



L-700 Spindle Alignment System

Operations Manual

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**HAMAR
LASER®**
ALIGN WITH THE BEST

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Introducing the L-700 Spindle Alignment System

The L-700 Spindle Alignment System is a complete alignment system for single or dual spindles. A laser and target are mounted between the spindle and the master part. The laser projects a beam. The center and angle of the laser beam in respect to the target determine the misalignment. The target is connected through an interface to a computer running the Lathe9 software, which provides a real-time graphic display of the alignment process. Lathe9 software is offered as a standalone program. The software runs on any Pentium PC-compatible computer running Microsoft Windows.

System Features

- **Complete Spindle Alignment System**
The spindle alignment system includes the laser, target, computer interface and software and a storage case.
- **Single or Dual Spindle Capability**
The spindle alignment system aligns single spindles or dual spindle heads.
- **Step-through Checklist**
The Lathe9 software uses an easy-to-follow checklist, with illustrations and step-by-step instructions prompting the user for information to complete each stage of spindle alignment.
- **Dynamic Misalignment Display**
The real-time display moves, showing changes in alignment as they are made.
- **Manual Data Mode**
The Lathe9 software has a manual data mode that allows the program to run without being hooked up to the alignment hardware. This simulation allows the user to become familiar with the software before performing an actual alignment.
- **Comprehensive Reporting Function**
Generate and save reports that include collected data and graphical views of the alignment. Reports can be modified and printed.
- **User-Definable Tolerances**
Alignment tolerances can be as tight or relaxed as the user requires for accuracy or speed. Accuracy assures precision and longer tool life; speed allows less downtime for repairs.



Figure 1 – Spindle Alignment System

Hardware Overview

This section provides a description of the hardware used in spindle alignment. The laser and target are factory-qualified and calibrated and require no adjustments by the user.

Model L-700 Spindle Laser

The Model L-700 Laser is a low-power, Class II visible light laser designed to mount in the spindle of a machine tool to project its axis of rotation during alignment. Vertical and horizontal controls on the front allow the user to fine-adjust the laser angle and center to the spindle's precise axis of rotation. The visible beam makes coarse alignment much easier, requiring no viewing devices. A simple shutter on the front closes off the beam for safety. The L-700 is designed for applications where the distance between target and laser is approximately 30 ft. (9.1 m). The L-701, which is identical in appearance and function to the L-700, has a slight modification to the beam pointing mechanism which allows finer angular adjustment over long distances, extending the adjustment operating range to 100 ft. (30.5 m).



Figure 2 – L-700 Spindle Laser

Built-in levels on the top and bottom provide easy indexing when inverting for error correction readings. Other features include a shutter to protect the optics and an LED to indicate when the beam is on. Power is provided to the laser by a standard 9V battery for up to 8 hours of operation. A 0.5 in. (12.7 mm) mounting stud simplifies fixturing and can be removed to adapt the unit to custom fixtures or other alignment applications.

These compact, self-contained lasers run for up to 8 hours on a standard, replaceable 9-volt battery, eliminating wires and external power sources. They measure 4 in. long, 3 in. high, and 1.75 in. wide, and their durable aluminum case and stainless-steel mounting stud are made to withstand the most demanding shop floor environments.

The L-700 and L-701 work with any Hamar Laser target, readout, or interface. They can be used for many types of alignment jobs, including spindle and bore alignment, and measuring and correcting the alignment of a workpiece on the machine.

Applications include:

- Transfer-line spindles
- Rotary dial machines
- Boring bars
- Turning applications (cylindrical, OD/ID grinders, lathes)
- Twin-barrel extruders

Features:

- Simple fixturing for mounting the laser and target.
- Mounts in the spindle to project its axis of rotation, allowing even the largest transfer line machines to be aligned quickly and effortlessly.
- Vertical and horizontal controls on the front for both angle and center for fine-adjustment of laser to spindle axis of rotation.
- Targets provide live measurement data in 4 axes (vertical and horizontal angle and center).
- Visible-light beam aids setup.
- Runs for up to 8 hours on a standard, replaceable 9-volt battery.

Laser Controls

The On/Off Switch

The laser has a small ON/OFF switch, located on the bottom of the laser housing behind the lower bubble level (see Figure 3). When the laser beam is switched on, the red LED on the faceplate lights up to safely indicate that the unit is powered on.

The Shutter Control

The shutter control closes off the laser beam to protect the user from accidental eye contact with the beam. It also protects the laser's lens from dust or damage. The shutter control is a simple slotted screw head on the lower left side of the faceplate (see Figure 4). Use a straight-edge screwdriver to open or close the shutter.

Centering and Angular Adjustments

The laser also has centering and angular adjustments on the faceplate. The beam is emitted from the large hole in the center. Figure 4 shows the location of the various adjustment screws.

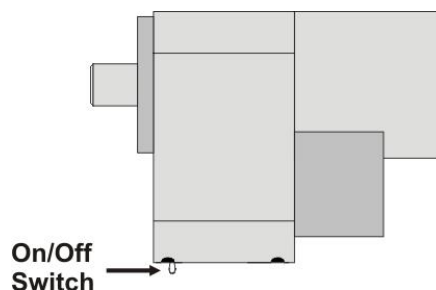


Figure 3 – On/Off Switch

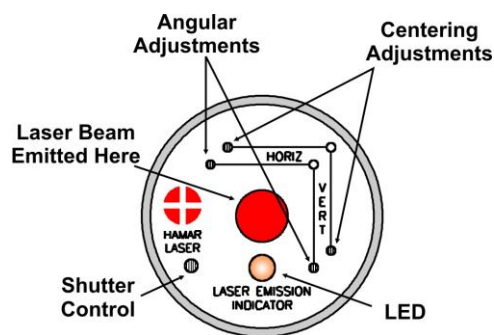


Figure 4 – Shutter Control and Adjustments

Replacing the Battery

The L-700 and L-701 Lasers use a standard, replaceable 9-volt battery for up to 8 hours of continuous use. For best results, use alkaline or rechargeable nickel-cadmium (NiCad) batteries.

To install or replace the battery:

1. Remove the battery cover.

Using the 3/32 in. hex key included with the laser, loosen the two hex screws on either side of the bubble level. The screws do not need to be removed.

2. Slide the cover out.

Pull the cover straight out of the laser to access the battery.

3. Replace the battery.

Remove the battery (rock it gently from side to side to disconnect it) and replace it with a new 9-volt battery. Make sure the battery is seated in the clips. If the battery won't snap in, check to see if the clips are bent or distorted.

4. Slide the cover on and tighten the screws.

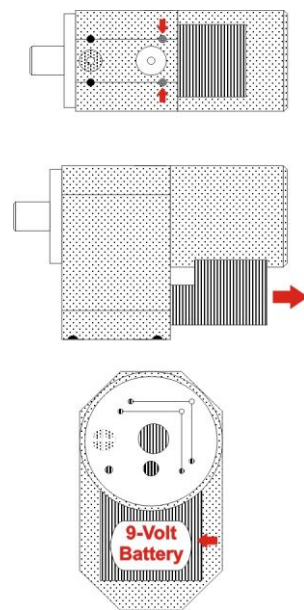


Figure 5 – Replacing the L-700 Laser battery

The T-261A Four-Axis Target

The T-261 Four-Axis Target reads both center and angle (pitch and yaw) simultaneously, allowing a real-time display of misalignment. Readings are accurate to .0001 in/ft. in angle mode and .0001 in in centering. Two bubble levels on the top and bottom make it easy to position when inverting for NORMIN readings (see Appendix A – *The NORMIN Procedure*, beginning on Page 16).

When the target is purchased as part of a system, it is calibrated at the factory before shipping. If the target is purchased separately, the user must calibrate it 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–*Target Calibration*, beginning on Page 22.



Figure 6 – T-261A Four-Axis Target

The R-358 Computerized Interface

The R-358 computer interface provides high accuracy (.00002 in. or 0.0005 mm resolution) for downloading live target data into a computer. It attaches to the computer with an RS-232 cable and is powered by a lithium ion battery for long life and usage and automatically turns on when the target starts taking measurements. An AC adapter/charger is provided, and the unit features "charging" and "power" LED indicators.

Hamar Laser's Alignment Software

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



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

Interpreting the Plus and Minus Signs in the Live Displays

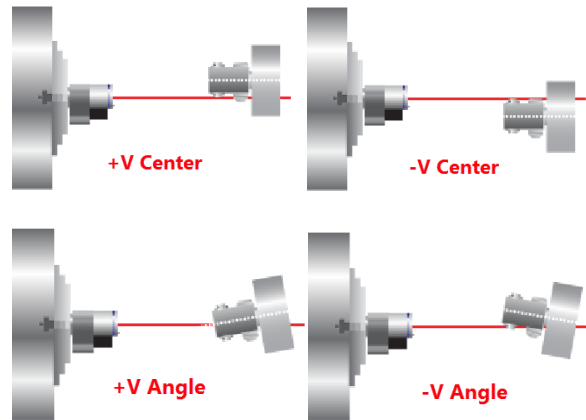
The signs of the data displays indicate the position (high/low or left/right) of the target is relative to the laser beam. See the interpretation below.



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.

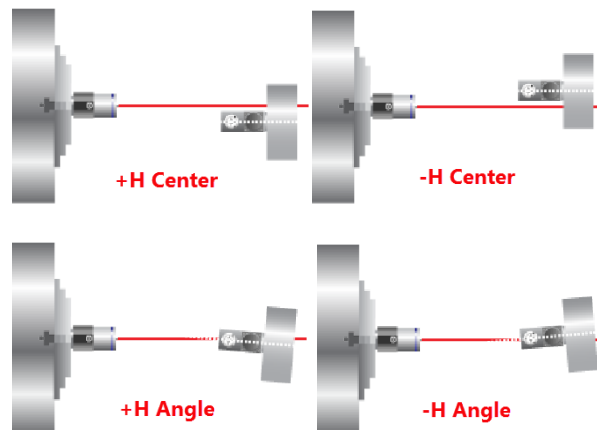


Horizontal Axis

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

With the R-358 Computer interface the resolution of the measurement is .00001 in. (0.00025 mm) for center and .00001 in/ft (0.00083 mm/m) for angle. The L-700 has 4-axis adjustment to align the laser beam to the spindle AOR:

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

In lathe alignment, it is best to use the tailstock or saddle guideways as a reference to align a headstock spindle axis. The L-700 is mounted in the headstock spindle and aligned to the AOR. The T-261 Target is then mounted in the tailstock chuck or in a fixture on the saddle, and then the straightness and flatness of the guideways is measured relative to the L-700 laser. The least-squares, best-fit algorithm is used to calculate the slope of the “best-fit” line for the straightness data. This slope is a measure of the headstock alignment to the lathe guideways.

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

Hardware Mounting

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

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

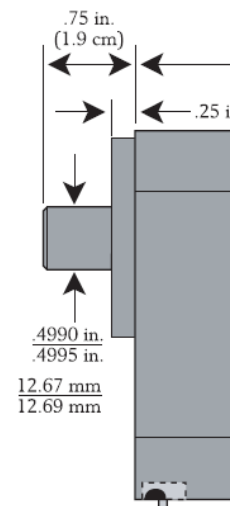


Figure 8 – Mounting Stud

Maintenance and Cleaning

The spindle to be aligned should be checked thoroughly to ensure that it is clean and working properly.

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 and Calibrating Lasers and Targets

Lasers and targets should be qualified before use. In the case of the L-700 Laser, the laser beam needs to be parallel and centered to the axis of its mounting stud. This is done using the A-801 Laser Alignment Fixture, which, when used with Lathe 9 **Step 2: Qualify Laser** aligns the L-700 laser beam to the mounting stud. This is important since it maximizes the L-700 range for each of the four alignment axes adjustments. See Page 10, *Qualifying the L-700 Laser Beam to its Mounting Stud*.

In the case of the target, the T-261 Target qualification means the cell must be centered and perpendicular to the axis of its mounting stud (which is done at the Hamar factory, so the target comes ready to use). Should the target qualification be out of spec, it is normally not a problem due to the NORMIN method used in Lathe9, which cancels out mounting errors of both the fixtures and the target mounting stud.

The T-261 Target must also be calibrated. When purchased as part of a system, target calibration factors are provided. If the target is purchased separately, it should be calibrated before use, which can be done at the factory or in the field 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 22.

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

Warning!!

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

Connecting to the R-358 Computer Interface

Hamar Laser's computer interfaces couple with a portable computer to act as a readout and allow the use of the software to perform calculations, display live laser beam-to-target position information, and plot results. The R-358 attaches to the computer with an USB/RS-232 converter cable and is powered by a lithium ion battery or an AC adapter. The resolution of the measurement is .00001 in. (0.00025 mm).

Important Note – you must install the software driver for the USB cable **BEFORE** plugging in the USB cable into your computer. The driver is located on the same thumb drive as Lathe9 software. Please see Page 9 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. Make all connections with computer power off.

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.

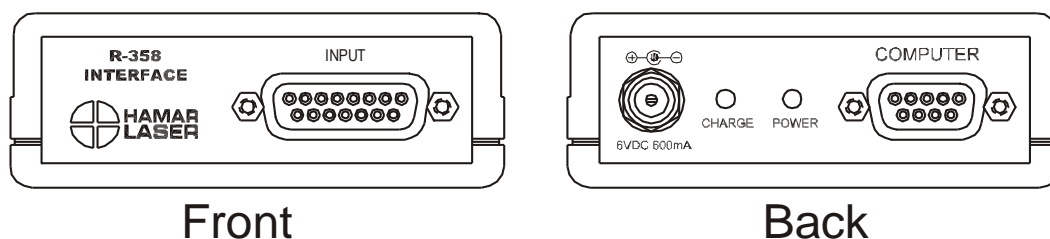


Figure 9 – R-358 Interface Connections

Note: The R-358 is powered on by the software. When you click any of the Lathe9 steps that have live data displays, the R-358 automatically turns on and the green "Power" LED lights.

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

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

3. Power on the computer.

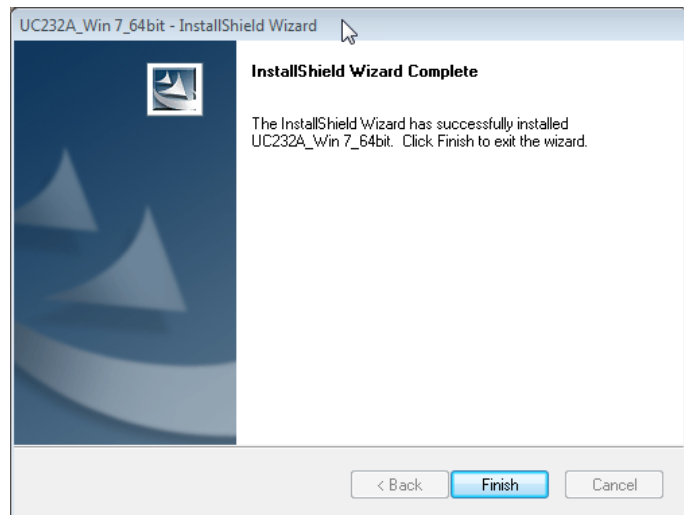
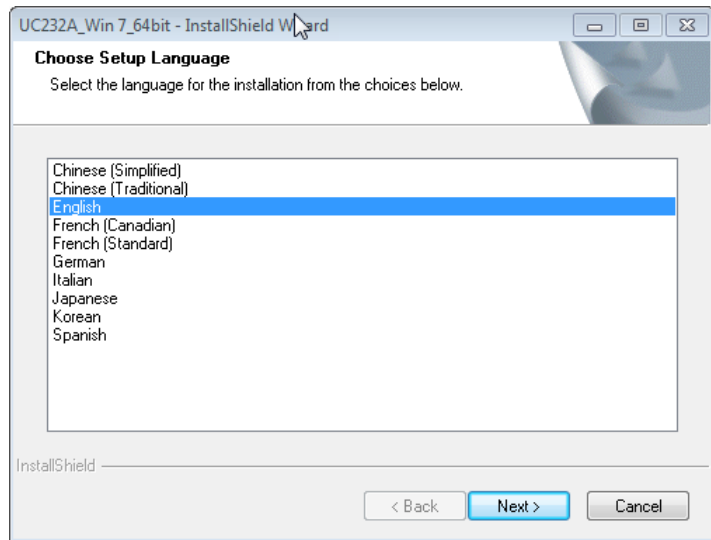
Installing the (RS-232) USB to Serial Driver

This driver is required for the R-358 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.



Qualifying the L-700 Laser Beam to its Mounting Stud

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

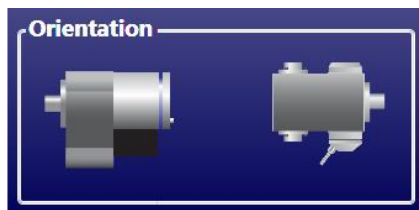
The following procedure is used to qualify the L-700 laser to its mounting stud.

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

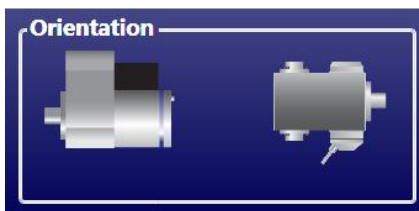
The NORMIN Method

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

To take NORMIN readings, the laser and target fixtures are set in the NORMAl position (cable or switch down) and the readings recorded. Then the target fixture is rotated 180 degrees to the INverted (cable or switch up) position and a second set of readings obtained. With a quick calculation, the two sets of readings are averaged to cancel out both laser and target mounting errors (center and angular) and provide a very accurate result. For a complete discussion of the NORMIN method, see Appendix A, beginning on Page 16.



NORMIN Reading
Laser NORMAl,
Target NORMAl



NORMIN Reading
Laser INverted,
Target NORMAl

Figure 10– Taking NORMIN Readings

Adjustments

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

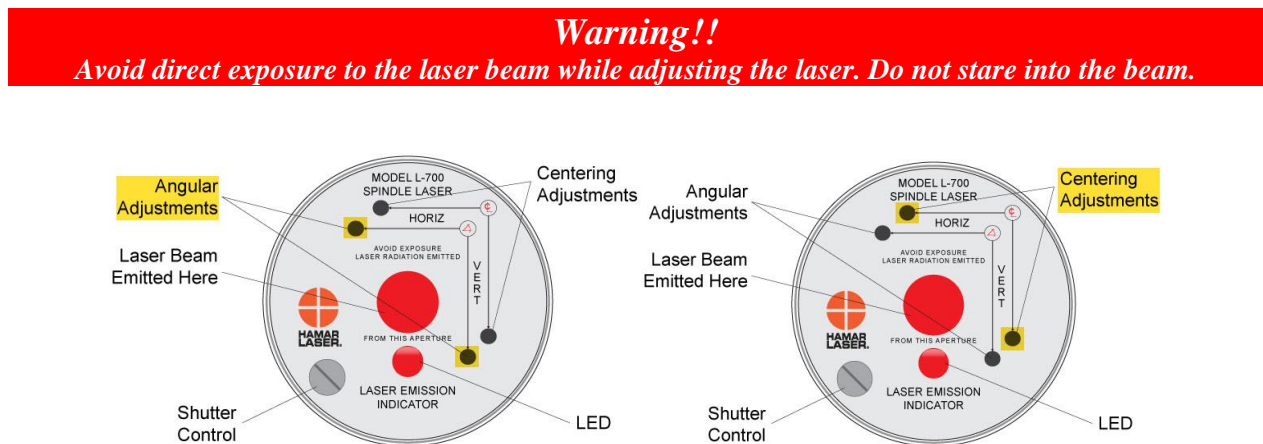


Figure 11– Laser Adjustment Screws

Manual/Software-Assisted Qualification

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

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.

Hardware Requirements

To qualify the L-700 to its mounting stud, the recommend fixture is the A-801 Alignment Fixture or the A-807 Calibration Fixture. You will also need the L-700 Laser, T-261 4-Axis Target, the R-358 Computer Interface and Lathe9, Spindle8 or Read8 software.



Figure 12 - A-801 Alignment Fixture

If using the manual procedure, then you will need two R-1307 readouts, one for the *center* readings and one for the *angular* readings. See Appendix B beginning on Page 18 for the manual procedure.

Qualifying Procedure Using Lathe9 Software

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

Setup

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

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

Important Note – you must install the software driver for the USB cable BEFORE plugging in the USB cable into your computer. Please see Page 9 for details on how to install the driver.

2. Install the L-700/T-261 into the A-801 Fixture.

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

3. Alignment Tolerance

The goal is to align the laser to the mounting stud to the following tolerances:

Center: $\pm .001$ in. (0.025 mm)

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

4. Open Lathe9

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

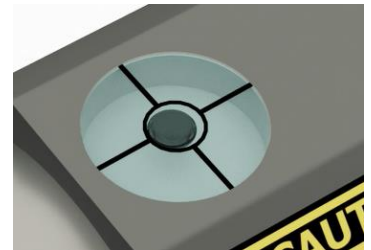
5. Go to Step 2: Qualify Laser

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



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

Rotate the laser to the INverted (switch up) position, with the target in the NORMAl (cable down) position and wait for the readings to stabilize (approximately 5 seconds). Ensure the bubble level is in the center of the circle.



7. Click RECORD.

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



8. Rotate the laser to the NORMAl position.

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



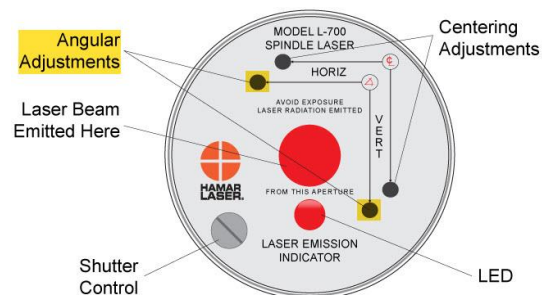
9. Click RECORD.

Click or press **Record** to record the NORMal value. Lathe9 automatically calculates display offsets so you can adjust the four adjustment axes to zero instead of the calculated Set Point. While it is not recommended, if you want to see the raw values, click **Offset** to turn the offsets off. Click **Offset** again to turn them back on.

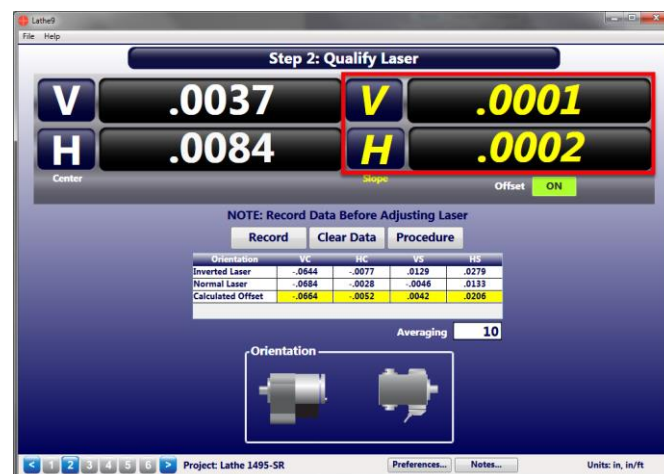
10. Adjust the V and H Angular (slope) adjustment on the L-700 until the Slope values in the Step 2 display are within $\pm .0002$ in/ft (0.015 mm/m) of zero.

Warning!!

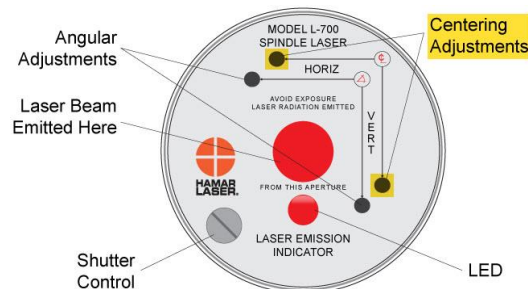
If the adjustments start getting tight or very loose, STOP! You might cause some damage to the laser adjustments if you turn them too far. The adjustments have about 3 full turns in either direction before they run out of range. If you run out of range, then there is likely a problem with the fixture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



Here are the L-700 V & H Slope values in tolerance.



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



Here are L-700 V & H Center values in tolerance.

Since the *Center* values were adjusted, the *Angular* values should not change or change very little.

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

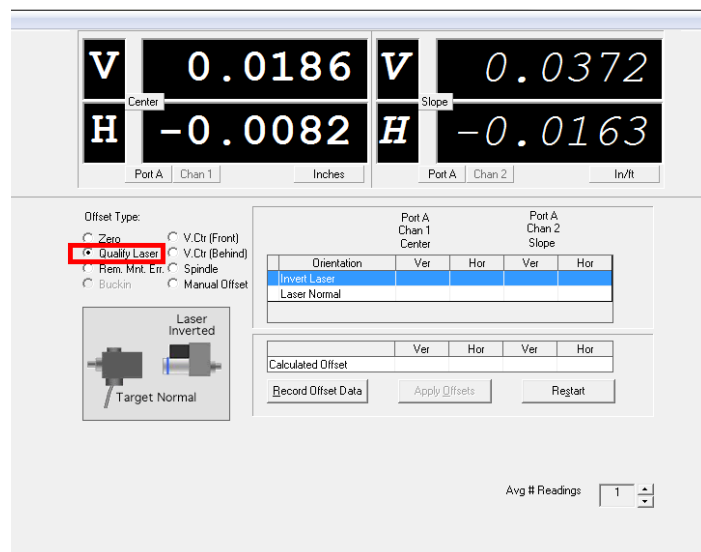
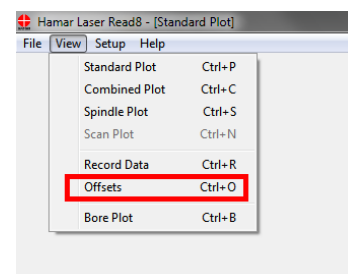
12. Repeat Steps 5-9 to verify the laser is aligned to the L-700 mounting stud.

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

Note on Using Read8 for this procedure.

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

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



Appendix 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 13.

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.

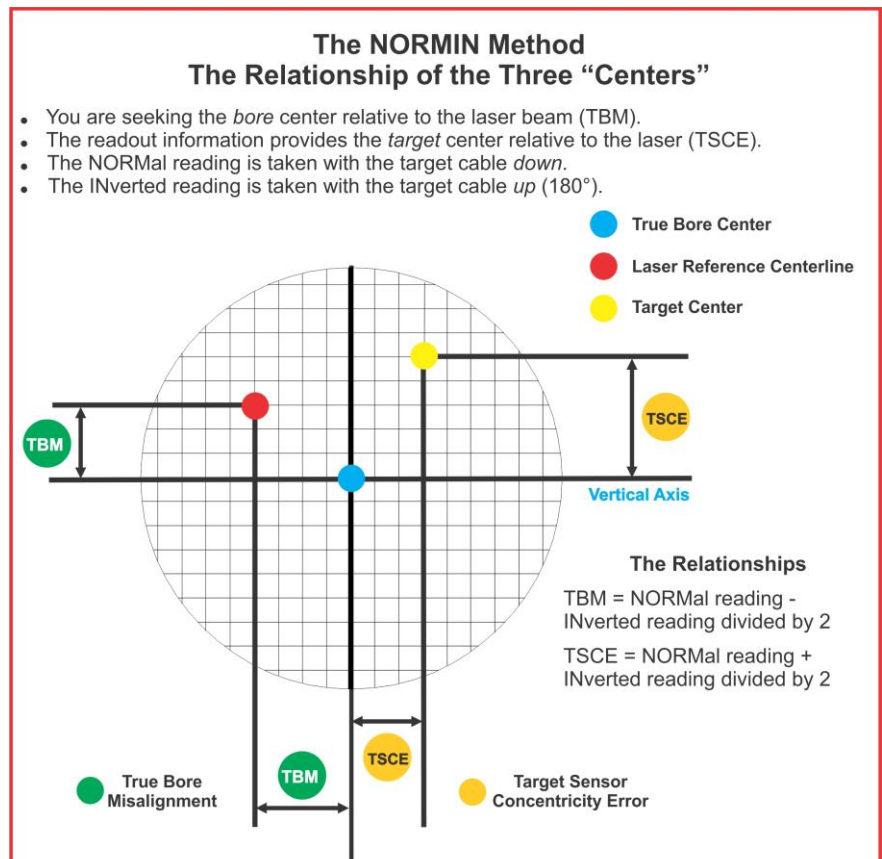


Figure 13 -- Three centers of bore alignment

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 14 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.).

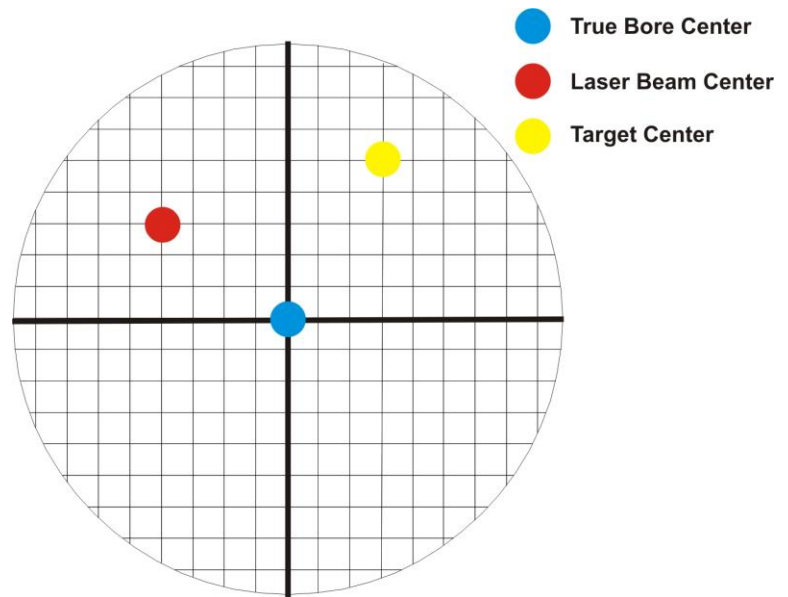


Figure 14 – Target in the NORMAl position

Figure 15 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 15, 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.

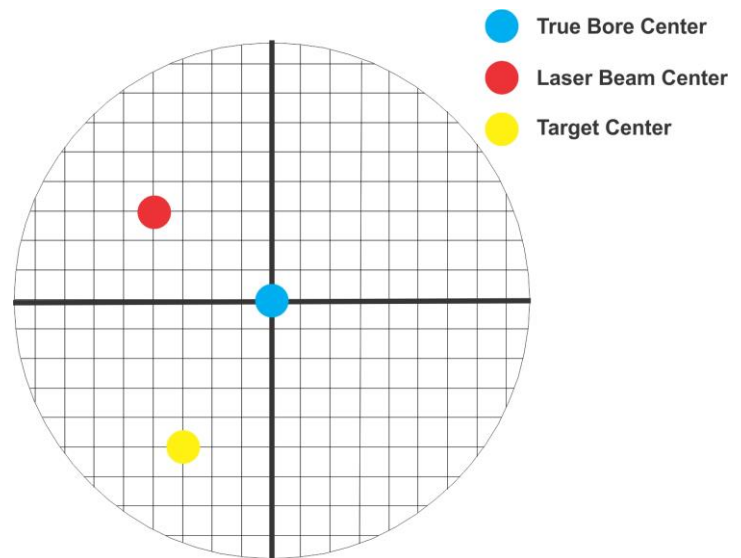


Figure 15 – Target in the INverted position

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

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

All Hamar lasers are factory qualified to the mounting stud axis. Sometimes, due to slight mounting errors, it is desirable to adjust a laser so that it is aligned to the spindle axis of rotation rather than to its own. A laser that has been qualified for a particular application may need to be re-adjusted for another. The following procedure is used to qualify the L-700 laser to a desired axis.

Warning!!

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

The NORMIN Method

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

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

For a detailed description of the NORMIN method, see Appendix A – *The NORMIN Method*, beginning on Page 16.

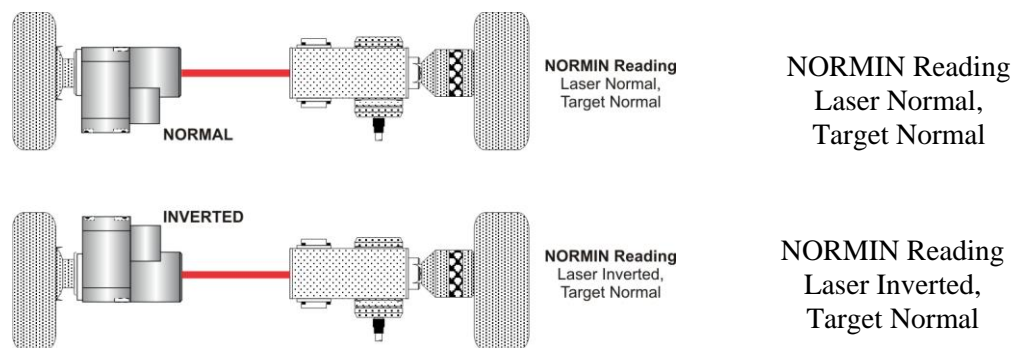


Figure 16 – Taking NORMIN Readings

Adjustments

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

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

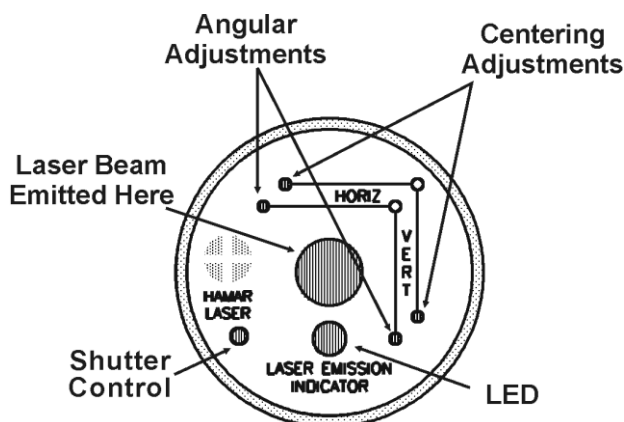


Figure 17 – Laser Adjustment Screws

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-700 laser, and the spindle or fixture to hold the laser and target. To measure both the angle and center, a two-axis target with an angle module (the T-212) or a four-axis simultaneous target (such as the T-261A) is required. If the laser is being qualified to its own mounting stud axis of rotation, the recommended fixture is the Hamar Laser Model A-801 alignment/calibration fixture.

Each method also has its own additional requirements. The manual procedure requires a readout. The software-assisted procedure requires a computer and interface and Lathe9, Spindle8 or Read8 software.

Manual Qualifying Procedure

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

Setup

1. Connect the target to the readout.

Plug the target into the readout and switch on the readout.

2. Set the laser and target in the spindle or fixture.

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

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

Adjusting the Laser Angle

1. INvert the laser with the target in the NORMal position.

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

2. Rotate the laser to the NORMal position.

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

3. Calculate set points for each axis.

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

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

If, for example, the following vertical NORMIN readings are taken:

NORMal = .0021, INverted = -.0017, the equation would read:

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

In this case, .0002 would be the vertical angular set point. Use the two vertical angular readings to calculate the set point for vertical angle. The horizontal angle set points would be calculated in the same way.

4. Adjust vertical and horizontal angle to set points.

Adjust the angle using the angular controls on the laser faceplate until the readout displays the calculated set points.

Adjusting the Laser Centering

1. INvert the laser with the target in the NORMal position.

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

2. Rotate the laser to the NORMal position.

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

3. Calculate set points for each axis.

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

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

If, for example, the following horizontal NORMIN readings are taken:

NORMal = -.0014, INverted = -.0006, the equation would read:

$$[(-.0014) + (-.0006)] / 2 = (-.0020) / 2 = \textbf{-.0010}$$

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

4. Adjust vertical and horizontal center to set points.

Adjust the center using the centering controls on the laser faceplate until the readout displays the calculated set points.

Checking Results

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

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

Appendix C – Target Calibration

Before a new target can be used, it should be calibrated. If the target is purchased as part of a system, it will be calibrated at the factory and the resulting calibration factors will be included with the target.

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

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

Calibration Setup

1. Mount the laser and target.

Note: Figure 18 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 19).

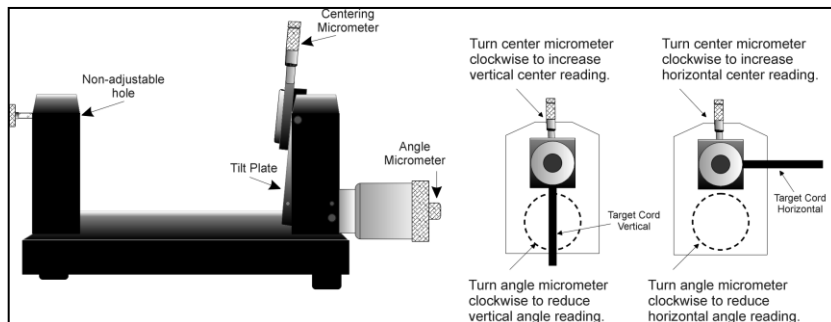


Figure 18 – Model A-807 Calibration Mounting Fixture

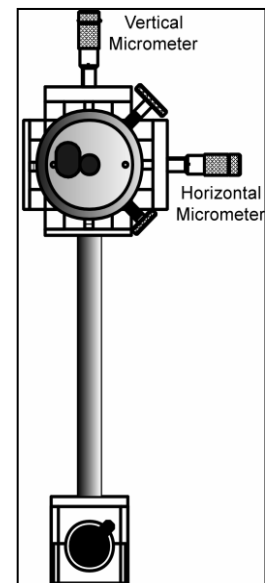


Figure 19 – T-230 Target Stand

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 20). 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.

Center	
V +	1.000
V -	1.000
H +	1.000
H -	1.000

Figure 20 – 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 18). If working with a fixture that has a horizontal micrometer, there is no need to rotate the target (see Figure 19).

The Select Channel/Port for Target menu displays (see Figure 21). Select the channel or the port to which the target is attached and click **OK**. The Calibration Screen displays and indicates the Port or Channel selected (see right arrow in Figure 22).

Target being calibrated is attached to:

Channel: ☒ 1 ☐ 2 ☐ 3 ☐ 4

Figure 21 – Channel/Port Selection Screen

Vertical Center (+) .0000

Channel: 1

1. Adjust Target until Current Reading is approximately 0.000. Press Spacebar.

2. Adjust Micrometer one full turn in the Positive Direction (+0.025 inch). Press Spacebar.

NOTE: For these readings, turn micrometer only in POSITIVE direction to eliminate backlash.

Figure 22 – Calibration Screen

Notes:

- Once the first calibration factor is recorded, the program adds the calibration date to the Calibration Constants screen.
- The double arrows next to the reading are visible only in Manual Data mode and are not available when actual targets are being read (see left arrow in Figure 22).
- 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 22).**

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.**
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 18) 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 18). 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 Figure 20 with Figure 23). 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 22).**
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 18) the target must be rotated 90° before performing a horizontal calibration. If the calibration fixture you are using has two centering micrometers, such as the T-230, the horizontal centering micrometer may be used and there is no need to rotate the target.*
6. **Select the next calibration factor from the Calibration Constants menu, and click the Calibrate button or Press Alt-C.**
Follow Steps 5-9 to obtain the next calibration factor. Repeat this procedure until all the necessary calibration factors have been obtained. *Ensure that the calibration factors for slope are obtained by using the angle micrometer.*
 7. **Save the calibration information.**
When the calibration procedure is completed, click the **Save** button to save the target profile. This target name will now display in the **Select Targets to Use** section of the Target Setup Screen.

New Target

Channel: Port A

Type: T-266 Coupling Target

Name: T-266

Serial #:

Description: Simultaneous Center & Angle

Focal Length: 2 inches

Calibration Constants

Calibration Date: 10-16-1997

	Center	Slope
V +	1.000	1.000
V -	1.000	1.000
H +	1.000	1.000
H -	1.000	1.000

Calibrate

Select An Item Above Then Press Calibrate

Print Save Exit

Figure 23 – 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. • Ensure laser cover is open. • Replace battery. If the battery is new, ensure that it is inserted correctly. • Check for switch damage.
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. • 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"> • Software sees the R-358 interface but not the target. • 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. • 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"> • Possible corrupt targets.ini file (in Windows folder) or Hamar.ini (in Software32 folder). Rename both files. WARNING!! This will delete all target setup and calibration factors. • 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.

Appendix F – Manual Method for Qualifying the Laser to its Mounting Stud

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

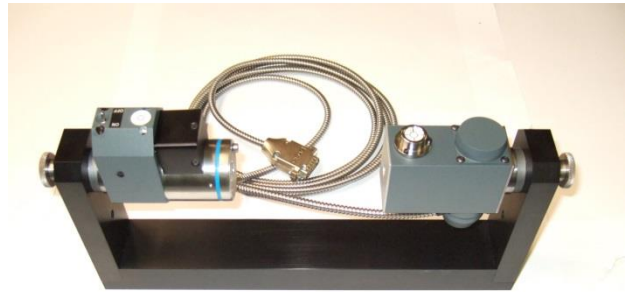
Setup

1. Connect the T-261 Target to 2 R-1307C Readouts using the T-237EL Splitter Adapter Cable

Connect the T-261 to the T-237EL adapter, taking note of the “Angle” and “Center” labels on the two cables. There should be an R-1307C with a “Center” label and another R-1307C with an “Angle” label on it. Make sure to match up the label on the cables to the labels on the readouts. The calibration factors in the readouts are matched to the center or angular axes of the T-261 target. Note it’s a good idea to screw in the set screws on the T-237EL into the connector on the T-261 Target.

2. Install the L-700/T-261 into the A-801 Fixture.

Mount the laser and target in the NORMal position in the A-801 calibration fixture and screw in the thumb screws. Note you do not need to make the thumb screws super tight. Finger tight is good enough. This procedure is only to align the laser to the mounting stud for the next alignment, so there is no need to worry about aligning it to .0001 in. (0.0025 mm).



3. Alignment Tolerance

The goal is to align the laser to the mounting stud to the following tolerances:

Center: .001 in. (0.025 mm)

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

3. Calculate set points for each axis.

Calculate the 4 set points, 1 for each axis:

- V Angle (slope)
- H Angle (slope)
- V Center
- H Center

using the following formula:

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



If, for example, the following vertical NORMIN readings are taken for the V Angle:

NORMal = .0031

INverted = -.0012

the equation would read:

$$(.0021 + (-.0017)) / 2 = (.0004) / 2 = \mathbf{.00095} \text{ (or .0010 rounded up)}$$

In this case, .0010 would be the V Angular Set Point.

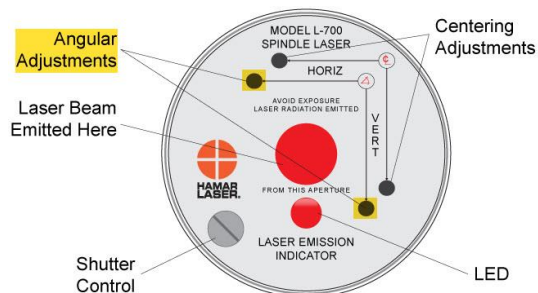
The same calculation is done for the Horizontal Angle, Vertical Center and Horizontal Center, so in all, you should have four Set Points calculated.

5. Adjust the L-700 Vertical and Horizontal *Angular* adjustment to Set Points.

Warning!!

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

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



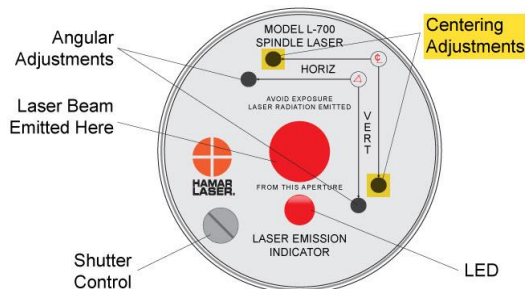
6. Adjust L-700 Vertical and Horizontal *Center* adjustments to equal Set Points.

Adjust the center values using the *Center* controls on the laser's faceplate until the *Center* readout displays the calculated V & H *Center* Set Points.

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

Confirming the Results

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



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