0021
- Pitch**: N/A
- H**: N/A
- Yaw**: N/A

Below these fields, it indicates "Center" and "Polling:". The target is set to "SN95-10003-Scan" in "T-1295 Scan Mode (1 Axis) FL=6 / BlueTooth" with a 97% battery level and an averaging of 10.

A table titled "Y-Axis Data" is shown, with columns for "Points" (1-8) and rows for various measurements:

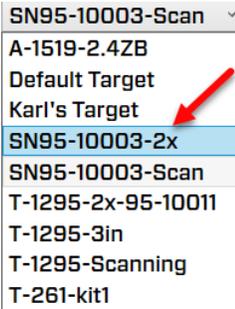
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Y Straightness in Z (V)								
Y Straightness in X (H)								
Pitch								
Yaw								
Squareness Z to Y	.0031	.0032	.0038	.0045	.0047	.0047	.0031	.0025

At the bottom, there are controls for "Target Mode" (set to "Squareness (V)"), a "Bucked-in to C1" indicator, and buttons for "Copy Sq. Data", "Clear Data", "Record", "Save", and "Results...". There is also a "Direction" control with left and right arrows and a "Preferences..." button.

Y-Axis Straightness Laser Setup #2

10. Buck-In Laser to Y Axis

Go to **Step 2: Qualify Laser** and buck-in the L-702SP to the Y Axis. See pages 27-28 for instructions. Make sure the target is in 2x Mode.



11. Go Back to Step 3 and Click Y Axis Tab

Go back to Step 3 and click on the Y-Axis Tab. Make sure the display is set to Center Mode (white numbers, left display).

Make sure the Y axis is at the *Near Point* from the 2-point buck-in procedure and click **Record**. Move the Y axis to Point #2 and click **Record** and continue until all the points are collected.

MultiTurn10 - MultiTurn10 Project - test alpha 8 - 2

File Tools Help

Step 3: Axis Straightness & Spindle-Axis Parallelism

V **-0.007** Pitch **N/A**
 H **.0018** Yaw **N/A**

Center
 Pitch Angle
 Center Angle

Rotation: 359.1°

Target: SN95-10003-2x T-1295 4-Axis (2 at a Time) FL-6 / BlueTooth 97% Averaging: 10

Y-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Y Straightness in Z (V)	-.0006	-.0010	-.0008	-.0010	-.0006	-.0006	-.0007	-.0007
Y Straightness in X (H)	.0019	.0016	.0018	.0018	.0017	.0025	.0020	.0017
Pitch								
Yaw								
Squareness Z to Y	.0031	.0032	.0038	.0045	.0047	.0047	.0031	.0025

Z (C1)-Axis W-Axis X-Axis **Y-Axis**

Bucked-In to C1 Auto Step Direction: < >

Copy Sq. Data Clear Data Record Save Results... Preferences... Notes... Units: in, in/ft



Y-to-X Squareness Data

12. Install T-243 Fixture and Switch to Scan Mode for X-Axis Squareness

Click on the X-Axis Tab. Switch the L-702SP and T-1295/1296 target into **Scan Mode** (see pg. 36-37). Install the T-1295/1296 Target into the T-243 Laser Scanning Stand and the L-102RA as shown (or with other custom fixturing). The T-243 stand allows the target to pivot on the mounting stud without changing the flatness value by more than ± 0.0004 in. (± 0.001 mm).

Adjust the Y axis up or down so the laser plane is going inside the window.

MultiTurn10 - MultiTurn10 Project - test alpha 8 - 2

File Tools Help

Step 3: Axis Straightness & Spindle-Axis Parallelism

V **0.0007** Pitch ---

H --- Yaw ---

Center Angle

Polling: Center Angle

Target: T-1295-Scanning T-1295 Scan Mode (1 Axis) FL-6 / BlueTooth 100% Averaging: 12

X-Axis Data								
Points	1	2	3	4	5	6	7	8
Distance	.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00
X Straightness in Z (V)								
X Straightness in Y (H)	.0010	.0012	.0016	.0013	.0009	.0009	.0012	.0013
Pitch								
Yaw								
Squareness X to Y								

Z (C1)-Axis W-Axis X-Axis Y-Axis

Target Mode: Squareness (V)

Bucked-in to C1

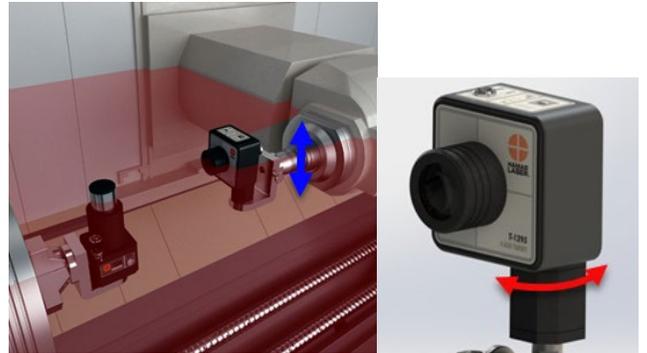
Clear Data Record Save Results...

Auto Step

Direction: < >

Project: test alpha 8 - 2

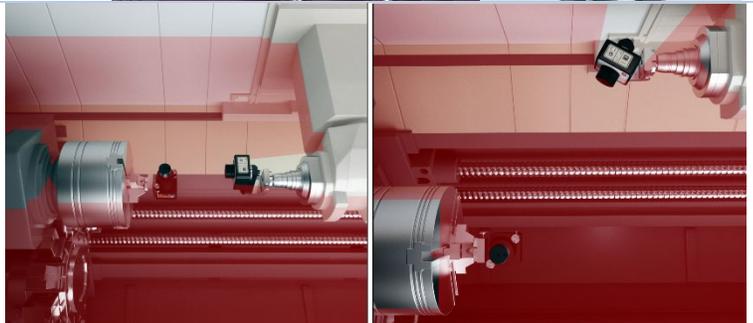
Preferences... Notes... Units: in, in/ft



13. Move the X-Axis to the End of its Travel and Record Data

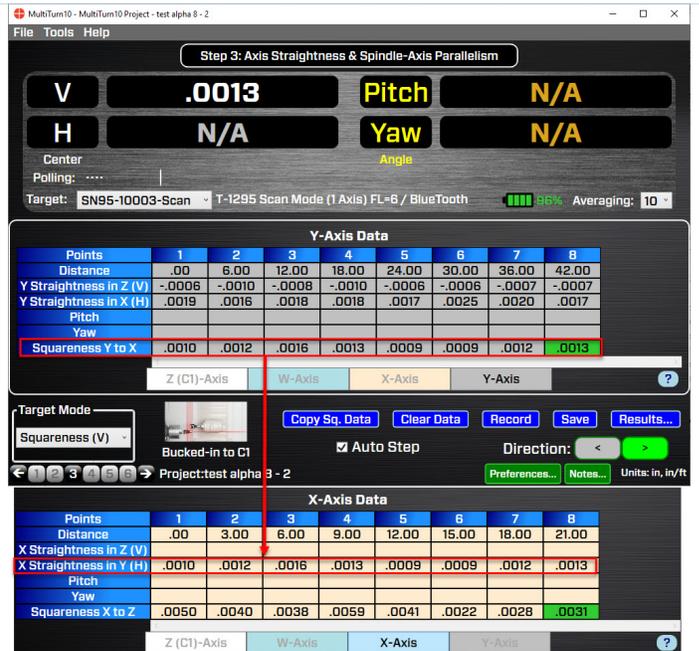
Move the X-Axis to the end of its travel (extended out) and hit **Record**. Move the head to point #2 and hit **Record**. Repeat to take all the data for X.

Note: as you move the X Axis in toward the back of the machine, you will need to periodically rotate the target head to make sure it's pointing at the laser.



14. Hit Copy Data to Transfer Data to X Axis Straightness in Y row.

By taking this squareness data for X relative to Y, the straightness of the X can also be recorded. MultiTurn10 records the same data in the X Straightness in Y row. The straightness of the X will be calculated in the Results Screen.



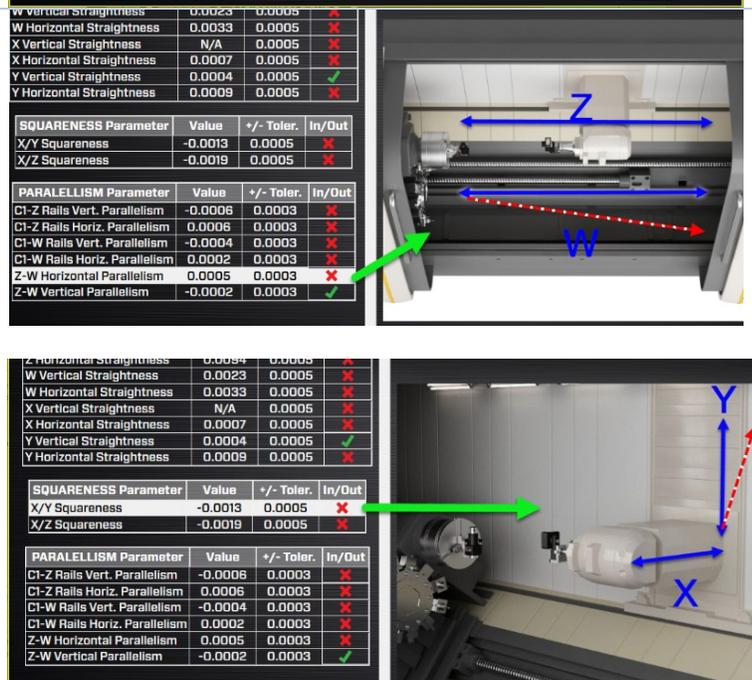
15. Click Results to Analyze the Data

Click on **Results** to pop up the Results



16. Hover the Mouse Over Squareness/Parallelism Parameter to See Direction

Hovering over a squareness or parallelism parameter will show which direction the axis is sloping relative to the datum axis. In this case the W axis is sloping to the right relative to the Z axis when the W axis is moving from left to right.



Checking C1 to C2 Alignment

After checking the machining axes of the multiturn, we need to now focus on the main spindle alignment (C1) to the sub-spindle (C2) in 4 axes. Here is a procedure to get that data and to align them if necessary.

1. MultiTurn10 Step 1 - Project Setup

Select the tolerance for the alignment:

- **Sub-Spindle (C2) – Center** – this is the allowable centering error between the C1 spindle and the C2 spindle.
- **Sub-Spindle (C2) – Angular** – this is the allowable angular error between the C1 spindle and the C2 spindle.

Enter the dimensions between the mounting bolts and the target location so MultiTurn10 can calculate shim values.



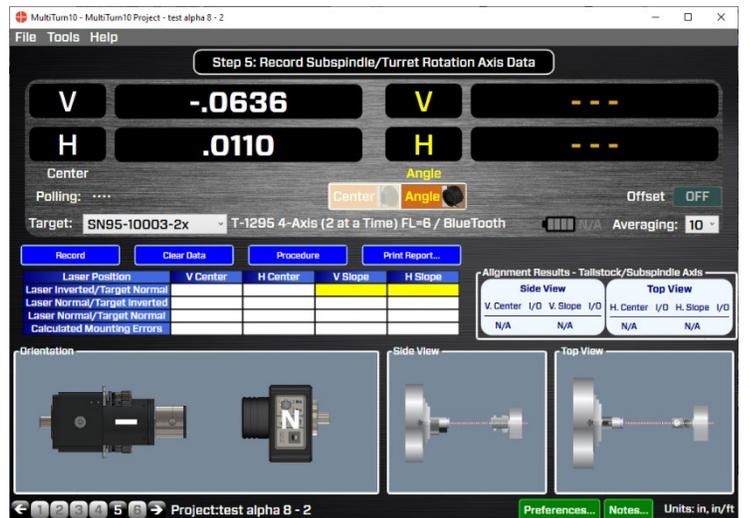
2. Go To Step 5: Record Sub-spindle/Turret Rotation Axis Data

Go to Step 5 to record the rotation axis data of the 2 spindles. You will need to take a total of 6 data points, 3 for Center and 3 for Angle. Start with the Center.

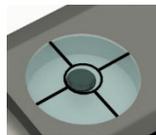
Note: when taking data in Step 5, you must always turn the spindle and the target together to ensure you are measuring the rotation axis and not the center of the chuck's jaws.

First, make sure the T-1295/1296 Target is in the NORMal position (± 0.5 deg from 0).

Next, rotate the C1 spindle+laser to the inverted position (A/C Adapter plug facing you), level the bullseye level and hit **Record**.



L-702 A/C Adapter Connector



Must be at ± 0.5 deg from 0



3. Rotate the Laser Back to NORMAL and Rotate Target to INVERTED Position

Rotate the laser back to the NORMAL position (L-702 Switch Panel facing you) and level it.



L-702 Switch Panel

Rotate the C2 spindle+T-1295/1296 to the INVERTED position watching the rotation axis sensor and stopping to be within ± 0.5 deg. of 180 deg.



Click **Record**. The data for the Center parameters has been taken.



4. Insert Lens, Switch to Angle Mode and Record First Point

The center values are recorded, now record the angular values. First, insert the lens into the target and switch the display to Angle Mode. The H & V angular values will display in the right-hand displays with yellow numbers.



Note: make sure the target type selected matches the lens. "FL=6" is the 6 in. (152 mm) lens.



Invert the Laser/Spindle, make sure the bubble is leveled, make sure the Target Rotation indicator is at 0 deg., and hit **Record**.



5. Rotate Laser to NORMal positon and Target/C2 Spindle to INverted position.

Rotate Laser+C1 Spindle to NORMal positon and Target+C2 Spindle to INverted position, making sure the Rotation indicator is set to 180 degrees and the laser bubble level is leveled. Hit **Record**.

Rotate the target back to 0 degrees and hit **Record** again.

Step 5: Record Subspindle/Turret Rotation Axis Data

V N/A V .0037
H N/A H -.0058

Center Angle
Polling: Rotation: 359.8° Center Angle Offset: ON

Target: SN95-10003-2x T-1295 4-Axis (2 at a Time) FL=6 / BlueTooth 100% Averaging: 10

Laser Position	V Center	H Center	V Slope	H Slope
Laser Inverted/Target Normal	-.0635	.0110	.0038	-.0053
Laser Normal/Target Inverted	.0635	-.0127	-.0038	.0062
Laser Normal/Target Normal	-.0636	.0111	.0041	-.0054
Calculated Mounting Errors	-.0001	-.0007	.0003	.0003

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
-.0635	X	.0038	X	.0118	X	-.0058	X

Orientation: [Z-axis view] [N-axis view] [Side View] [Top View]

Project: test alpha 8 - 2 Preferences... Notes... Units: in, in/ft

6. View Results

The data has now been taken and MultiTurn10 calculates mounting errors and subtracts them from the data to produce the alignment Results, which are displayed in the **Alignment Results – Tailstock/Sub-spindle Axis** – area. It also indicates if the results are in or out of tolerance by a red X (out) or green check mark (in).

Below the results are graphics that illustrate the 4 alignment parameters?

- V Center (offset)
- V Slope (angle)
- H Center (offset)
- H Slope (angle)

In the example to the right, the C2 spindle rotation axis is below the C1 spindle and tilted down. It is also to the right of C1 rotation axis and pointed to the left.

Print Report...

H Slope
-.0053
.0062
-.0054
.0003

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
-.0635	X	.0038	X	.0118	X	-.0058	X

Side View Top View

Preferences... Notes... Units: in, in/ft

Step 6: Sub-spindle/Turret Rotation Axis Data – Move Screen

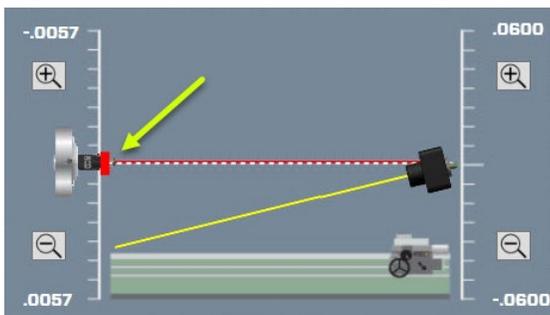
7. Step 6: Sub-Spindle/Turret Rotation Axis Data Move Screen

If the alignment values are out of tolerance and they need to be re-aligned, then hit the “Next” button (right arrow) or the “6” at the bottom of the screen to go to the **Sub-Spindle/Turret Rotation Axis Data Move Screen**, where you have on-screen graphics showing the alignment and which way the C2 rotation axis is tilted or offset from the C1 rotation axis.

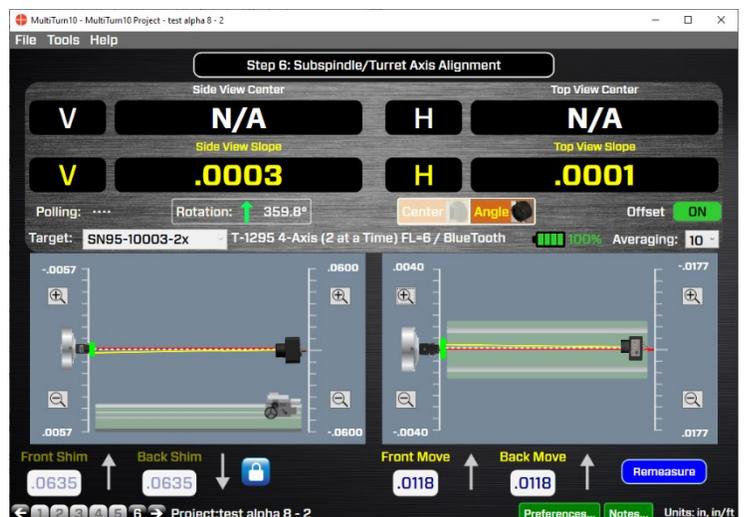
8. Fix Angular Errors First

The program should still be in Angular Mode (and the lens still attached) when switching to Step 6. Start by fixing the angular errors. The values update in real time, as do the on-screen graphics. The target icon and yellow sloping line will move as the angle is adjusted.

There is a red vertical line on the *left* scale that represents the tolerance band for the angular error.



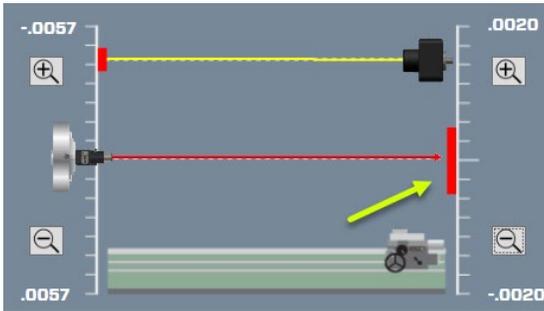
When the value gets within tolerance, the tolerance line turns green.



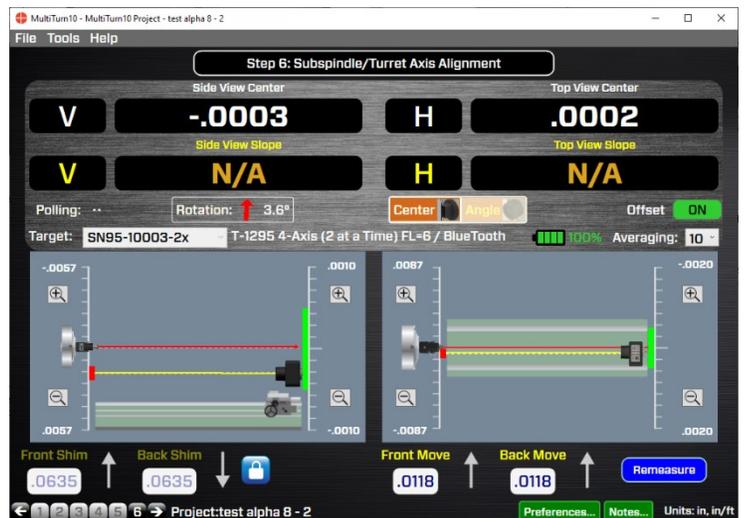
9. Fix Center Values

With the Angular parameters being aligned, switch the display to Center Mode by removing the lens and hitting the Center/Angle button. The values will show up in the upper displays and will be white.

There is a red vertical line on the *right* scale that represents the tolerance band for the angular error.



When the value gets within tolerance, the tolerance line turns green



10. Print Report

From the Tools menu, click on Print Report to get a detailed report on the alignment parameters.



Measuring Straightness & Squareness with L-702SP & T-261 & A-1519-2.4ZB

With the L-702SP Laser, a rotating turret is added to the L-702SP Laser to create a scanning laser plane that is perpendicular to the laser beam to 1 arc second (.00006 in/ft or 0.005 mm/m). The L-702SP scanning laser plane is flat to 0.5 arc seconds (.00003 in/ft or 0.0025 mm/m) and can measure straightness and squareness of a cross-slide axis or of a multi-turn machining axis.

If using the T-261, then to measure a cross-slide or a machining axis of a multi-turn machine, the A-1519-2.4ZB Single-Axis Wireless target is needed to measure the scanning plane. The data values can be sent to MultiTurn10 just as they are when using the T-1295/1296 target.



Figure 27—A-1519-2.4ZB Single-Axis Wireless Target



Figure 28—A-1519-2.4ZB Target with R-1308 Single-Axis Readout

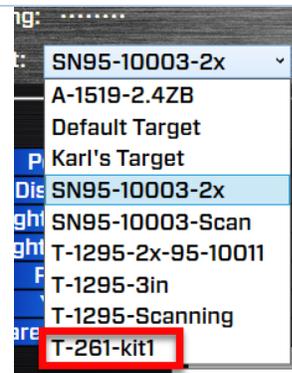


Figure 29—T-261 4-Axis Target

W, X, Y & Z Straightness – T-261

1. Measure W, X, Y & Z Straightness

Select the T-261 Target from the dropdown list in Step 3. Make sure the T-261 is connected to the R-358 Readout and is connected to the PC via the USB cable (see Connecting T-261 on pgs. 10-11).



2. Insert T-261 into Z-Axis Chuck/Collet & Position Machine Head to Zero

Insert the T-261 in the Z-Axis chuck/collet and move the X & Y Axes to until the V and H center values to near zero (within ± 0.001 in. or 0.025 mm).

3. Record Data

Hit **Record** to record the first data point. Move the machine to Point #2 location and hit **Record** again. Continue until all the data has been taken.

Note: the T-261 Target records all 4 data axes simultaneously.



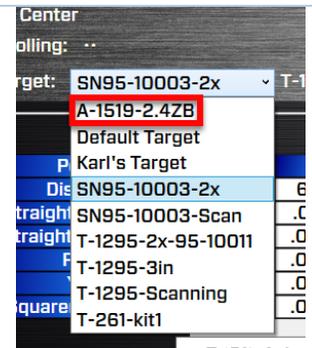
4. Continue for W, X & Y Axes

See pgs. 34-42 to record the data for the remaining axes. In general, the procedure is the same as above but you do not need to change the display to Angle Mode to record Pitch/Yaw data since they are recorded simultaneous with the straightness values.

X & Y Squareness to Z – A-1519-2.4ZB

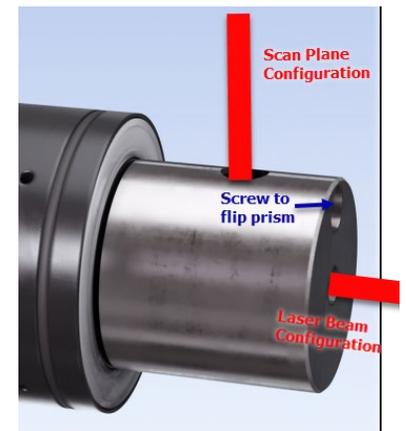
1. Select A-1519-2.4ZB Target in MultiTurn10

From the dropdown list in Step 3, select the Target serial number you are using with “-Scan”, which is Scan mode.



2. Switch L-702SP & T-1295/1296 into Scan Mode to Record X and Y Squareness

First switch L-702SP into Scan Mode by pressing the power button until the *I/O* LED is always on (not blinking). Flip the prism on the end of the L-702SP turret. Make sure the laser beam is coming out the side of the turret (see Page 4 or 26).



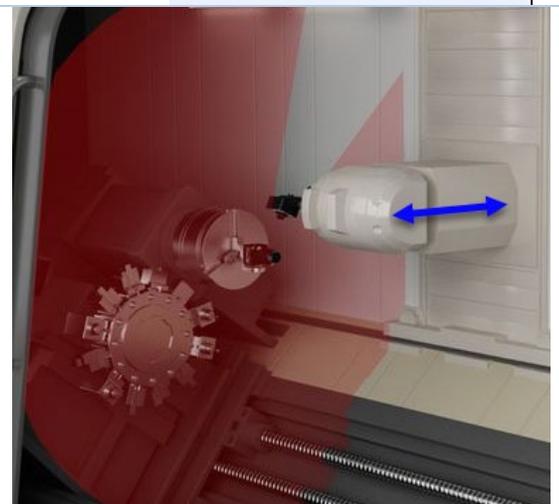
3. Attach the A-1519-2.4ZB Target to the Machine Head

Attach the A-1519-2.4ZB Target to the machine head spindle using custom fixturing or the magnetic base that comes with the target.

Note: the top of the target should be facing toward the C1 side of the machine. See image.

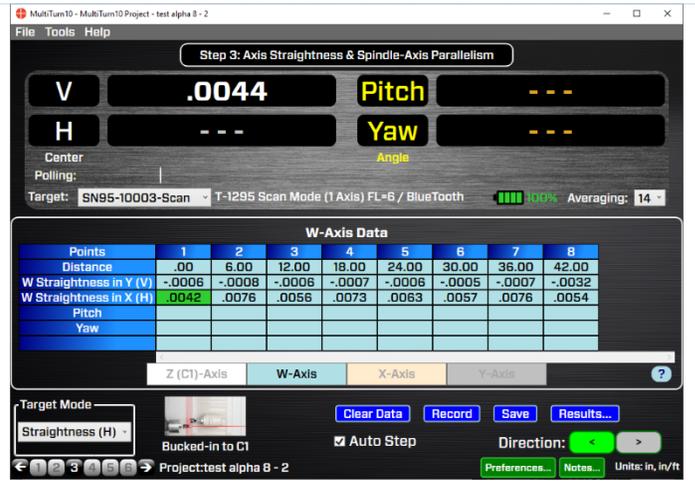
Adjust the height of the target so the laser plane is in the middle of the window. You can rotate the laser turret by hand to see where the laser beam is hitting the window to easily adjust the post in the fixture or magnetic base.

Bring the X Axis to the most extended (or most retracted) position in its travel.



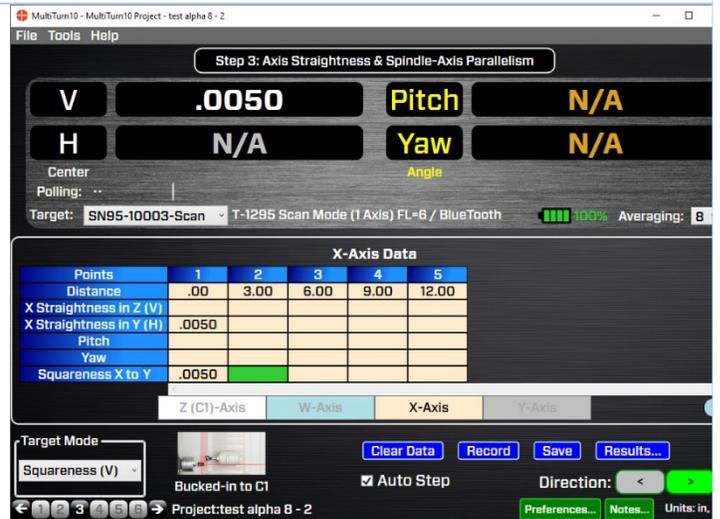
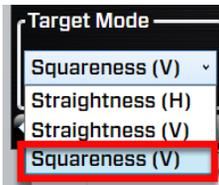
4. Turn on Scan Plane to Get Data & Adjust Target Height

Turn on the scan plane and you should see a value in the V Center display. Adjust the target height to get the raw value below ± 0.10 in. (0.25 mm).



5. Select X-Axis Tab & Squareness (V) for Data Type

Select the X-Axis tab and Squareness (V) from the lower left corner dropdown list. This will enable a row in the grid for X-to-Z Axis squareness and ready the program to record the data. You will see the green cursor in the Squareness X to Z row.



6. Take Measurements for the X Axis Squareness

Hit **Record** to record the first data point. Move the X Axis to the next point and hit **Record** and continue to record all the points.

Note: Since the L-702SP scan plane is perpendicular to the laser beam, the laser is measuring the squareness of the X Axis to the Y Axis to within .00006 in/ft (0.005 mm/m). When analyzing the squareness data using the Least-Squares, Best-Fit algorithm, the straightness can also be calculated for the X Axis in the Y direction. MultiTurn10 automatically puts a copy of the squareness data into the X Straightness in Y row. The straightness will be calculated in the Results screen by hitting the **Results** button.



MultiTurn10 - MultiTurn10 Project - test alpha 8 - 2

File Tools Help

Step 3: Axis Straightness & Spindle-Axis Parallelism

V **.0037** Pitch **N/A**

H **N/A** Yaw **N/A**

Center
Polling:

Target: SN95-10003-Scan T-1295 Scan Mode (1 Axis) FL-6 / BlueTooth 100% Averaging: 8

X-Axis Data					
Points	1	2	3	4	5
Distance	.00	3.00	6.00	9.00	12.00
X Straightness in Z (V)					
X Straightness in Y (H)	.0050	.0040	.0038	.0059	.0041
Pitch					
Yaw					
Squareness X to Y	.0050	.0040	.0038	.0059	.0041

Z (C1)-Axis W-Axis X-Axis Y-Axis

Target Mode
Squareness (V) Bucked-in to C1

Clear Data Record Save Results...

Auto Step Direction: < >

Project: test alpha 8 - 2 Preferences... Notes... Units: in, in/ft

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 19 represents the target in the NORMal position, with the cable *down*. If each square represents .001 in., 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.).

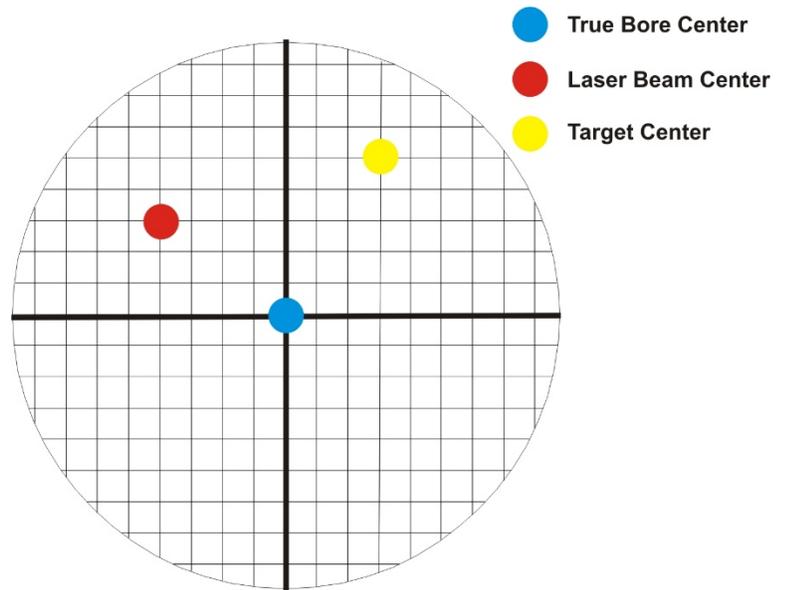


Figure 31 – Target in the NORMal position

Figure 20 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 20, the vertical readings will be positive, and the horizontal readings will be negative. When the vertical TCE is calculated, (Normal Inverted divided by 2) the Target Center is .004 in. higher and .003 in. to the right of the True Bore Center in the NORMal position.

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

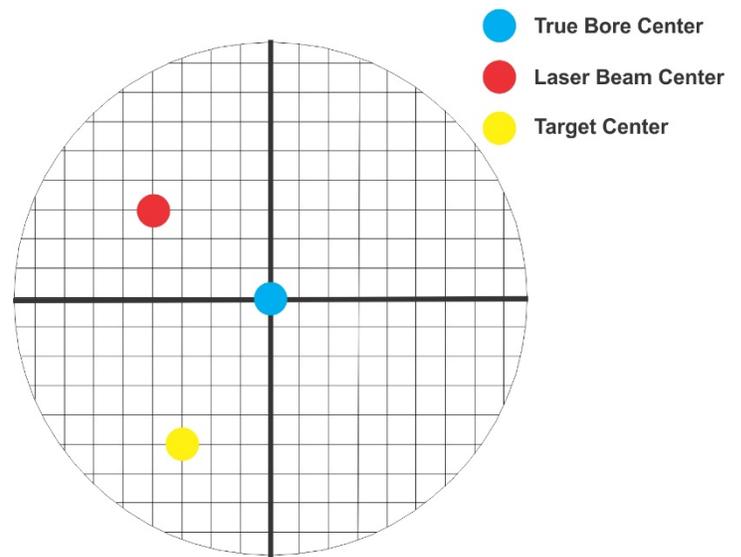


Figure 33 – Target in the INverted position

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 – L-700 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-702SP 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 53.

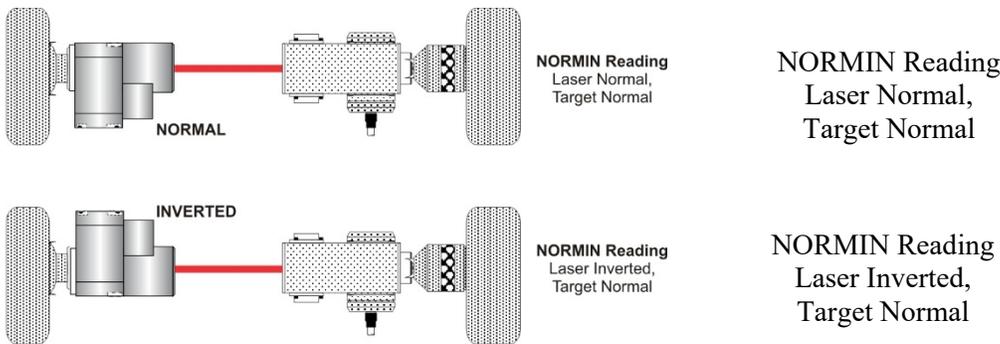


Figure 34—Taking NORMIN Readings

Adjustments

The L-700 laser has centering and angular micrometer adjustments. 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.

Hardware Requirements

The common equipment required to perform a qualifying procedure would be a target, an L-702SP 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 power 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:

$$[(.0021) + (-.0017)] / 2 = (.0004) / 2 = \mathbf{.0002}$$

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 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 22 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 34).

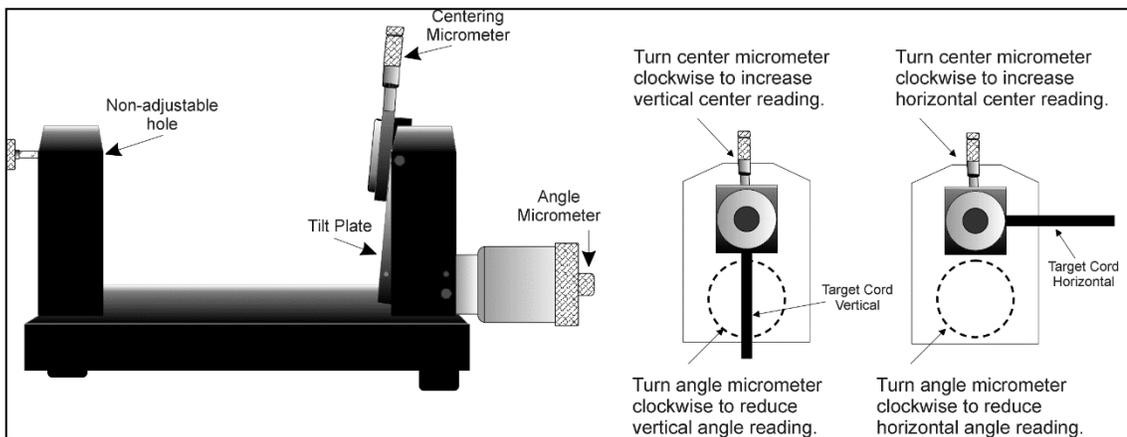


Figure 35—Model A-807 Calibration Mounting Fixture

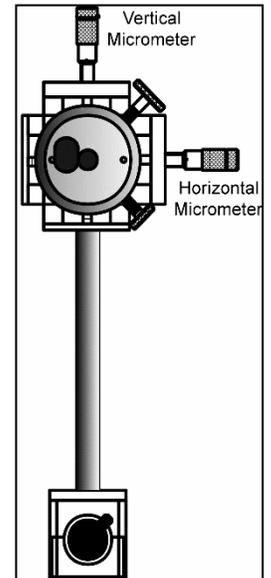


Figure 36—T-230 Target Stand

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 35).
4. **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.

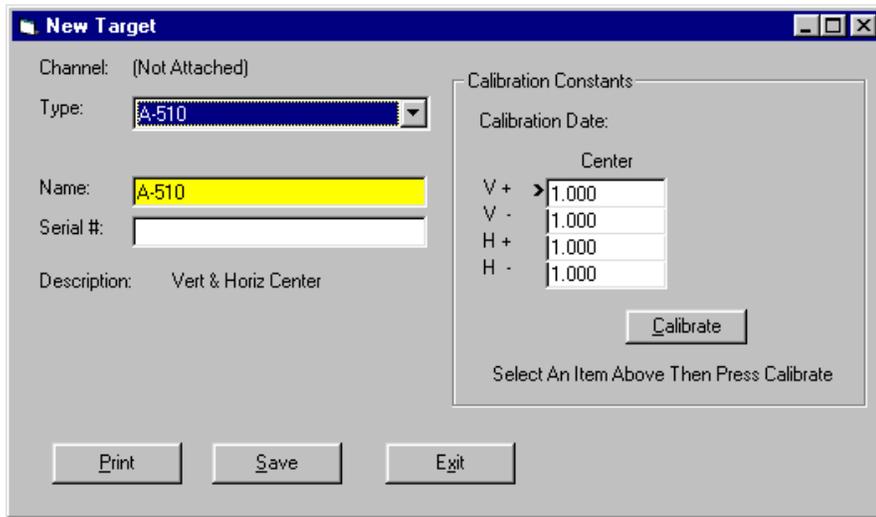


Figure 37—New Target Screen—2-axis Target

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 22). If working with a fixture that has a horizontal micrometer, there is no need to rotate the target (see Figure 23).

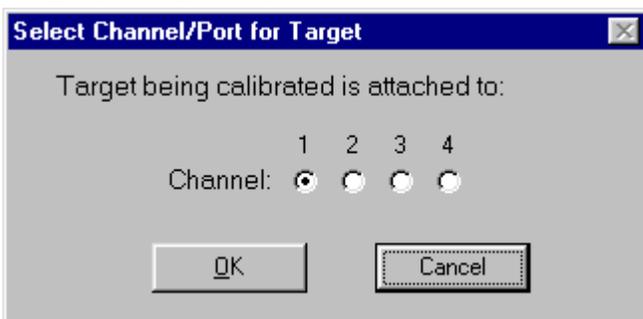


Figure 38—Channel/Port Selection Screen

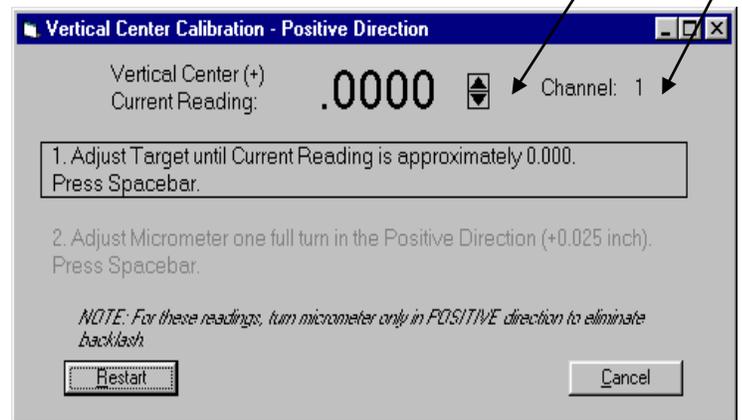


Figure 39—Calibration Screen

The Select Channel/Port for Target menu displays (see Figure 36). 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 the right arrow in Figure).

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 37).
- 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 26).**

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 23) 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 23). 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 27). 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 26).

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 33) 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. **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.

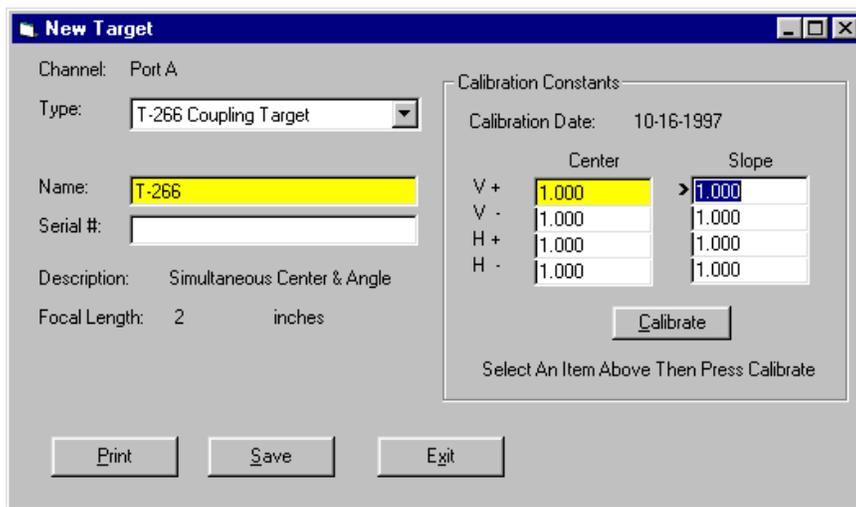
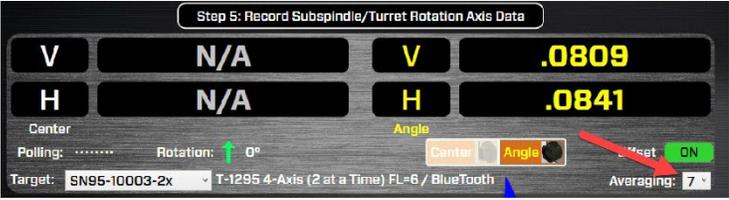


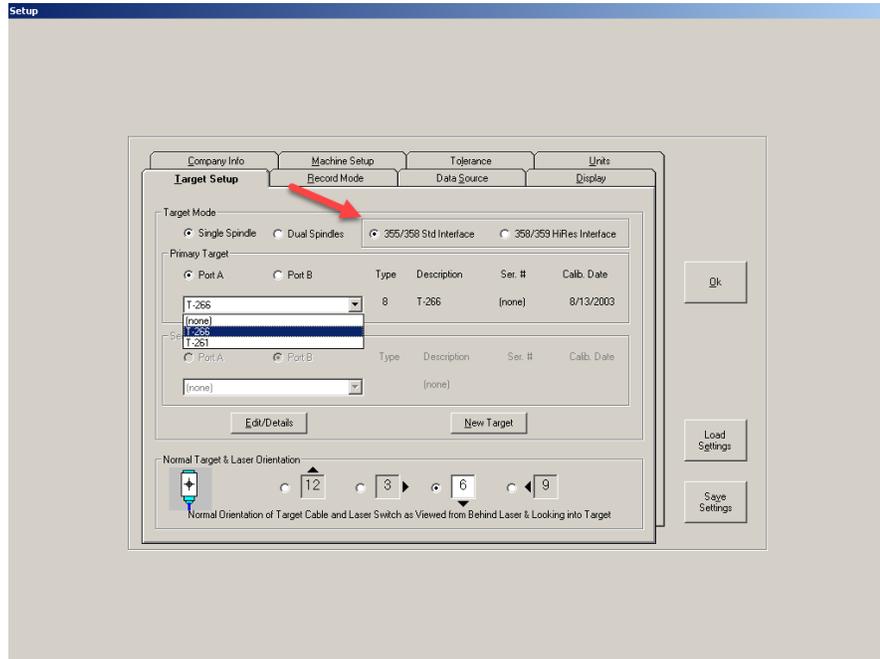
Figure 40 – New Target Screen – 4-axis Target

Appendix D – Troubleshooting Guide

Problem		Possible Solutions
1	<i>No laser beam</i>	<ul style="list-style-type: none"> Ensure laser is powered on and check switch. If LED on front of laser is dim, the battery is probably low. If LED is bright, diode has probably failed. Plug in the A/C adapter as the battery might be dead. Check for switch damage. If you don't feel a click, chances are the switch is damaged and will need to be replaced.
2	<i>No beam coming out the top of the L-702SP</i>	<ul style="list-style-type: none"> Is laser beam coming out the side hole? Laser must be in Beam Mode, (See Laser Control Panel and Functions) Power LED turned on?
3	<i>L-702SP Won't turn on</i>	<ul style="list-style-type: none"> Has battery been charged? If so, then it may need to be returned for repair. Battery charging LED light up when you plug in the charger? Do you feel a click when hitting the power button? If not, then unit should be sent in for repair. <div data-bbox="1084 611 1479 804" data-label="Image"> </div> <div data-bbox="1198 852 1468 1033" data-label="Image"> </div> <p data-bbox="1182 1037 1468 1062">L-702 A/C Adapter Connector</p>
4	<i>L-702SP - I can't get the fine angular adjustments to work</i>	<ul style="list-style-type: none"> Did you tighten the set screw on the coarse adjustment? <div data-bbox="1110 1108 1468 1396" data-label="Image"> </div>
5	<i>Beam is not round (use white paper to see beam)</i>	<ul style="list-style-type: none"> Clean laser optics with alcohol. Ensure optics are not scratched or cracked.
6	<i>Beam has satellites (use white paper to see beam)</i>	<ul style="list-style-type: none"> Clean laser optics with alcohol. Use Q-tips and only swipe in one direction, one time. Then use a new Q-tip or cotton swab. Ensure optics are not scratched or cracked.
7	<i>T-1295 – No values displayed in MultiTurn10 software</i>	<ul style="list-style-type: none"> Is target (Bluetooth) paired with computer? (See manual for procedure) Is Bluetooth enabled/disabled? Check computer settings for Bluetooth. Is correct target selected in software? Match serial number on back of target with serial number listed in MultiTurn 10 software. <div data-bbox="1227 1640 1479 1894" data-label="Image"> </div>

		<ul style="list-style-type: none"> • T-1295 2X Mode - Is the L-702SP set to the correct laser pattern? It requires the double blink (see manual) • T-1295 Scan Mode – Is the L-702SP Prism Flipped to allow the beam to come out the side? • Is the laser set to Scan Mode (continuous beam is needed for scan mode)? Note: there are 3 modes: Double Blink (needed for T-1295/1296), Single Blink – needed for R-1307 and Continuous (needed for Scan Mode) – see manual • Is laser turned on and beam visible? • Has the T-1295 target battery been charged?
8	<i>T-1295 Will not switch to Beam Mode</i>	<ul style="list-style-type: none"> • Has L-702SP laser been turned off or beam blocked? User must turn off or block laser beam prior to switching to Beam Mode.
9	<i>T-1295 Spindle with shims is moved but display numbers do not match</i>	<ul style="list-style-type: none"> • Is the display set to Center Mode? • Is the lens not installed?
10	<i>T-1295 Spindle with shims is moved but the angle display numbers do not match what was added</i>	<ul style="list-style-type: none"> • Is the display set to Angle Mode? • Is the lens installed? 
11	<i>T-1295 values in display take long time to update</i>	<ul style="list-style-type: none"> • Is the AVG set too high? We recommend 16 for 2X Mode and 8 for Scan Mode. 
12	<i>T-1295 Not Charging</i>	<ul style="list-style-type: none"> • Has the unit been fully charged? Battery level can be checked with the MultiTurn10 software. • If unit still will not charge, contact Technical Support.
13	<i>T-1295 When spindle is rotated slightly, display numbers do not change</i>	<ul style="list-style-type: none"> • There is a rotation angle correction routine that is used in Steps 2, 5 and 6. This routine use the rotation angle value to correct the raw values so they always appear to be at the 12:00 position. This increases accuracy of the measurements when rotating the axes using our NORMIN method.
14	<i>"---" shown in software target display</i>	<ul style="list-style-type: none"> • Software does not see the computer interface. Check target connections. • Check cable connections. • Ensure target is connected to R-358. • Ensure R-358 is fully charged. The R-358 takes 3-5 minutes to show a connection to the software when battery is fully charged. • Check connectors for broken pins or wires in connectors. • For Spindle8 Software: Ensure that ACTUAL TARGETS is selected under the DATA SOURCE tab in TARGET SETUP. • For Spindle8 Software: Ensure the correct R-358 interface type is selected: If you are unsure whether your R-358 is a standard or Hi resolution, please contact Technical

Support.



- Check for kinks in the cables.
- Extremely bright light shining on the face of the target may cause the display to go blank.
- The software sees the R-358 Interface, but the target does not detect the laser beam.
- Check target connection.
- Ensure target is connected to R-358.
- Check connectors for broken pins or wires.
- Check for kinks in the cables.
- Ensure laser is powered on.
- Ensure laser beam is bright (use white paper to see beam).
- Ensure the beam is hitting the center of the target window.
- Ensure the target angle is not too severe. The angular range of the T-261A is somewhat limited, so the angle of the target must be within ± 0.5 degrees.

15	<i>OFF TGT shows in target display</i>
16	<i>Numbers in the target display “jump” (Spindle8 software)</i>
17	<i>Numbers in target display are noisy (jump up/down by more than 0.002 mm in 2 m)</i>
18	<i>Software crashes when loading – R-358 Only</i>
19	<i>Either no negative or positive readings are displayed</i>
20	<i>Very odd results display</i>

- In **TARGET SETUP**, ensure that **ACTUAL TARGETS** (not **RANDOM DATA**) is chosen under the DATA SOURCE tab.
- Check for vibration (turn off machine).
- Check for warm or cold air (relative to ambient temperature) blowing between laser and targets.
- Some A/C power chargers for laptops are noisy and can cause noise in the measurements. Try using laptop battery only.
- Check laser and target mounting setups to ensure tight clamp.
- Increase data averaging in software.
- Ensure USB/serial converter cable is connected to the laptop.
- Check for broken wires or pins pushed out of target connectors. If so, target will probably need repairs. Try moving the cable around. If this changes the readings the cable is damaged and needs repair.
- Ensure the screws on target connector are tightened on the R-358.
- Make sure the screws on target connector are tightened on the R-358.

Appendix E – Care and Cleaning of Target Optics

The proper care and cleaning of optical windows and/or lenses of Hamar Laser’s position-sensing devices (targets) assures optimum performance. Contaminants on an optical surface increase scatter, absorb laser energy, and eventually degrade the accuracy of the position-sensing devices. Because cleaning any precision optics risks damaging the surface, optics should only be cleaned when absolutely necessary. When cleaning is required, we recommend the following supplies and procedures.

Required Supplies

- **Optics Cleaning Tissue:** Soft, absorbent, lint-free lens tissue
- **Swabs:** Cotton swabs with wooden handles or polyester swabs with polypropylene handles
- **Dust Blower:** Filtered dry nitrogen blown through an antistatic nozzle is best. Canned dusters such as Dust-Off will also work.
- **Mild Soap solution:** Neutral soap, 1 percent in distilled water. Avoid scented, alkali, or colored soap such as liquid dishwashing detergents or hand soap. Ten drops of green soap (available at a pharmacies and optical cleaning suppliers) per 100 cc of distilled water is an acceptable alternative.
- **Isopropyl Alcohol:** Spectroscopic grade. Over-the-counter alcohol contains too much water and may have impurities.
- **Acetone:** Spectroscopic grade. Do not use over-the-counter Acetone, such as the type intended for nail polish removal.

NOTE: *When cleaning precision optics, even with the best quality optical cleaning tissue, use gentle pressure to avoid scratching the surface or damaging the optical coating(s). Always wipe using a figure-eight motion in one direction (begin at the top and work toward the bottom in a figure-eight motion).*

Use only moistened (not soaked) optical cleaning tissue, swabs and Spectroscopic grade Acetone and Isopropyl Alcohol. Never spray any type of liquid directly on the device or submerge any part of the device.

Removing Dust

Dust can bind to optics by static electricity. Blowing only removes some of the dirt. The remainder can be collected by using wet alcohol and Acetone swabs wrapped with optical lens tissue. Acetone dries rapidly and helps to eliminate streaks.

1. Blow off dust.
2. If any dust remains, twist lens tissue around a cotton swab moistened in alcohol and repeat as necessary.
3. Repeat using Acetone.

Cleaning Heavy Contamination

Fingerprints, oil, or water spots should be cleaned immediately. Skin acids attack coatings and glass and can leave permanent stains. Cleaning with solvents alone tends to redistribute grime.

1. Blow off dust.
2. Using a soap-saturated lens tissue around a swab, wipe the optic gently. Repeat as necessary.
3. Repeat using a distilled water-saturated lens tissue wrapped around a swab.
4. Repeat using an alcohol-saturated lens tissue wrapped around a swab.
5. Repeat using an acetone-saturated lens tissue wrapped around a swab.