



*L-702 / L-702SP Lathe and Multi-Turn
Alignment System*

Operations Manual

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HAMAR LASER INSTRUMENTS, INC.
www.hamarlaser.com

Five Ye Olde Road, Danbury, CT 06810
Phone: (800) 826-6185 Fax: (203) 730-4611

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L-702/L-702SP Spindle and Multi-Turn Alignment System

The L-702/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. There are two configurations:

- **L-702** – This version is used only to align spindles to subspindles, check flatness and straightness of the lathe and turning-center guideways, and alignment of headstocks to tailstocks. It can also be used to check the parallelism of the headstock to the lathe-bed guideways.
- **L-702SP** – This version adds an automatically rotating turret 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 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.
- **Spindle8 Software:** Designed for transfer-line spindle alignments, Spindle8 features large, easy-to-read alignment displays, live alignment data and spindle graphics, and a four-step procedure that guides users through aligning spindles to master parts on transfer-line spindle applications

Hardware Overview

Model L-702/L-702SP Spindle Laser

The Model L-702/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-702 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 0.50 in. (12.7 mm) mounting stud simplifies fixturing and can be removed to adapt the unit to custom fixtures or other alignment applications.

Both lasers feature a built-in, rechargeable, lithium ion battery that provides operation for up to eight hours on a single charge.

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

Applications include:

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



Figure 1– L-702 Spindle Laser



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 **ON/OFF** 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.

L-702SP Scan button

Power the L-702SP on and press the **SCAN** button to turn on the turret laser rotation and create a scan plane. Press it again to turn it off.

Note: *The Pentaprism in the turret will need to be pivoted into place to create the scan plane. See Switching L-702SP Turret into Scan Mode on Page 19 for instructions.*

A/C Connector

The L-702 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 – tighten the set screw to disable the fine adjustment.
- Fine Adjustment – loosen the set screw to enable the fine adjustment, which is 12 times finer adjustment resolution.



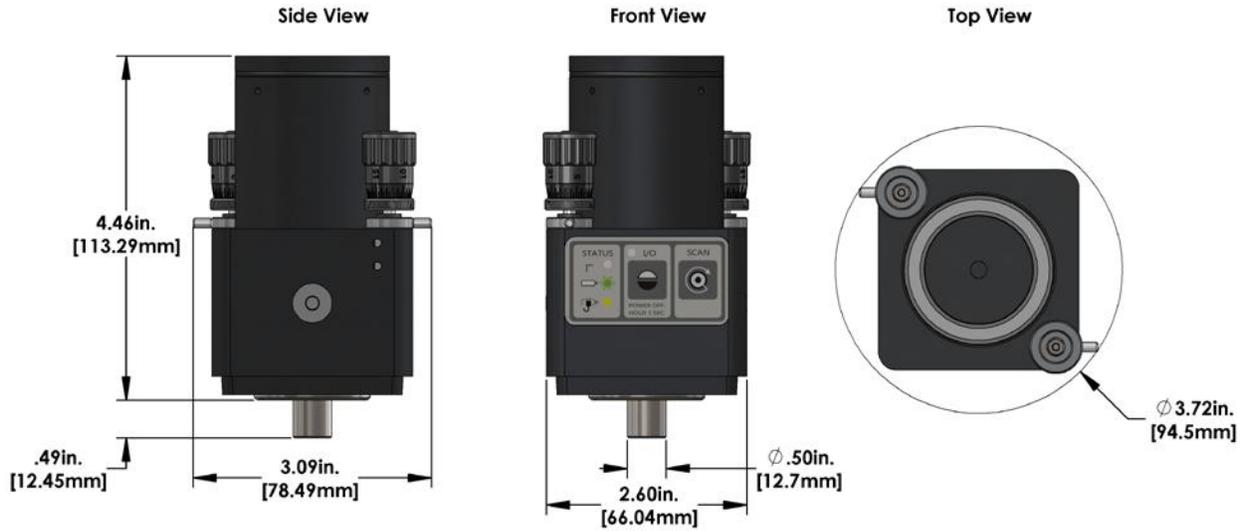
Figure 4– Differential Micrometer



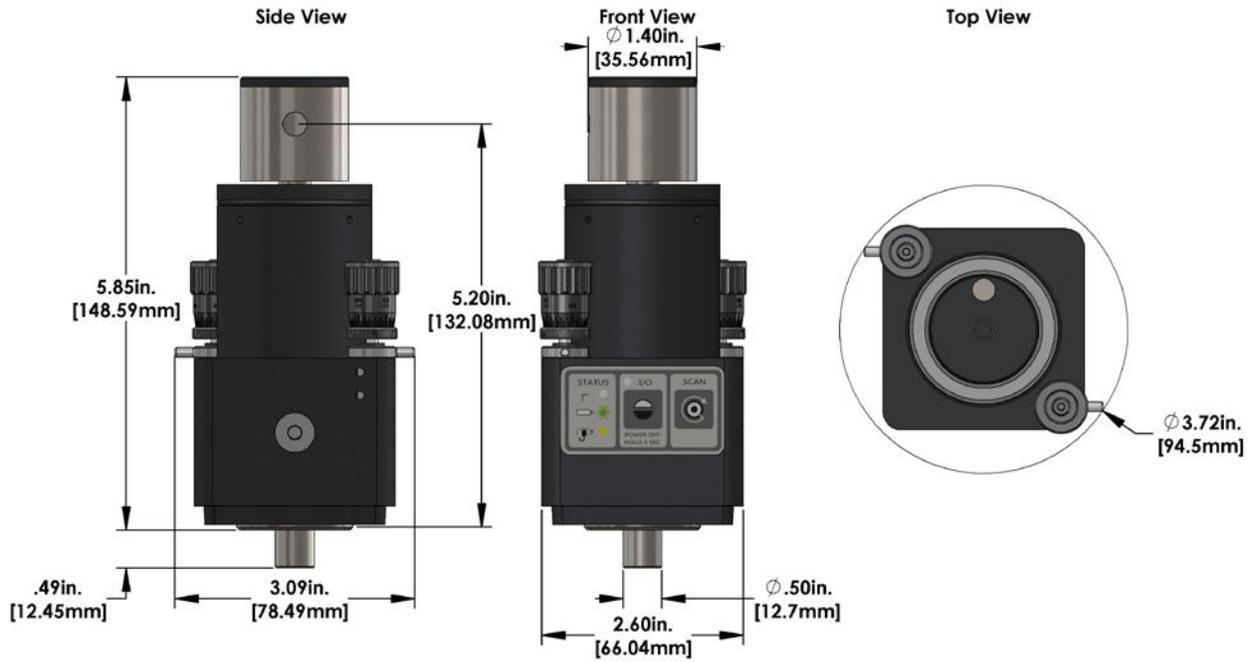
Figure 3– L-702/L-702SP Control Panel

L-702/L-702SP Laser Dimensions

L-702 Spindle Laser



L-702SP Spindle Laser with Scan Plane



The T-261A Four-Axis Target

The T-261 Four-Axis Target reads both center and angle (pitch and yaw) simultaneously, allowing a real-time display of misalignment. The 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 26).

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 31.



Figure 6—T-261 Four-Axis Target

The R-358 Computerized 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.

Hamar Laser's Lathe9 Alignment Software

Hamar Laser provides alignment software as standalone programs. The latest software 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.



Figure 7— Lathe9, Step 6 – Tailstock/Turret Alignment

Interpreting the Plus and Minus Signs in the Live Displays

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

Note the T-261 provide 4 simultaneous axes:

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



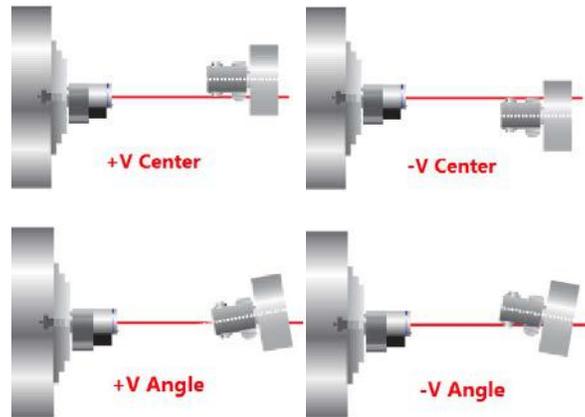
Vertical Axis

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.



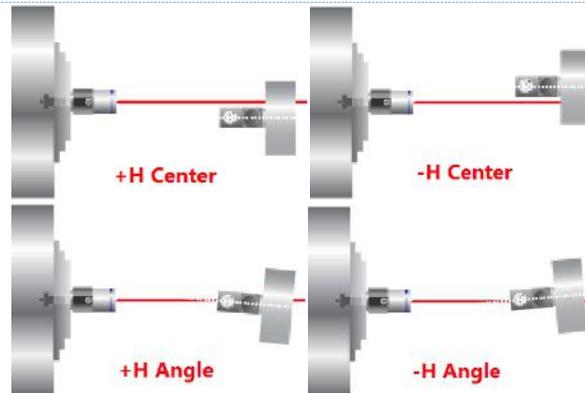
Horizontal Axis

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.



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 is 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 subspindle 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-702/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-702/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 subspindle AOR be checked for alignment to the headstock AOR. The T-261 offers a live four-axis display of the tailstock, subspindle or turret centers or AOR relative to the laser beam (headstock AOR).

Hardware Mounting

Both the L-702/L-702SP Laser and T-261 Target have a standardized .4995 in. (12.69 mm) mounting stud that simplifies fixturing and that can be removed to adapt the unit to custom fixtures or other alignment applications. A .500 in. reamed hole that is square to a face is all that is required to mount the laser/target mounting stud. The mounting stud also has a 1/4-20 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-261 is mounted in the tailstock chuck, subspindle chuck or the turret center.



Figure 8—L-702 Mounting Stud

Maintenance and Cleaning

The spindle to be aligned should be checked thoroughly to ensure that it is clean and working properly. The window on the 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, subspindle or turret. This information is necessary for the software setup. Use only the distance that the unit realistically travels during use, not the full distance of which it is capable.
- Keep records of all procedures. Log all data file names and keep record copies of all reports and printed data.

Qualifying Lasers and Target Calibration

In the case of the L-702 Laser, the laser beam needs to be parallel to the axis of its mounting stud, providing the maximum amount of adjustment range. This is done by aligning the L-702 Base cover with the thin white line on the L-702's mounting base (see *Qualifying the L-702 Laser Beam to its Mounting Stud* on Page 11).

The T-261 4-Axis Target 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 31.

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

Warning!!

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

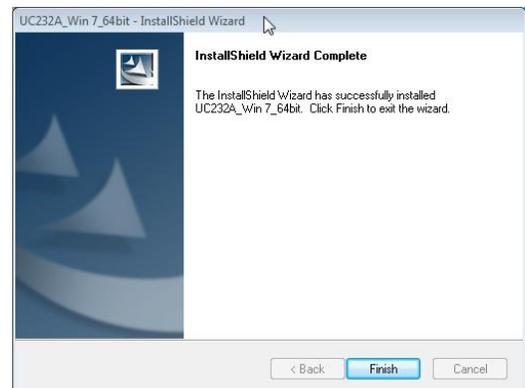
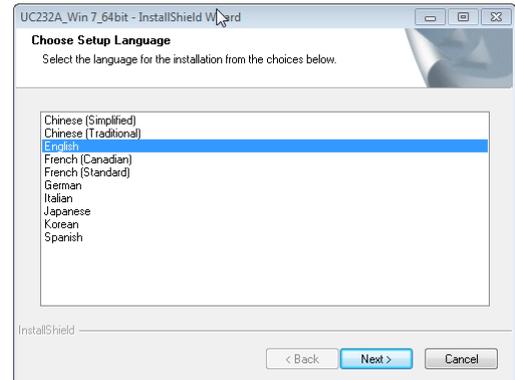
Installing the (RS-232) USB to Serial Converter Cable Driver

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.

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

Installing the Driver

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



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.

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. Please see Page 11 for details on installing the driver.

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.

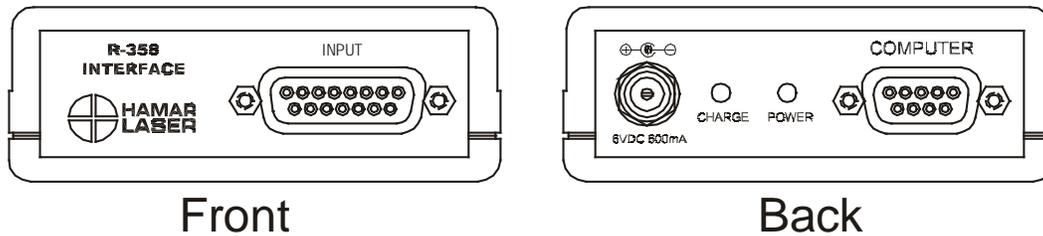


Figure 9—R-358 Interface Connection

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.

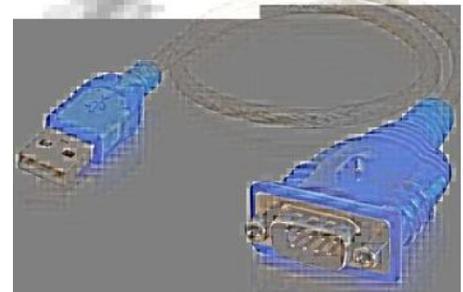


Figure 10 – USB to Serial Converter Cable

Qualifying the L-702 Laser Beam to its Mounting Stud

All Hamar Laser's L-702 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 re-qualify the laser to its mounting stud, which puts the L-702 angular adjustments in the center of their adjustment range.

To return the L-702 angular adjustments to the middle of their adjustment range, adjust the Pitch and Roll COARSE adjustment axes so that the bottom of the L-702 base cover is aligned to the white line on the mounting base (see Figure 11).



Figure 11—Returning the L-702 Pitch/Roll Adjustments to the middle of their range

Qualifying the L-702 Laser Beam to a Spindle AOR

In spindle alignments on lathes and turning centers, it is important to ensure that the L-702 laser beam is aligned, or qualified, 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-702 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 26.

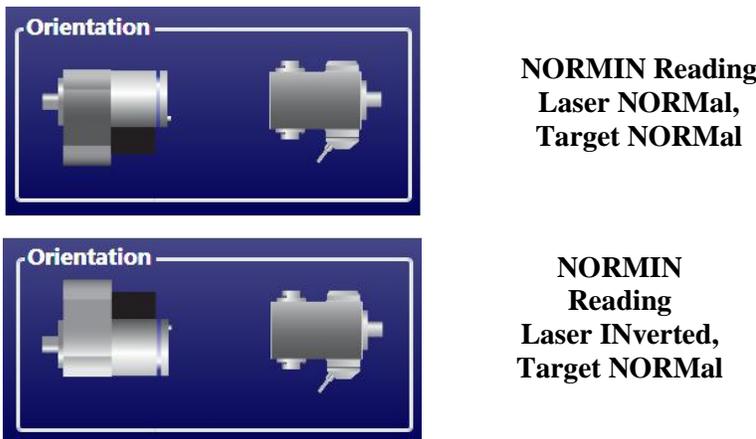


Figure 12—Taking NORMIN Readings

To qualify a laser, error correction readings are taken to cancel out mounting and other errors, and Lathe9 calculates *Set Points*. The laser beam is then adjusted to the *Set Points*, making it parallel to/coincident with the desired axis of rotation. A computer program such as Lathe9 calculates the *Set Points* for the user and zeroes the display at that point. The user then adjusts the laser beam to zero.

Adjustments

The L-702 laser has Pitch and Yaw angular adjustments with coarse and fine resolutions. The beam is emitted from the large hole in the center of the spindle or from the side of the turret in the L-702SP version.

Warning - Do not stare into the beam.

Pitch/Yaw Adjustment

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

- **Coarse Adjustment** – tighten the set screw to disable the fine adjustment.
- **Fine Adjustment** – loosen the set screw with the provided Allen wrench to enable the fine adjustment, which is 12-times finer adjustment resolution.

Hardware Requirements

To qualify the L-702 to the spindle's AOR you will also need the L-702 Laser, T-261 Four-Axis Target, the R-358 Computer Interface and Lathe9 or Spindle8.

If using the manual procedure, then you will need two R-1307 readouts, one for the *center* readings and one for the *angular* readings. (See Appendix B beginning on Page 27 for the manual procedure.)



Figure 13– L-702/L-702SP Pitch and Roll Adjustments



Figure 14—Differential Micrometer

Spindle Qualifying Laser Procedure Using Lathe9 Software

The following procedure explains how to qualify (align) the L-702 laser to the spindle's rotation axis using a 4-axis target and Lathe9 software.

Setup

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

Connect the T-261 to the R-358 and 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 11 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.

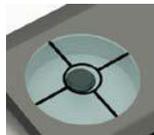
5. Go to Step 2: Qualify Laser

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



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

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



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-702 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.



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 $\pm .0001$ in/ft (0.012 mm/m) of zero.



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

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



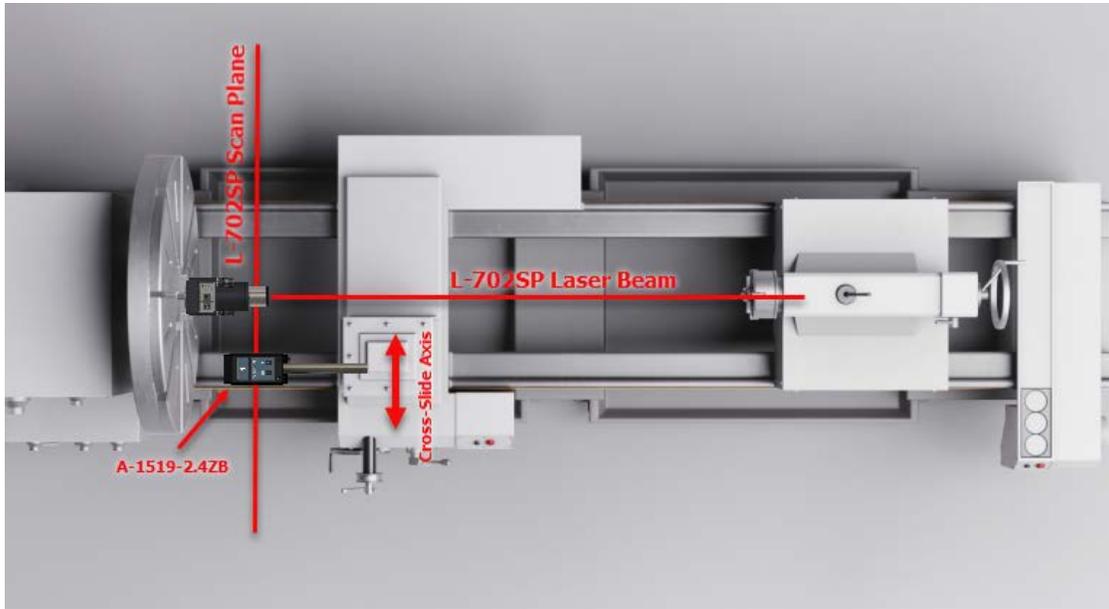
11. Repeat Steps 6-10 to verify the laser is aligned to the spindle rotation axis.

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.



Measuring Cross-Slide Squareness and Straightness with L-702SP

With the L-702SP Laser, a rotating turret is added to the L-702 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.



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 our: R-1356-2.4ZB PDA Readout, R-1308 Single-Axis Readout or the R-1307W-2.4ZB 2-Axis Readout.



Figure 15—A-1519-2.4ZB Single-Axis Wireless Target



Figure 16—A-1519-2.4ZB Target with R-1308 Single-Axis Readout



Figure 17—R-1356-2.4ZB PDA Readout with Read15 Software

Switching L-702SP Turret to Scan Mode

To create the L-702SP perpendicular laser scan plane a flip mechanism is used to move a pentaprism into the laser beam that bends the beam 90 degrees. This creates a perpendicular laser beam that emits from the side of the spindle, which is then rotated to create the scanning laser plane. The flip mechanism is controlled by a screw in the top of the spindle. Use a standard screwdriver to turn the screw until you feel a “click”, which is 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.

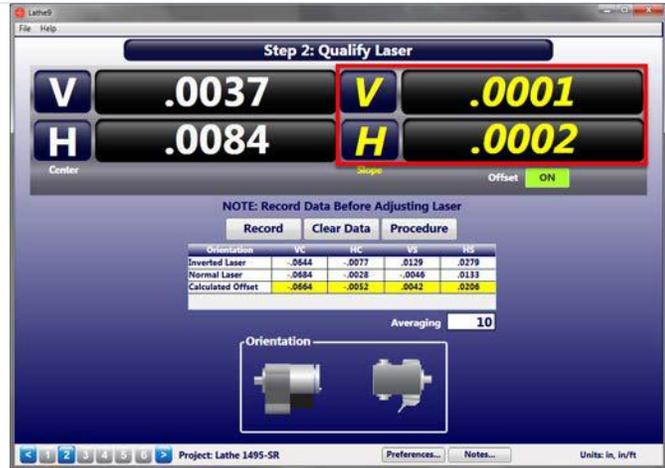


Procedure to Measure Cross-Slide Squareness/Straightness

1. Align L-702SP Beam to Spindle Rotation Axis.

As shown in Qualifying L-702 Laser on Page 11, align the L-702SP laser beam to the spindle rotation axis.

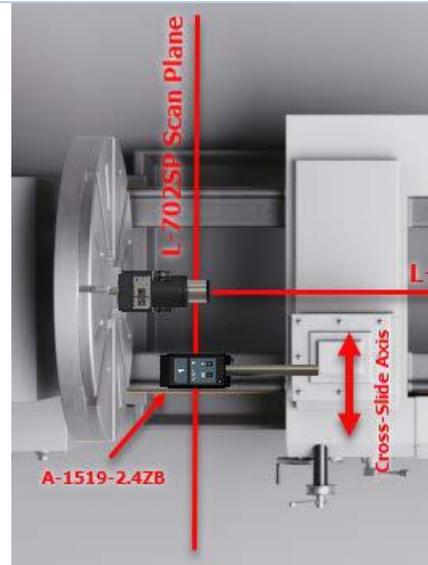
Flip prism in turret to Scan Mode (see Page 19).



2. Attach A-1519-2.4ZB Target to the Cross Slide.

Attach the A-1519-2.4ZB Target to the cross slide using custom fixturing or the magnetic base that comes with the target. Adjust the height of the target so the laser plane is in the middle of the window by rotating the turret by hand to see where the laser beam hitting the window.

Adjust the cross-slide axis to the end of its travel.



3. Turn on Scan Plane and Connect Readout and Zero Target

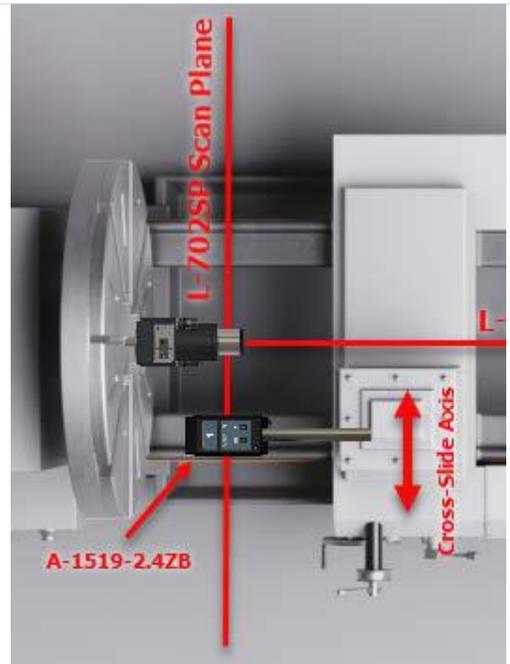
Turn on the scan plane, which also automatically turns on the A-1519-2.4ZB Target. Connect the R-1308 Readout or turn on the R-1356-2.4ZB PDA Readout and open the Read15 software.

Zero the target.

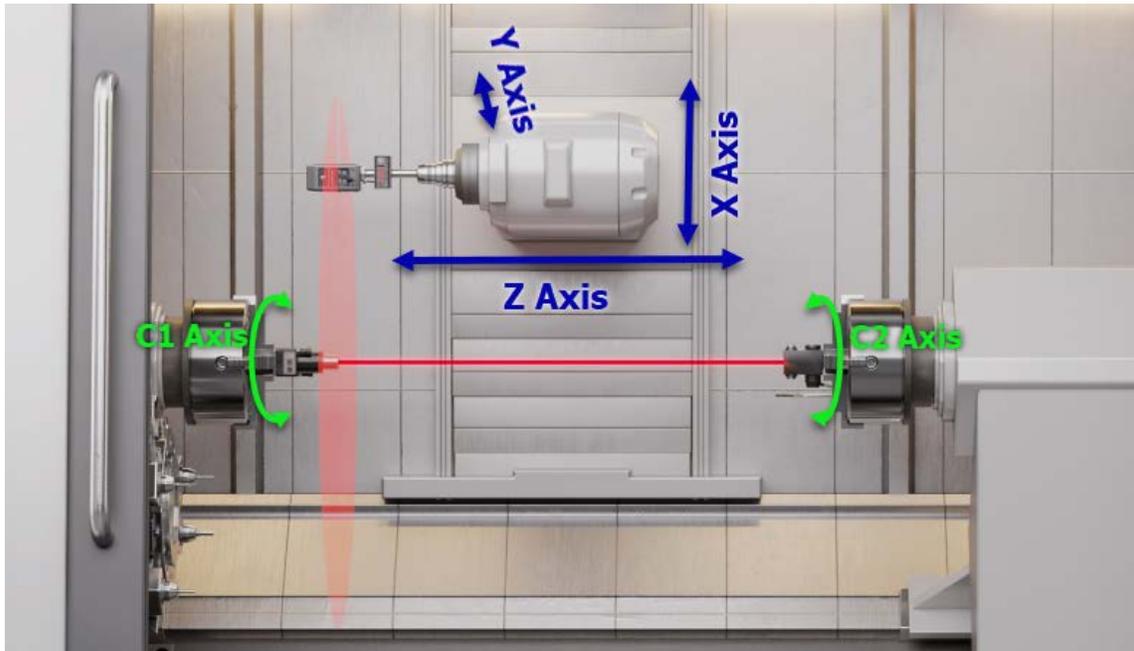


4. Move the Cross Slide Axis and Take Measurements

Move the cross slide axis a short distance and note the value on the readout. Write down the readings and the distance traveled. Any deviations from zero are a measure of squareness but also straightness.



Procedure to Measure Multi-Turn Machines for Squareness and Straightness



1. Align L-702SP Beam to Spindle Rotation Axis.

As shown in Qualifying L-702 Laser on Page 11, align the L-702SP laser beam to the spindle rotation axis.

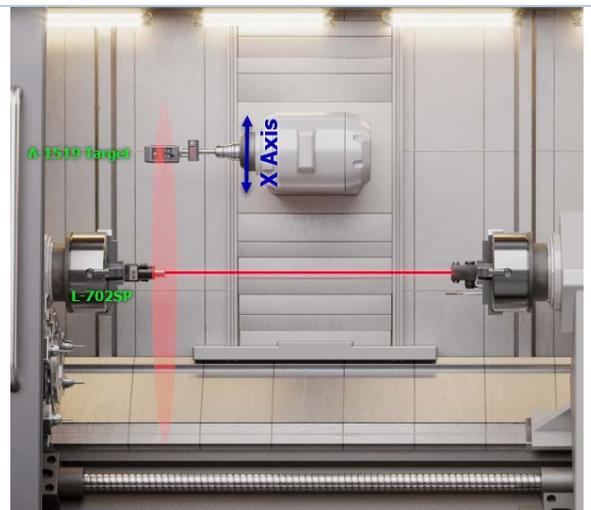
Flip the prism in the turret to Scan Mode (see Page 19).



2. To Measure X Axis Straightness (in C) and Squareness to C

Attach the A-1519-2.4ZB Target to the spindle using custom fixturing or the magnetic base that comes with the target. Adjust the height of the target so the laser plane is in the middle of the window. As noted above, 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 top of its travel.



3. Turn on Scan Plane, Connect the Readout and Zero the Target

Turn on the scan plane. Connect the R-1308 Readout or turn on the R-1356-2.4ZB PDA Readout and open Read15.

Zero the target.



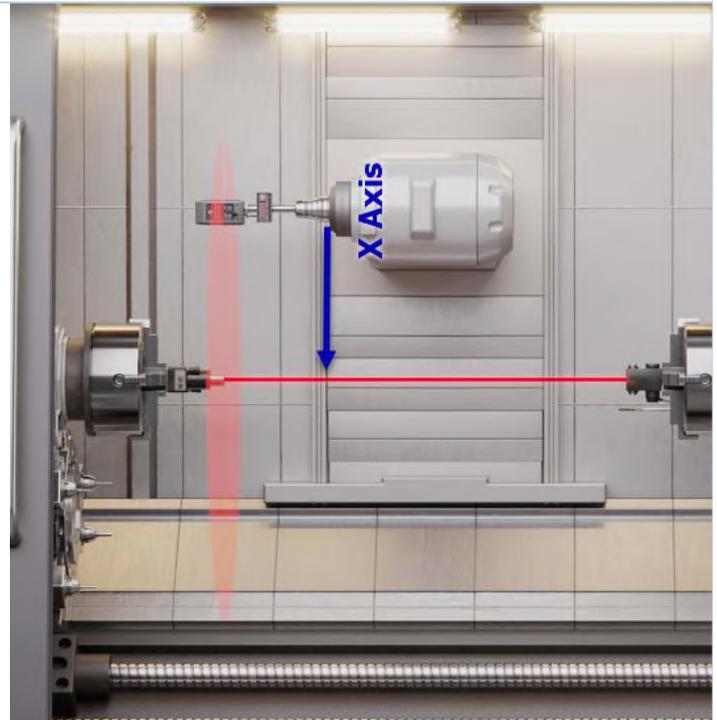
4. Take Measurements for the X Axis (in C)

Move the X down a short distance and note the value on the readout. Write down the readings and the distance traveled. Any deviations from zero are a measure of squareness but also straightness (in the C direction).

Note: *The straightness of X in the Y direction cannot be measured with the L-702SP with this setup. To measure the straightness of X in Y, the L-702SP would have to be mounted to the side of the headstock spindle and bucked-in to the Y axis with the A-1519-2.4ZB mounted on the side of the X axis spindle.*

Alternatively, the L-742 Dual Scan or L-743 Triple Scan® Lasers could be used for this check.

The straightness/flatness data can be recorded in Machine Tool Geometry Software using the A-910-2.4ZB USB Receiver.

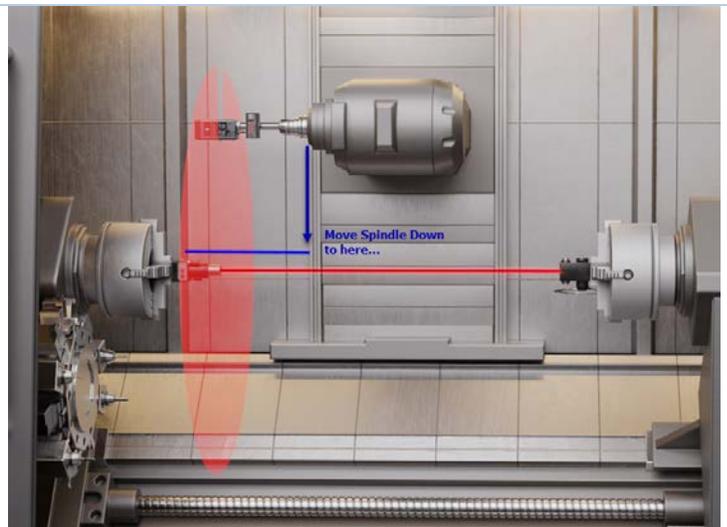


5. To Measure Y Axis Straightness (in C) and Squareness

With the A-1519-2.4ZB attached to the spindle as described above, move the X axis down so that the A-1519-2.4ZB is just above the L-702SP.

With the Y axis fully retracted, power on the scan plane and zero the target. Move the Y axis a short distance and note the value.

Continue until the spindle is at the end of its travel, making sure to not hit the L-702SP with the A-1519-2.4ZB Target.

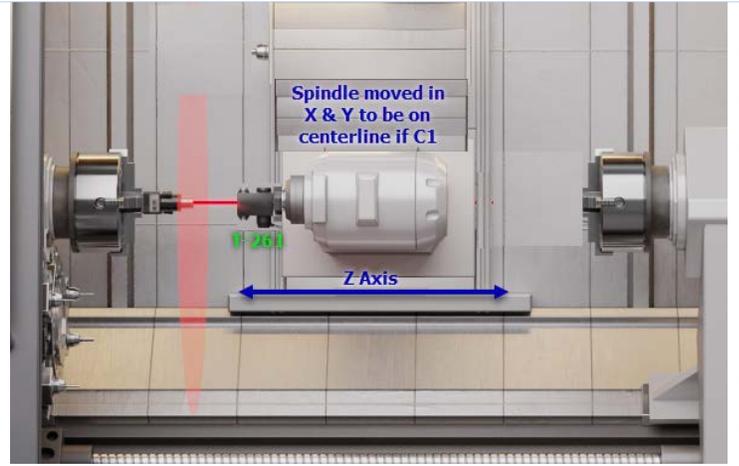


6. To Measure the Z Axis for Straightness and Parallelism to C

Move the machining spindle to be on center to the headstock centerline.

Install the T-261 4-Axis Target into the machining spindle.

Move the machining spindle until the T-261 is close to the L-702SP within 4 in. (100 mm). In Lathe9, take data in Step 3 (see the Lathe9 Manual) by moving the machining spindle along its Z Axis in short increments, pausing and pressing RECORD. Lathe9 analyzes the straightness and parallelism.



7. Lathe9 Step 3 and Results Screen

Step 3: Spindle Axis Parallelism

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

Center Slope

Points	1	2	3	4	5	6	7	8	9	10	11	12
Distance	.000											
Tailstock VC	.0129	.0139	.0094	.0135	.0079	.0437	.0160	.0411	.0442	.0116	.0443	.0057
Tailstock HC	-.0060	-.0064	-.0140	-.0085	-.0137	-.0098	-.0238	-.0134	-.0084	-.0174	-.0087	.0024
Tailstock VS	.0613	.0613	.0622	.0643	.0562	.0543	.0428	.0652	.0569	.0434	.0543	.0027
Tailstock HS	-.0017	-.0015	-.0007	-.0041	-.0113	-.0020	-.0109	-.0009	-.0021	-.0127	-.0044	.0003

Clear Data Record Save Finish Move... Results... Laser Position

Auto Stop: On Tailstock Saddle

Project: test 3

Step 3 Alignment Results

Item	Tailstock Data			Saddle Data		
	Value	Tolerance	In/Out	Value	Tolerance	In/Out
V Straightness	.0586	.0003	X	N/A	.0003	
H Straightness	.0302	.0003	X	N/A	.0003	
V Parallelism	-.0073	.0007	✓	N/A	.0007	
H Parallelism	.0048	.0007		N/A	.0007	

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

Move Step 4 Close

Appendix A – The NORMIN Method (Bore and Spindle)

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

There are three centers involved in bore alignments: True Bore Center, Target Center, and Laser Reference Centerline. If mounting fixtures were perfect, the Target Center would be located at the True Bore Center, and if perfectly aligned, the True Bore Center would be located at the laser beam center. However, they seldom line up. An example of the three centers with respect to one another is shown in Figure 18.

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

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

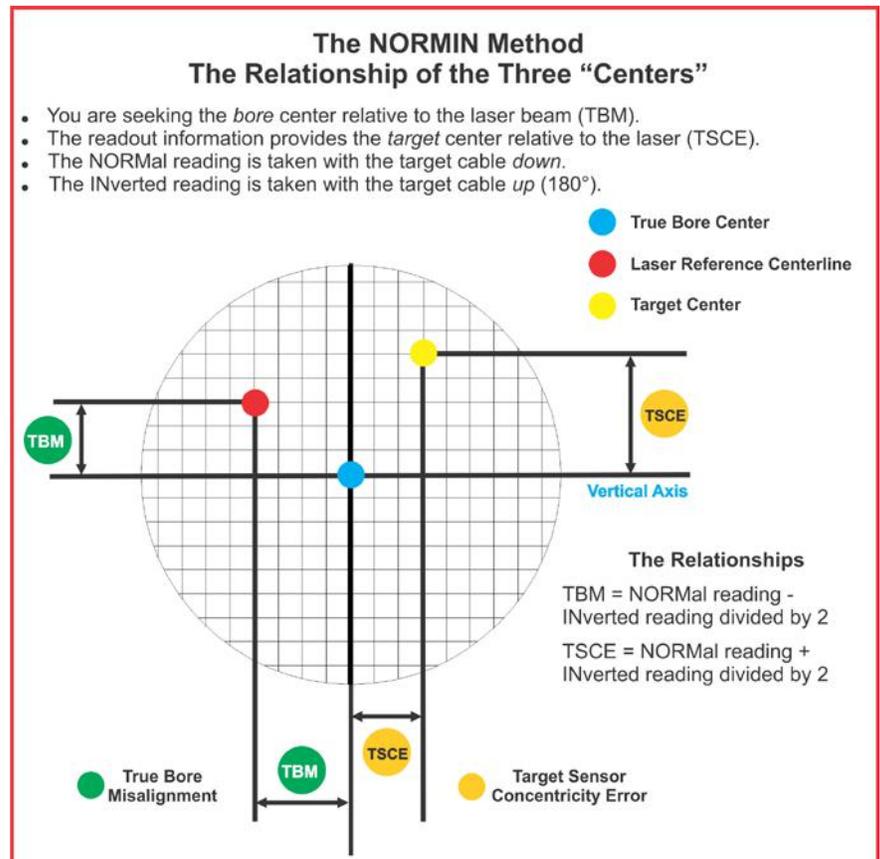


Figure 18 -- Three centers of bore alignment

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

Figure 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.).

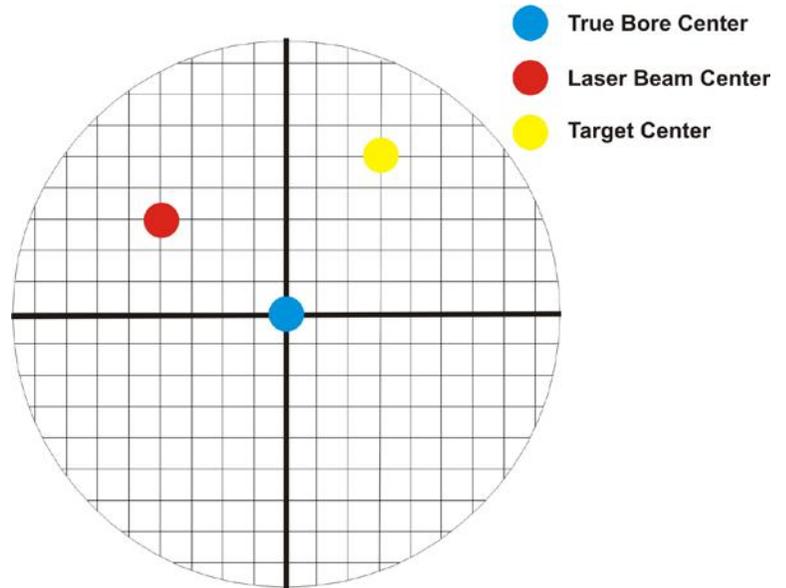


Figure 19 – Target in the NORMal position

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.

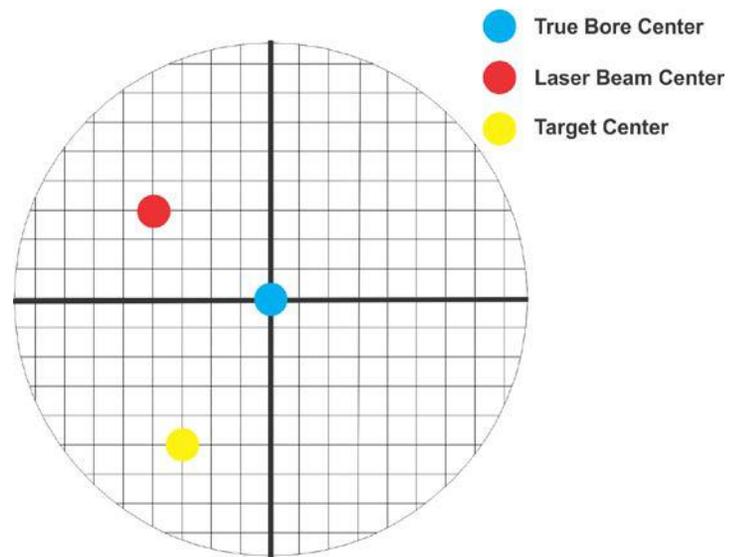


Figure 20 – Target in the INverted position

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

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

Appendix B – Qualifying the Laser – 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-702 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 26.

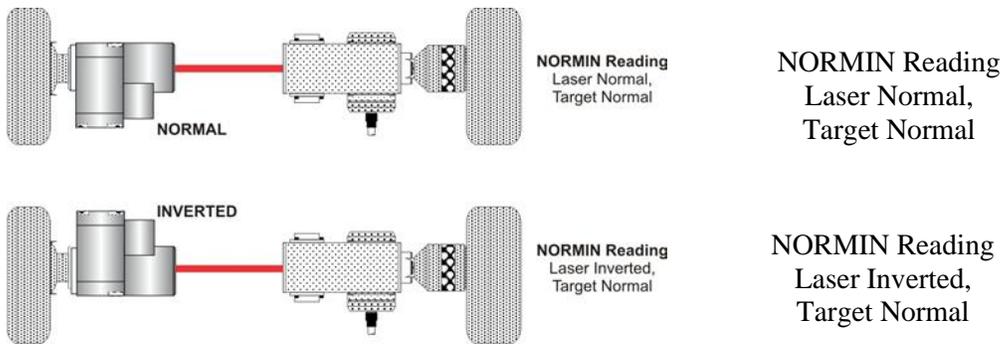


Figure 21—Taking NORMIN Readings

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-702 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 23).

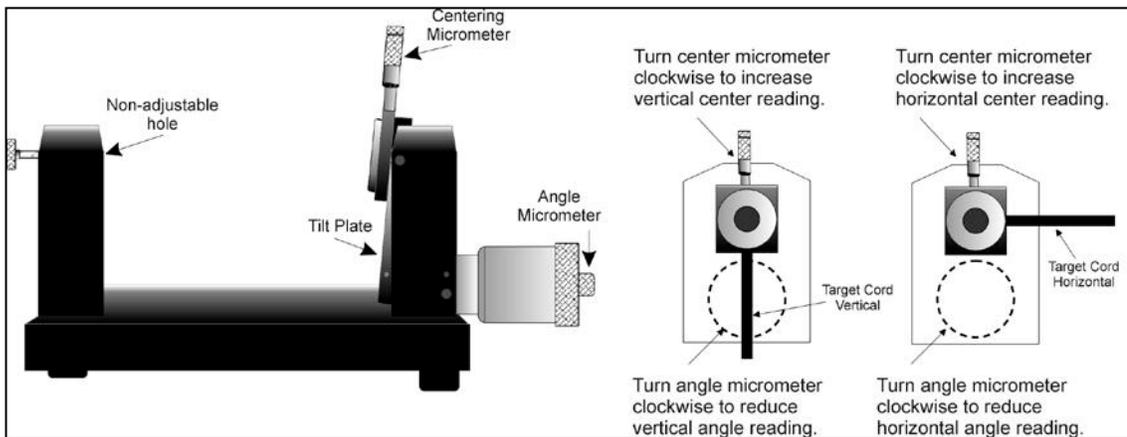


Figure 22—Model A-807 Calibration Mounting Fixture

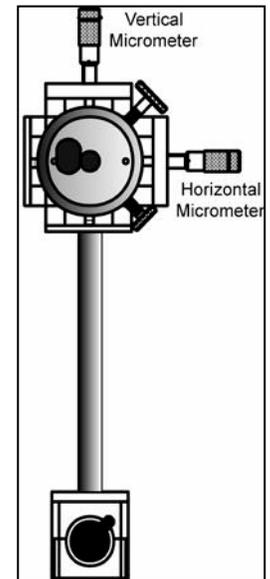


Figure 23—T-230 Target Stand

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 24).

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.

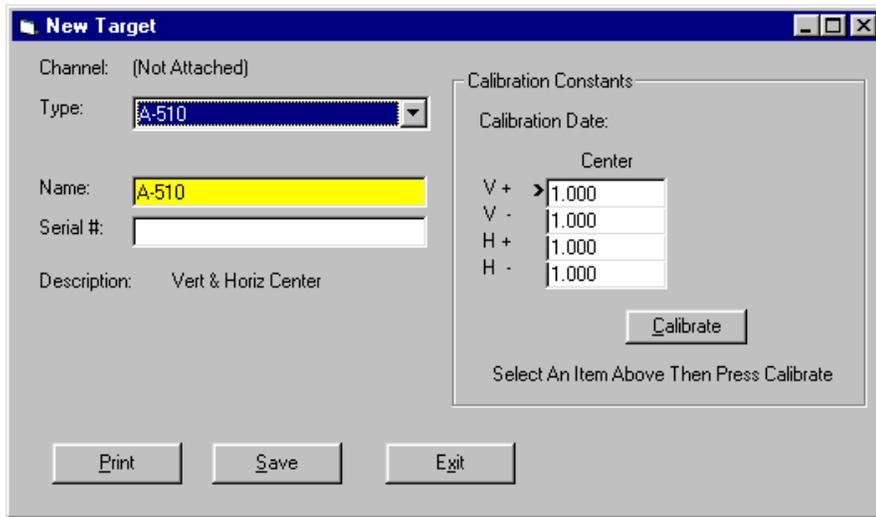


Figure 24—New Target Screen—2-axis Target

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).

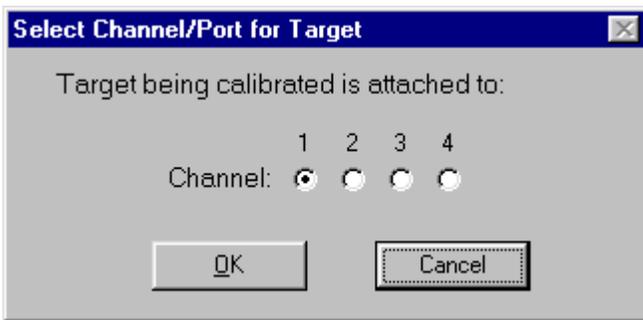


Figure 25—Channel/Port Selection Screen

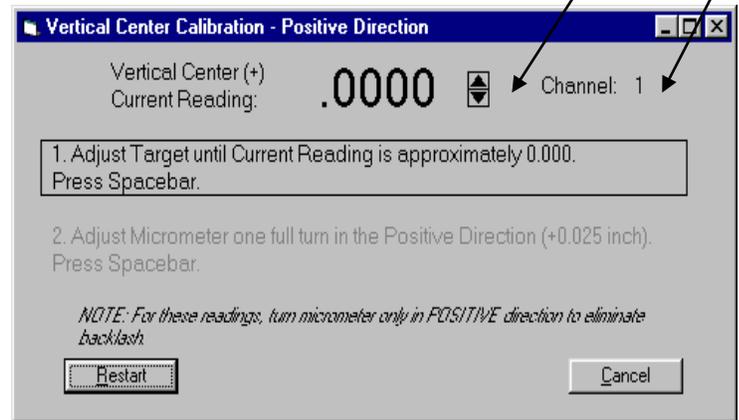


Figure 26—Calibration Screen

The Select Channel/Port for Target menu displays (see Figure 25). 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 26).

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 26).
- 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 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. **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.

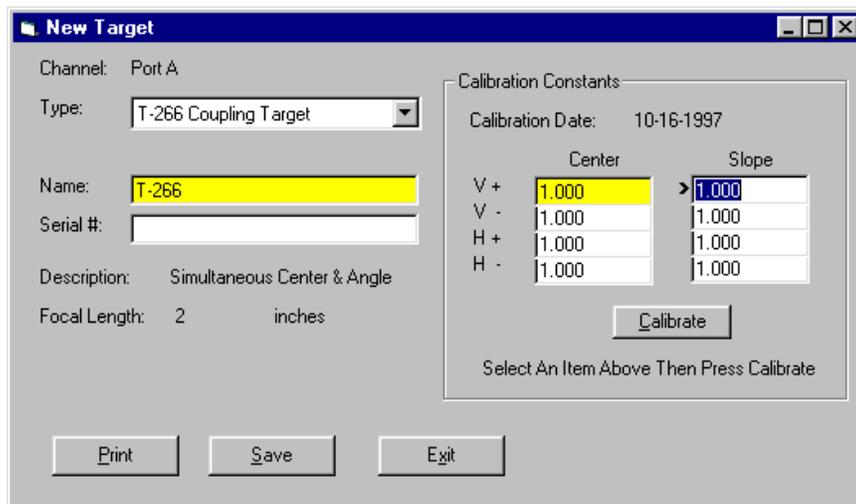


Figure 27 – New Target Screen – 4-axis Target

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>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.
3	<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.
4	<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. • Ensure that ACTUAL TARGETS is selected under the DATA SOURCE tab in TARGET SETUP. • Check for kinks in the cables. • Extremely bright light shining on the face of the target may cause the display to go blank.
5	<i>OFF TGT shows in target display</i>	<ul style="list-style-type: none"> • 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.
6	<i>Numbers in the target display "jump"</i>	<ul style="list-style-type: none"> • In TARGET SETUP, ensure that ACTUAL TARGETS (not RANDOM DATA) is chosen under the DATA SOURCE tab.
7	<i>Numbers in target display are noisy (jump up/down by more than 0.002 mm in 2 m)</i>	<ul style="list-style-type: none"> • 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 unplugging computer. • Check laser and target mounting setups to ensure tight clamp. • Increase data averaging in software.
8	<i>Software crashes when loading</i>	<ul style="list-style-type: none"> • Ensure USB/serial converter cable is connected to the laptop.
9	<i>Either no negative or positive readings are displayed</i>	<ul style="list-style-type: none"> • 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.
10	<i>Very odd results display</i>	<ul style="list-style-type: none"> • Make sure the screws on target connector are tightened on the R-358.
11	<i>Live readings do not display in Spindle8 Software</i>	<ul style="list-style-type: none"> • Open the Windows Control Panel and select the DISPLAY icon. Click the APPEARANCE tab. Ensure that the Color Scheme is set to DEFAULT (blue).

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.