General Training Manual

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STEALTH SERIES™

HAMAR LASER®
ALIGN WITH THE BEST

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An Introduction to Laser Alignment

Laser alignment is a simple and extremely accurate method of aligning machinery. A laser alignment *system* consists of a laser, a target (or targets), and some form of readout (either a hand-held device or a computer interface). The laser provides an intense, narrow beam of light that stays focused over distances of up to 100 ft. The target is a light sensitive cell that can detect the absolute center of the laser beam. When the target is placed in the line of the laser beam, the readout displays the offset between the center of the laser beam and the center of the target cell, either graphically, numerically, or both.

In addition to lasers that produce a *straight* beam of light, Hamar Laser also manufactures laser that produce a continuously sweeping *plane*. These planes are produced by bending a laser beam precisely 90° using an optical penta prism. A laser plane is used for alignment by making it parallel (or "bucked-in") to three reference points or a datum plane, and then using targets to measure deviations from those points. Once the laser is bucked in, any point within range of the laser system (up to a 100 ft. radius (30.5 m)) can be aligned to the reference points.

Hamar Laser's multi-plane lasers, such as the L-733 and L-743, generate up to three ultra-flat laser planes (both horizontal and vertical) and can be used with multiple targets on multiple axes to check alignment. In most cases, this requires only one setup procedure.

Laser "buck-in" refers to the adjustment of a laser plane or line to be parallel to the surface being measured (a tabletop, a surface plate, or a way surface). Three points are required to buck-in a laser plane to a reference surface. Two points are needed to buck-in a straight-line laser to a reference line (i.e., centerline). For most machining centers, the alignment process begins by bucking-in the laser to five reference points, three points using the horizontal laser plane (usually on the machine's table) and two using one of the vertical planes. The two reference points for the vertical plane are usually chosen from either the X or Y straightness motion of the machine. The horizontal plane is measured using vertically mounted targets and the vertical plane uses horizontally mounted targets. The pitch, roll and yaw of the laser planes are adjusted by using adjustment knobs built into the base of the laser.

After bucking in, the target is moved to various points along the surface where it measures deviation from the laser reference plane. For squareness, a target is placed (usually horizontally) on one part of the column and zeroed. The column is then traversed up or down and any deviation becomes a measurement of squareness since the laser plane used for measuring is perpendicular to the reference laser plane.

This manual will cover the four procedures that are necessary to use a Hamar Laser alignment system:

1. Reading and Calibrating the Laser's Precision Level vials
2. Three-Point Buck-In
3. Two-Point Buck-In
4. The NORMIN Procedure

Any alignment you perform consists of one or more of these procedures. This manual will explain these procedures and how to perform them. By fully understanding them, you will be able to align virtually *any* machine, transfer line or production setup. In addition, this manual contains several appendices that cover more advanced procedures and alignments using older Hamar Laser products.

Alignment System Components

Warning!
Always operate the L-730 and L-740 series lasers described below in an upright position.
Do NOT invert!

Lasers

The L-743 Ultra-Precision Triple Scan® Laser

The L-743 Ultra-Precision Triple Scan® Laser is Hamar Laser's most versatile and powerful machine tool alignment laser. It has been designed specifically for 3-5-axis machining centers to measure and correct machine geometry. In most cases, all it takes is one setup to measure flatness, straightness, parallelism and squareness of the main axes of most typical machining centers.

Since the system provides live measurements, any errors that are found can be fixed with the same setup. The laser mounts on a machine or stable base so that the laser plane can project the measurement reference out to 100 ft. (30.5 m) in radius for each laser plane.

Applications: (for alignments with tolerances of .00002 in/ft or 0.0017 mm/m or greater)

- Machining centers (HBMs, VBMs, HMCs, VMCs, VTLs, gantries and surface grinders)
- Automotive transfer-line wing bases
- Injection molding machines and presses
- Aircraft assembly (seat track alignment, setting water, butt and station planes, wing-to-body and body-to-body join alignment, etc.)

Roll parallelism in:

- High-precision, laser and water-jet cutting machines
- Circuit board drilling machines
- Paper mills
- Printing presses
- Film lines
- Blown-film lines

Measuring and aligning:

- The flatness of almost any surface (squares, frames, ways, flanges, circles, etc.)
- The squareness of up to 3 surfaces
- Measuring surfaces up to 200 ft. (61 m) long with one setup
- The parallelism of horizontal and vertical surfaces up to 100 ft. (30.5 m) apart
- Checking way twist and parallelism between horizontal surfaces
- The straightness of horizontal and vertical surfaces
- The straightness and flatness of horizontally and vertically traversing axes
- Checking plumb of a vertical surface up to 100 ft. (30.5 m)
- Checking way twist and parallelism between vertical surfaces

Features

- 3 continuously rotating laser planes with operational range of 100 ft. (30.5 m) in radius.
- Instant on with virtually no warm-up
- Top-to-Back and Top-to-Side Laser Planes are square to 1 arc sec (.00006 in/ft or 0.005mm/m).
- Side-to-Back Laser Planes are square to 3 arc sec (.00018 in/ft or 0.015mm/m).
- Standard levels are accurate to 2 arc second (.00012 in/ft or 0.01 mm/m).
- Split-Prism Upgrade Levels are accurate to 1 arc second (.00006 in/ft or 0.005 mm/m).
- Targets provide live data display
- Standard target: A-1519-2.4ZB Single-Axis Wireless Target with 0.5 micron (.000002 in.) resolution
- Uses A-1520-2.4ZB Single-Axis Wireless Target with 0.25 micron (.000001 in.) resolution for higher accuracy applications.
- Laser and targets fit into a small, portable shipping case
- M-124-LiPo 9V Lithium Polymer Rechargeable Battery Pack or 110-240V A/C 9V Adapter
- Laser planes flat to ½ arc seconds (.00003 in/ft or 0.0025mm/m) in 180º sweep and ¼ arc second (.000015 in/ft or 0.0008mm/m) in 90º sweep).
- Includes Pitch/Roll/Yaw base with coarse and fine adjustments and lighted levels.
- System uses Windows-based software for quickly recording and analyzing machine geometry data
- Typical setup time 20 minutes or less

The L-733 Precision Triple Scan® Laser

The L-733 Triple Scan Laser was specifically designed for machining centers to measure and correct machine geometry. It has all of the innovative and highly useful features of the L-743 Ultra-Precision Triple Scan Laser, with lower accuracy and a medium adjustment base. It is very useful for checking the alignment of large fabrications or aligning large airplane sections in aircraft manufacturing.

In most cases, all it takes is one setup to measure flatness, straightness, parallelism and squareness. Since the system provides live measurements, any errors that are found can be fixed with the same setup. The laser mounts on a machine or stable base so that the laser plane can project the measurement reference out to 100 ft. (33 m) in radius for each laser plane.

Applications: (for alignments with tolerances of .0005 in/ft or (0.038 mm/m) or greater)

- Machining centers (HBM, VBM, VTL, VMC, HMC, gantries, surface grinders)
- Checking the alignment of large bearing surfaces and fabrications
- Aircraft assembly (seat track alignment, setting water, butt and station planes, wing-to-body and body-to-body join alignment, etc.)
- Water jet and laser cutting machines
- Leveling machine beds and ways
- Roll alignment (rubber, steel, textile and lower accuracy film lines)
- Sawmills
- Vertical press alignment

Measuring and aligning:

- The flatness of almost any horizontal or vertical surface (squares, frames, ways, flanges, circles, etc.) or axes
- The squareness of any 2 vertical surfaces or axes
- Way twist and parallelism between vertical or horizontal surfaces
- Way twist and parallelism between vertical or horizontal surfaces
- Checking plumb of a vertical surface up to 100 ft. (33 m)
- The straightness of vertical and horizontal axes
- Measuring surfaces up to 200 ft. (66 m) long with one setup
- The parallelism of vertical or horizontal surfaces up to 100 ft. (33 m) apart
- The squareness of any vertical machine axis or surface to horizontal axis or surface

Features:

- Continuously rotating laser planes with operational range of 100 ft. (33 m) in radius.
- Standard target: A-1519-2.4ZB Single-Axis Wireless Target with 0.5 micron (.000002 in.) resolution
- System uses Windows-based software for quickly recording and analyzing machine geometry data
- Typical setup time 20 minutes or less
- Laser planes flat to 2 arc seconds in 180º sweep and 1 arc-second in 90º sweep.
- Top-to-Back and Top-to-Side Laser Planes are square to 2 arc sec (.00012 in/ft or 0.01mm/m).
- Side-to-Back Laser Planes are square to 3 arc sec (.00018 in/ft or 0.015mm/m).
- Includes Pitch/Roll/Yaw base with medium-resolution adjustments and lighted levels. Levels accurate to 2 arc seconds.
- M-124-LiPo 9V Lithium Polymer Rechargeable Battery Pack or 110-240V A/C 9V Adapter

The L-742 Dual Scan® Ultra-Precision Roll Alignment Laser

With two continuously sweeping, ultra-flat, orthogonal laser planes, the L-742 Dual Scan® Laser is ideally suited to roll alignment applications. The laser can be configured at the factory to have either 2 vertical planes (typically used for roll alignment), or 1 horizontal and 1 vertical plane, allowing a user to not only measure, but also fix alignment problems in a fraction of the time needed with conventional methods.

Using the L-742 you can quickly and easily check and correct horizontal roll parallelism of even the tallest process mills, pick up and check offset centerline benchmarks, and perform similar alignments with increased accuracy and shorter setup times.

Applications: (for alignments with tolerances of .00002 in/ft or 0.0017 mm/m or higher)

- Roll parallelism in paper mills, printing presses and film lines
- Roll forming machines
- High-precision, laser and water-jet cutting machines
- Measuring surfaces up to 200 ft. (61 m) long with one setup
- Circuit board drilling machines
- Leveling almost any surface (squares, frames, ways, flanges, circles, etc.
- Checking plumb of a vertical surface up to 100 ft. (30.5 m)
- Checking way twist and parallelism between surfaces

Measuring and aligning:

- The flatness and straightness of almost any surface (squares, frames, ways, flanges, circles, etc.)
- The parallelism of vertical or horizontal surfaces, even if those surfaces are 100 ft. (30.5 m) apart
- The flatness and straightness of horizontally and vertically traversing axes
- The squareness of any 2 surfaces
- The flatness and straightness of vertical surfaces

Features

- Continuously rotating laser planes with operational range of 100 ft. (33 m) in radius.
- Standard target: A-1519-2.4ZB Single-Axis Wireless Target with 0.5 micron (.000002 in.) resolution
- Standard levels are accurate to 2 arc second (.00012 in/ft or 0.01 mm/m).
- Split-Prism Upgrade Levels are accurate to 1 arc second (.00006 in/ft or 0.005 mm/m).
- System uses Windows-based software for quickly recording and analyzing machine geometry data
- Typical setup time 20 minutes or less
- Laser planes flat to 0.5 arc seconds in 180º sweep and 0.25 arc-second in 90º sweep.
- Top-to-Back Laser Planes are square to 1 arc sec (.00006 in/ft or 0.005 mm/m).
- Side-to-Back Laser Planes are square to 3 arc sec (.00018 in/ft or 0.015mm/m).
- Includes Pitch/Roll/Yaw base with fine and medium-resolution adjustments and lighted levels.
- M-124-LiPo 9V Lithium Polymer Rechargeable Battery Pack or 110-240V A/C 9V Adapter

The L-732 Dual Scan® Precision Roll Alignment Laser

Primarily designed for roll alignment and other similar alignment applications that do not require the exacting tolerances of the L-742 Ultra-Precision Dual Scan® Laser, the L-732 Precision Dual Scan® Laser also offers 2 automatically rotating laser planes that can be configured at the factory to have either 2 vertical planes (typically used for roll alignment), or 1 horizontal and 1 vertical laser plane.

Using the L-732 you can quickly and easily check and correct horizontal roll parallelism of even the tallest process mills, pick up and check offset centerline benchmarks, and perform similar alignments with increased accuracy and shorter setup times.

Applications: (for alignments with tolerances of .00015 in/ft or (0.01 mm/m) or greater

- Normal or blown-film lines (roll alignment)
- Rubber (roll alignment)
- Laser cutting machines
- Water-jet cutting machines
- Steel (roll alignment)
- Sawmills
- Textiles (roll alignment)
- Leveling almost any surface (squares, frames, ways, flanges, circles, etc.
- Checking plumb of a vertical surface up to 100 ft. (30.5 m)
- Checking way twist and parallelism between vertical surfaces

Measuring and aligning:

- The flatness of almost any vertical surface (squares, frames, ways, flanges, circles, etc.)
- The parallelism of vertical or horizontal surfaces, even if those surfaces are 100 ft. (30.5 m) apart
- Measuring surfaces up to 200 ft. (61 m) long with one setup
- The straightness of horizontally and vertically traversing axes
- The squareness of any two vertical surfaces
- The flatness and straightness of vertical surfaces

Features

- Continuously rotating laser planes with operational range of 100 ft. (33 m) in radius.
- Standard target: A-1519-2.4ZB Single-Axis Wireless Target with 0.5 micron (.000002 in.) resolution
- Standard levels are accurate to 2 arc second (.00012 in/ft or 0.01 mm/m).
- Split-Prism Upgrade Levels are accurate to 1 arc second (.00006 in/ft or 0.005 mm/m).
- System uses Windows-based software for quickly recording and analyzing machine geometry data
- Typical setup time 20 minutes or less
- Laser planes flat to 2.0 arc seconds in 180º sweep and 1.0 arc-second in 90º sweep.
- Top-to-Back Laser Planes are square to 2 arc sec (.00012 in/ft or 0.01mm/m).
- Side-to-Back Laser Planes are square to 3 arc sec (.00018 in/ft or 0.015mm/m).
- Includes Pitch/Roll/Yaw base with fine and medium-resolution adjustments and lighted levels.
- M-124-LiPo 9V Lithium Polymer Rechargeable Battery Pack or 110-240V A/C 9V Adapter

The L-730 Precision Leveling Laser

Different applications require different levels of accuracy, which is why we developed two accuracy levels for our leveling lasers.

The L-730 Precision Leveling Laser is ideal for precision-level work where tolerances are not as critical, such as simple fabrication alignment checks, fabrication machinery beds, soles plates, etc.

Features

- Flatness capability to .00006 in/ft. (0.005 mm/m) in 90 degree sweep
- Standard leveling capability of .00018 in/ft (0.015 mm/m)
- 100 ft. (30 m) radius operating range
- Pitch/Roll Coarse Adjustment Base with coarse tilt resolution of .010 in. in 100 ft. (0.25 mm in 30 m)

Applications

- Fabrication machinery beds and guideway
- Sole plates
- Platen parallelism (small presses and injection molding machines
- Tablet glass flatness

Capabilities

- Flatness single and interrupted surfaces
- Levelness
- Parallelism vertical/horizontal surfaces
- Straightness
- Machine bed guideway twist
- Pitch and roll angular measurements

The L-740 Ultra-Precision Leveling Laser

The L-740 Ultra-Precision Leveling Laser is our most accurate and ultra-precise laser. The L-740 is used for more demanding "mission critical" tasks, such as: leveling machining centers, gantries, large-bed lathes, surface plates, presses, turbine split joints, etc. where the four times greater accuracy is required.

Features

- Flatness capability to .000015 in/ft. (0.0013 mm/m) in 90 degree sweep
- Split-Prism leveling capability of .00006 in/ft (0.005 mm/m) with upgrade
- 100 ft. (30 m) radius operating range
- Pitch/Roll Coarse/Fine Adjustment Base with coarse tilt resolution of .010 in. in 100 ft. (0.25 mm in 30 m) and fine tilt resolution of .001 in. in 100 ft. (0.025 mm in 30 m)

Applications:

- Machine tool guideways
- Surface Plates
- Sole plates
- Steam turbine split joints
- Platen parallelism – large presses and injection molding machines
- Tablet glass flatness

Capabilities

- Flatness single and interrupted surfaces
- Levelness
- Parallelism vertical/horizontal surfaces
- Straightness
- Machine bed guideway twist
- Pitch and roll angular measurements

The L-741 Ultra-Precision Leveling Laser with Plumb Beam

For customers with limited budgets, the L-741 Ultra-Precision Leveling Laser with Plumb Beam is a good choice for measuring many different applications. It features a continuously sweeping, ultra-flat, laser plane with a perpendicular plumb beam for not only measuring, but also fixing alignment problems in a fraction of the time needed with conventional methods.

Features

- Continuously rotating laser planes with optional range of 100 ft. (33 m) in radius.
- Standard target: A-1519-2.4ZB Single-Axis Wireless Target with 0.5 micron (.000002 in.) resolution.
- Standard levels are accurate to 2 arc seconds (.00012 in/ft or 0.01 mm/m).
- Split-Prism Upgrade Levels are accurate to 1 arc second (.00006 in/ft or 0.005 mm/m).
- System uses Windows-based software for quickly recording and analyzing machine geometry data.
- Typical setup time 20 minutes or less.
- Laser planes flat to 0.5 arc seconds in 180 degree sweep and 0.25 arc second in 90 degree sweep.
- Plumb laser beam is square to the scan plane to 1 arc sec (.00006 in/ft or 0.005 mm/m).
- Includes Pitch/Roll/Yaw base with fine and medium-resolution adjustments and lighted levels.
- Optional M-124 LiPo 9V Lithium Polymer Rechargeable Battery Pack or included 110-240V A/C 9V Adapter.

Applications:

- Machining centers, gantries and boring mills.
- Measuring surfaces up to 200 ft. (61 m) long with one setup
- Leveling almost any surface (squares, frames, ways, flanges, circles, etc.
- Checking plumb of a vertical surface up to 100 ft. (30.5 m)
- Checking way twist and parallelism between surfaces

Measuring and Aligning

- Flatness and straightness of almost any surface (squares, frames, ways, flanges, circles, etc.
- Parallelism of horizontal surfaces, even if those surfaces are 100 ft. (30.5 m) apart
- Flatness and straightness of horizontally and vertically transversing axes
- Squareness of any two surfaces
- Flatness and straightness of vertical surfaces

Targets

***Note:** The targets discussed in this section can easily be converted to a height gage, as the center of the target cell is set to a known distance from the bottom of the target housing. By attaching precision spacers to the base of the target, the exact dimension from the laser plane to the measured surface can be obtained. These precision spacers are available in 1 in. (25.4 mm), 2 in. (51 mm), 3 in. (76 mm) and 6 in. (154 mm) sizes, all of which are accurate to .0003 in. (0.008 mm).*

A-1519-2.4ZB and A-1520-2.4ZB Single-Axis Wireless Targets

The A-1519-2.4ZB Single-Axis Wireless Target provides wireless communication with a ±.5 in. (±12 mm) measuring range, an electronic "zero" function and an indoor operating range of 100 ft. (30.5 m) from laser to target. The targets feature a resolution of .00002 in. (0.0005 mm), a fully linearized, position-sensitive detector with automatic background-light correction, automatic on/off operation (laser turns it on), and an on-target indicator.

The A-1519 is linearized to within ±.00015 in. (±0.0038 mm) over the useful range of the target. These targets can easily be converted to a height gage, as the center of the target has been set to a tightly controlled dimension. Attach the 2.565 in. (65.15 mm) spacer to the base of the target and the exact dimension from laser plane to the measured surface can be obtained. Optional precision spacers are available in 1 in. (25.4 mm), 2 in. (51 mm), 3 in. (76 mm) and 6 in. (154 mm) sizes, all of which are accurate to .0003 in. (.008 mm).

For applications where greater accuracy is needed, such as surface plates, the A-1520 has a resolution of .00001 in. (0.25 microns) and is linearized to within ± .00006 in. (0.0015 mm) over 80% of the sensor area. It has a .250 in. (6.35 mm) measuring range and all the other features of the A-1519.

Figure 1—*A-1519-2.4ZB Single-Axis Wireless Target*

Applications

- Flatness, levelness, straightness, squareness and parallelism of machine tools, roll alignment applications, and surface plates (A-1520). Primarily for use with L-740 series of lasers but can also be used with the L-730 series.

Features

- Wireless infrared communication with a range of up to 100 ft. (30.5 m) with direct line of sight.
- The A-1519 has a resolution of .0001 in. (0.0025 mm). The A-1520 has a resolution of .00002 in. (0.0005 mm).
- The A-1519 is linearized to within: .0005 in. (0.012 mm). The A-1520 is linearized to within .00004 in. (0.001 mm).
- A-1519 has a 1 in. (25.4 mm) measuring range. The A-1520 has a .250 in. measuring range (6.35 mm).
- Automatic background-light correction for added accuracy.
- Can easily be converted to a height gage by attaching optional precision spacers.
- Automatic on/off operation with no switches, wires or connections.
- Flashing target indicators provide immediate "off-target" status.
- Powered by a rechargeable lithium-ion battery and comes with AC adapter/charger.
- Low battery and charging indicators show when charging is complete.

Readouts

The R-1357-2.4ZB Wireless, Ruggedized PDA Data Receiver with Read16 Android Software

The R-1357-2.4ZB offers hand-held convenience, wireless communication via the ZigBee Networking protocol, and multi-purpose Read16 Android Software. The R-1357-2.4ZB uses a rugged, IP 68 Android PDA combined with Read16 Android Software to display the data for our A-1519/A-1520 wireless targets and any of our L-730-740 Series rotating lasers. When combined with our R-1307-2.4ZB Readout, it can also display the data for our 2-axis targets. Data can be displayed for up to five single-axis targets and two 2-axis targets.

The radios employ a frequency-hopping protocol to avoid interference with other radio devices that might be operating at the same frequency. The radio allows the selection of different system IDs so that two or more systems can work in the same area and will not interfere with each other.

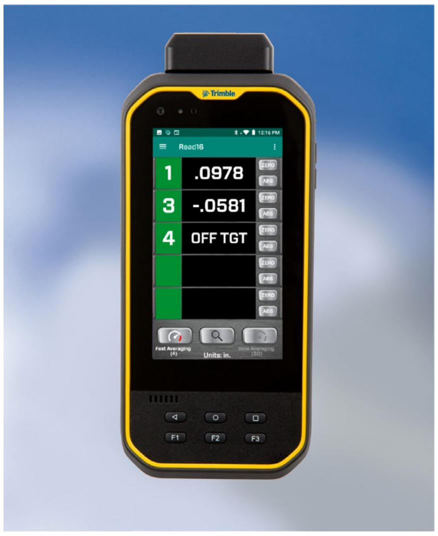


Figure 2 – *R-1357-2.4ZB PDA Data Receiver with Read16 Android Software*

Features of the R-1357-2.4ZB

- A rugged PDA with a sealed wireless transmitter and an IP 68 environmental rating that can survive water up to three feet with no harm.
- Long battery life of 10½ hours with a 4½ hour recharge time.
- Read16 Software pre-installed for basic alignment functions.
- Data display for up to five wireless targets.
- Wireless range of up to 133 feet.
- Compatibility with any of Hamar Laser’s continuously rotating lasers.

Features of the Read16 Software

- Two-Point Buck-In Wizard
- Roll Alignment Buck-In Tool
- Date recording for up to 500 points
- Adjustable data averaging to minimize air noise

The R-1356-2.4ZB Wireless, Ruggedized PDA Readout with Read15 Software

The R-1356 is an innovative readout that comes with Hamar Laser's Read15 alignment software preinstalled on a ruggedized personal digital assistant (PDA). The R-1356 operates with both the A-1519-2.4ZB and A-1520-2.4ZB radio wireless targets and any continuously rotating laser. The readout can display data from up to eight wireless targets and has a wireless range of up to 133 ft., eliminating cabling and multiple readouts. It allows a user to perform many alignment functions with the convenience and portability of a handheld computer. The display screen shows a measurement value for each of the connected targets (with the numbers corresponding to the labels on the targets). Each numeric value represents the position of the laser plane relative to the target centerline. A positive reading indicates that target is above the laser plane; a negative reading indicates that the target is below the laser plane.

Figure 3 – *R-1356-2.4ZB Wireless PDA Readout with Read15 Software*

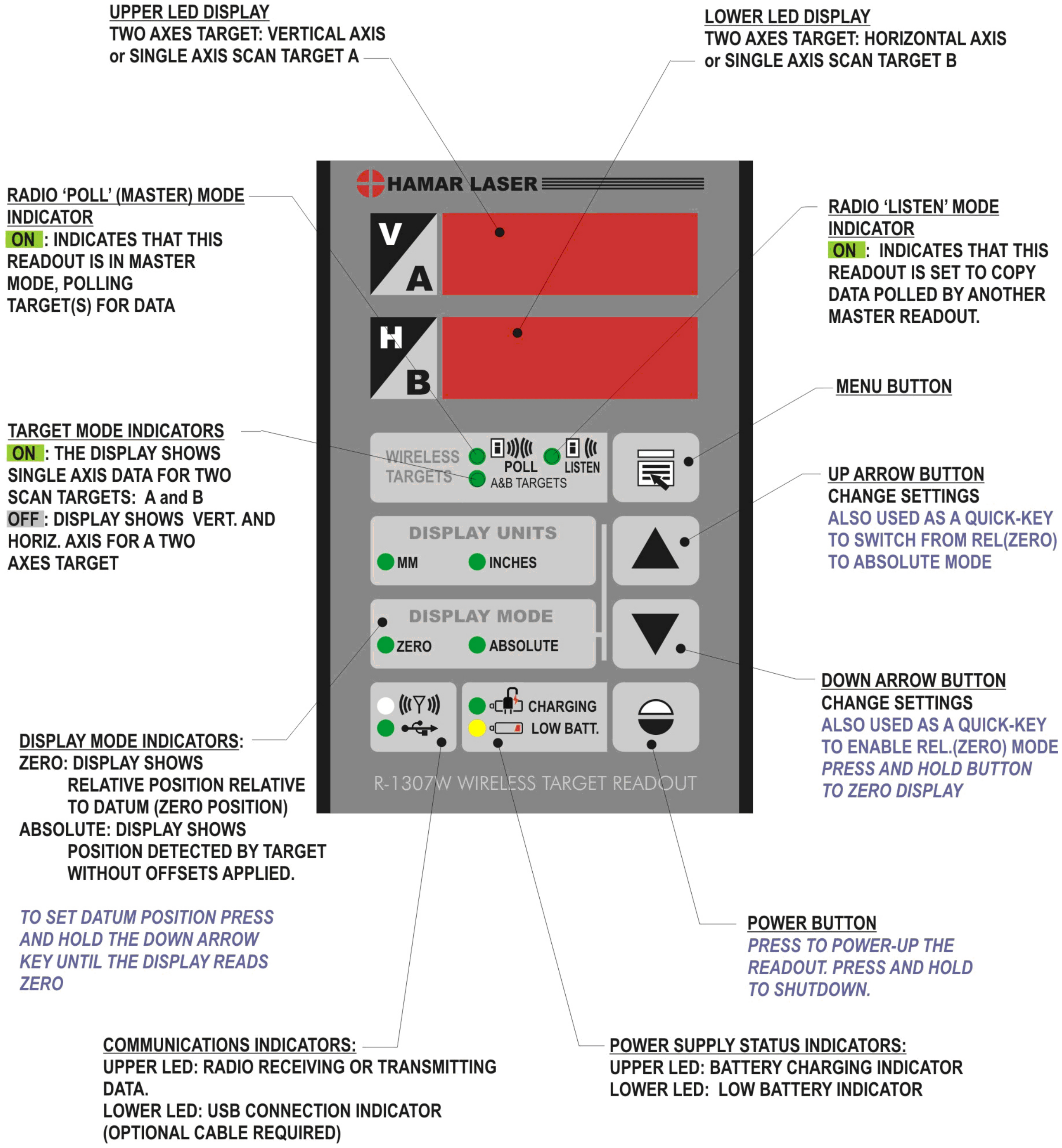
The R-1356-2.4ZB can toggle between **Absolute** (indicating exactly where the laser plane hits the target cell) and **Relative** modes. In Relative mode, the readout shows the measurement relative to the user-determined zero point. It also shows a display of the difference between two target measurements, a very useful feature for "buck-in," roll alignment and angular measurements, and a graphical display of each target's position relative to the laser plane.

Features

- A rugged PDA with a sealed wireless transmitter and an IP 67 environmental rating that can survive water up to 3 ft. with no harm.
- Long battery life (15 hours), with a 2.5 hour recharge time.
- Read15 software pre-installed for basic alignment functions.
- Data display for up to 8 wireless targets.
- Wireless range of up to 133 ft.
- Compatibility with any of Hamar Laser's continuously rotating lasers.
- Protective RF cap to cover and seal the Zigbee radio module.
- Radio powered by and sealed inside the PDA, requiring no external power supply.

The R-1307W Readout

The R-1307W Readout can be used for any 2-axis target as well as two A-1519-2.4ZB/A-1520-2.4ZB wireless targets. The readout may be configured in Master Mode or Listen Mode (see the R-1307 manual for complete configuration instructions).



UPPER LED DISPLAY
TWO AXES TARGET: VERTICAL AXIS
or SINGLE AXIS SCAN TARGET A

LOWER LED DISPLAY
TWO AXES TARGET: HORIZONTAL AXIS
or SINGLE AXIS SCAN TARGET B

RADIO 'POLL' (MASTER) MODE INDICATOR
ON : INDICATES THAT THIS READOUT IS IN MASTER MODE, POLLING TARGET(S) FOR DATA

RADIO 'LISTEN' MODE INDICATOR
ON : INDICATES THAT THIS READOUT IS SET TO COPY DATA POLLED BY ANOTHER MASTER READOUT.

MENU BUTTON

TARGET MODE INDICATORS
ON : THE DISPLAY SHOWS SINGLE AXIS DATA FOR TWO SCAN TARGETS: A and B
OFF : DISPLAY SHOWS VERT. AND HORIZ. AXIS FOR A TWO AXES TARGET

UP ARROW BUTTON
CHANGE SETTINGS
ALSO USED AS A QUICK-KEY TO SWITCH FROM REL(ZERO) TO ABSOLUTE MODE

DOWN ARROW BUTTON
CHANGE SETTINGS
ALSO USED AS A QUICK-KEY TO ENABLE REL.(ZERO) MODE
PRESS AND HOLD BUTTON TO ZERO DISPLAY

DISPLAY MODE INDICATORS:
ZERO: DISPLAY SHOWS RELATIVE POSITION RELATIVE TO DATUM (ZERO POSITION)
ABSOLUTE: DISPLAY SHOWS POSITION DETECTED BY TARGET WITHOUT OFFSETS APPLIED.

TO SET DATUM POSITION PRESS AND HOLD THE DOWN ARROW KEY UNTIL THE DISPLAY READS ZERO

POWER BUTTON
PRESS TO POWER-UP THE READOUT. PRESS AND HOLD TO SHUTDOWN.

COMMUNICATIONS INDICATORS:
UPPER LED: RADIO RECEIVING OR TRANSMITTING DATA.
LOWER LED: USB CONNECTION INDICATOR (OPTIONAL CABLE REQUIRED)

POWER SUPPLY STATUS INDICATORS:
UPPER LED: BATTERY CHARGING INDICATOR
LOWER LED: LOW BATTERY INDICATOR

Figure 4 – *R-1307W Readout Control Panel Features*

Computer Interface

A-910-2.4ZB Wireless Computer Interface

The A-910-2.4ZB computer interface is a small, compact USB dongle wireless receiver that communicates with up to 99 2.4GHz ZigBee® targets. Power is supplied by a laptop computer's USB port. The A-910-2.4ZB allows a data link for Hamar Laser software other than Read15, which is used on the R-1356. Both the R-1356 and the A-910-2.4ZB Computer Interface can be used in the same area when one is configured in Listen Mode and the other in Master Mode (the unit in Master Mode controls the send/receive commands to get the targets to send their data). System IDs can be changed in the software (see Page 88).

Figure 5 – *A-910-2.4ZB Dongle*

Preparing to Perform an Alignment

Please Note!

Our level vials are designed to be calibrated ***by the customer****. We cannot guarantee that the level vials are calibrated when you receive the equipment because of movement during shipping. Please follow the procedure below specific to the level vials on your laser.*

Defining Flatness and Level

"Measuring level" usually means measuring flatness using a level. The proper definition of flatness is: a surface is said to be flat to a tolerance if all the points on that surface fall within two parallel lines, or planes, separated by the tolerance value.

For example, if the flatness tolerance is .0030 in. TIR, then all the points must deviate from zero by no more than ± .0015 in.

There are two ways to measure flatness using our lasers:

- Level the laser, using our high-accuracy, built-in level vials, and measure the surface relative to the level laser plane
- Use three reference points on the surface, align the laser ("bucking-in") to those points and measure the flatness relative to those three points.

After recording the data, it is best to use our Plane5 Software to analyze the data using the Least-Squares, Best-Fit algorithm, which removes any slope error if the laser plane is not parallel to the surface, or if the surface is not level but the laser plane is.

Setting Up the Targets

Targets may be mounted to a surface via the magnetic base. Target operation is automatic, with no switches, wires or connectors, and flashing indicators provide immediate "off target" status. The wireless targets transmit data every time the laser beam scans across the position detector and a new reading is obtained. They rely on the laser to set the pace of the data transmission.

Using the Control Panel

Figure 6 shows the control panel for the L-743 and L-733 lasers, including the locations of:

- The battery pack/AC adapter connection
- The power switches and POWER ON indicator for the laser
- The power switches for the individual scanners
- The light for the precision level vials
  Note: *As of January 1, 2014, the level light switch has been modified. The level light now stays on permanently to increase stability and allow the laser to warm up faster.*
- The rotation speed buttons. These controls slow the scanner spin until you can see the laser beam pass over the target (the farther away the target is located, the slower the turret must spin). Select **SLOW**, **MEDIUM**, or **FAST**.

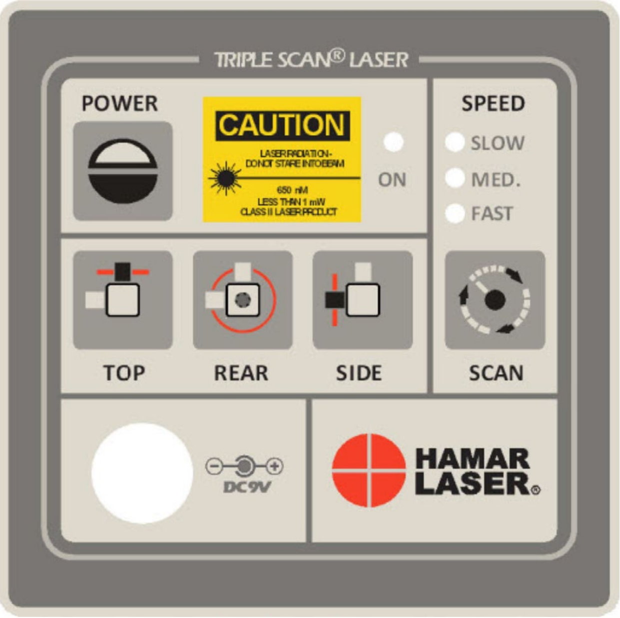


Figure 6 -- *Laser Control Panel—L-743 and L-733 Lasers*

Figure 7 shows control panels for the L-742 and L-732 lasers, both the “Wall-Wall” configuration with two vertical laser planes, and the “Wall-Ceiling” configuration, with one vertical laser plane and one horizontal laser plane. Also shown is the front panel for the L-730/L-740.

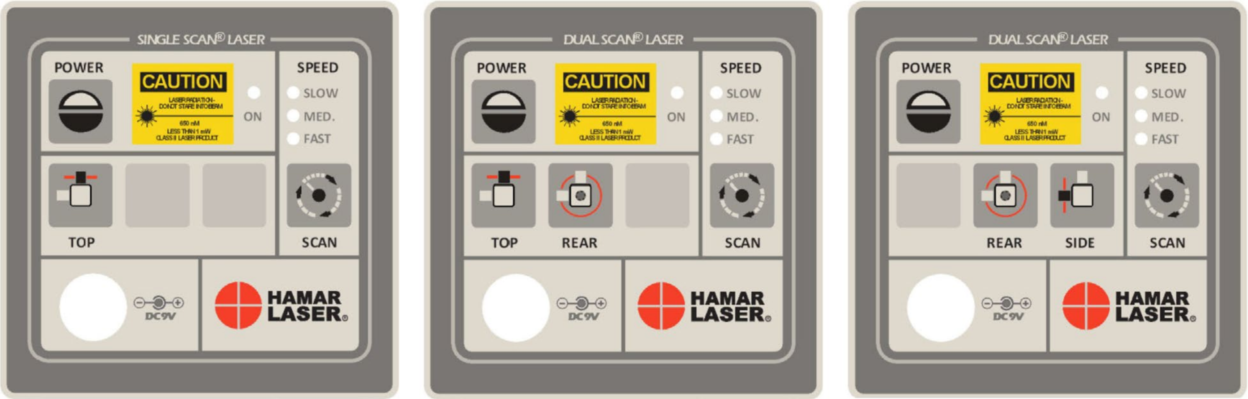


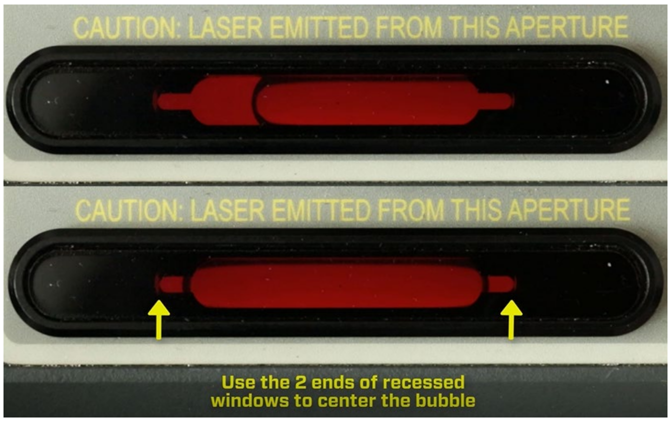
Figure 7 – *Laser Control Panels for the L-742, L-732 and L-730/L-740 Lasers. On the left is the* “Wall-Wall” *configuration, or two vertical laser planes. In the center is the* “Ceiling-Wall” *configuration, or one vertical plane and one horizontal plane.*

The Precision Level Vials

Reading the Precision Level Vials

Secure the laser base to a metal surface by turning the locking magnetic base ON. Once the laser is in position, power it on and use the adjustment knobs to bring the bubbles to the center of both vials (see Figure 8).

When both the PITCH and ROLL vials are reading level, the laser plane will be level to earth to within .00016 in/ft (0.015 mm/m) for the Precision Levels and .00006 in/ft (0.005 mm/m) for the Split-Prism Levels



Use the 2 ends of recessed windows to center the bubble

Figure 8 – *Precision Level Vial off center (top) and centered (bottom)*

Reading the L-740SP Split-Prism Level Vials

Once the laser unit is in position on the base, power it on and use the *coarse* alignment micrometers to bring the bubbles to the center of the level window.

When the bubbles are close to the center, use the *fine* adjustment micrometers to align the bubble halves to each other in the viewing prism window (see Figure 9). When both the PITCH and ROLL axis vials are reading level, a level beam can be scanned at 360 degrees with a .0003 in. (0.0075 mm) deviation per 10 ft. (3 m).

2 Halves of Bubble Not Aligned - Laser not Leveled

2 Halves of Bubble Aligned - Laser is Leveled

Figure 9 –*L-740SP Split-Prism Level Vial Assembly for L-740 Series Lasers*

Calibrating the Level Vials

Note 1: *This procedure calibrates* ***only one level vial at a time*** *and must be repeated for the other axis. It is very important to ensure to* ***level both levels*** *when calibrating each one. Failure to do this makes it nearly impossible to calibrate the levels.*
Note 2: *It is very important to warm up the laser for at least 30 minutes before starting this procedure.*

The calibration procedure involves a series of steps to adjust the laser beam to be level to earth. Because the leveling process is subject to so many variables, repeat the procedure to check for accuracy once the initial readings are taken and adjustments are made. A typical sequence would be as follows:

- *Determine* the Set Point and set the Pitch Axis.
- *Use* the Set Point value to set the Roll Axis.
- Check both the Pitch and Roll axes. Reset the levels if necessary.
- If the levels are reset, make a final check to determine if the laser level error is acceptable.

When calibrating the precision level vials, work on a surface that is level to earth within .001 to .002 in/ft. A surface that is 10 to 20 ft. in length is ideal. When calibrating to shorter surfaces, do so with the readout set to the .0001 in. mode. If you are using the A-1519 or A-1520 Wireless Targets with the R-1356 PDA or with Hamar Laser's alignment programs, set the readout display through the software.

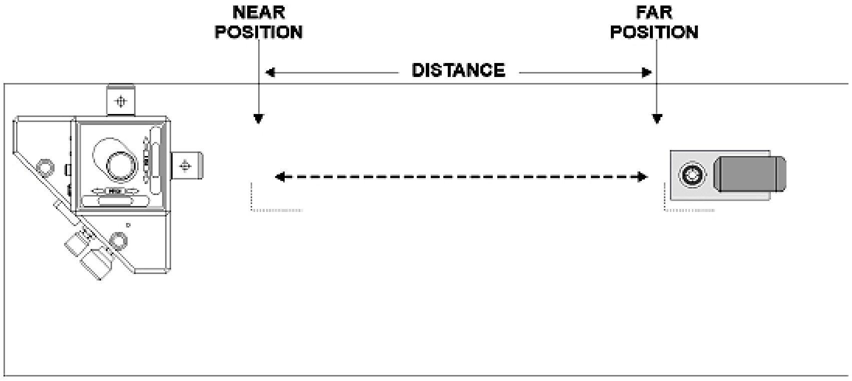


Figure 10 -- *Laser and Target Setup for Calibrating the Precision Level Vials*

Zeroing the Targets

The following sections refer frequently to "zeroing" the target. When a target is zeroed, the readout is reset to zero at the point where the laser beam currently hits the target cell.

When using the A-1519/A-1520 Universal Targets, this is accomplished through the Read15/Read16 software (or through Hamar Laser's other alignment programs) by clicking the ZERO button, which zeroes out the ABS (Absolute Mode) value. This reading is stored in memory and then subtracted from all future readings. Once the target is zeroed, subsequent readings show only the *difference* from the original reading in ABS Mode.


1 -.00012
2 +.00937
3 -.00189
- - -
- - -

Avg: ● BI-Fast(4) ○ BI-Slow(20) ○ Meas.(20)

Calculating the Calibration of the Level Vials – Roll Axis

Note: *It is very important to warm up the laser for at least 30 minutes before starting this procedure. It is also very important to* ***level both the Pitch and Roll axis level vials*** *during this procedure. Failure to do this makes it nearly impossible to calibrate the levels.*

1. **Level the laser.**
   Using the adjustment knobs, level the laser so *both* the Pitch and Roll levels are exactly level (see top of Figure 8).
2. **Zero the target in the Near Position.**
   Beginning with the Roll Axis, place a target on a point near to the laser. Mark this point with a Sharpie® or other marker so you can always reposition the target at the same point. Zero the target according to the readout you are using.
3. **Determine Far Reading 1.**
   Move the target to the Far Point and again mark this point on the surface and record (write it down) the target reading. This is *Far Reading 1*.
   Measure the distance (D1) between the Near Point and the Far Points and write it down.
   Note: *It is recommended to repeat the measurements 2 or 3 times to check repeatability.*

4. **Determine Far Reading 2.**
   Rotate the entire laser unit 180 degrees. Re-level the laser using the adjustment knobs so that *both* the Pitch and Roll levels are exactly level. Return the target to the Near Position, ensuring that it is placed in the exact position as before. Re-zero the target on this point. Move the target back to the Far Position, again ensuring that it is positioned exactly as before. Record the target reading. This is *Far Reading 2*.

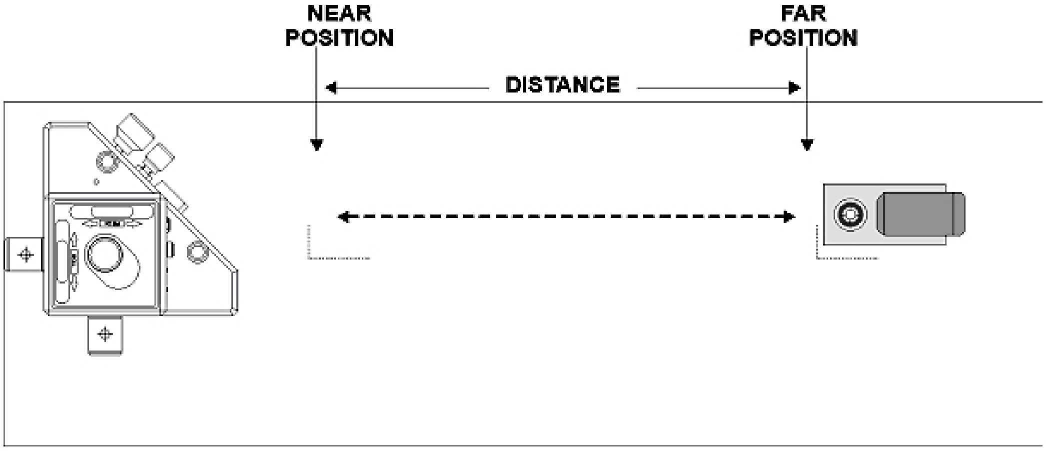


Figure 11 -- *Setup after rotating the laser 180 degrees*

5. Calculate the Set Point – Roll Axis

Set Point = (Reading 1 + Reading 2) / 2. Subtract the Set Point from Reading 1 and divide the result by the D1 (distance between the points). The result is the calibration of the level vial in units of in/ft or mm/m. To be within specifications, the calibration result should be as follows:

Split Prism Vial Assembly:	≤ .00006 in/ft (0.005 mm/m)
Standard Levels:	≤ .00018 in/ft (0.015 mm/m)

Example:

15 ft. (D1)
.000 (Near Reading)

.020 (Far Reading 1)
+ -.010 (Far Reading 2)
+.010 (Sum of the two readings)

Set Point: +.010 / 2 = +.005

In/Out of Calibration Calculation = (Far Reading 1 - Set Point) / D1
(.020-.005) / 15 = .001 in/ft - this is out of spec!

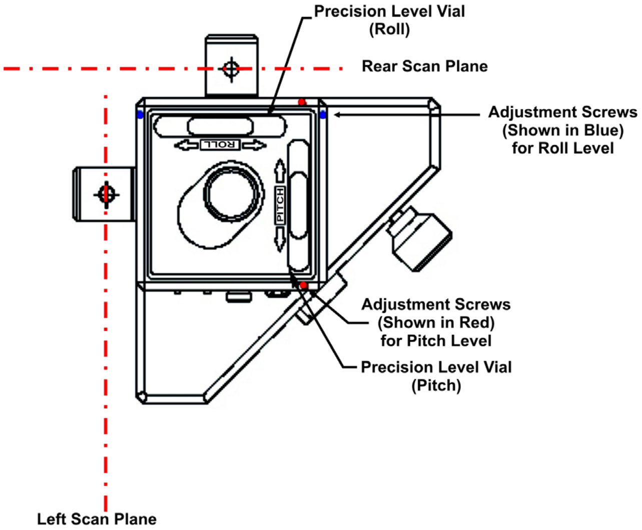
If this value is out of the specification, then you will need to use the Set Point to bring the level vial window back into specification. See Step 6.

Setting the First Level Vial – Roll Axis

6. **Tilt the laser to the Set Point**
   Move the target back to the Near Point to verify it still reads zero. If not, re-zero it. Then move the target back to the Far Point and tilt the laser by adjusting the *Roll Axis* adjustment knob on the laser base until the readout displays the calculated Set Point (see Step 5).

7. **Adjust the level.**
   Locate the two recessed adjustment screws for the *Roll Axis* level you are adjusting (see Figure 12). Using the wrench provided, adjust the level assembly until the bubble is centered in the window for the Standard Level Vials or the two halves of the bubbles line up for the Split Prism Level Vial (see Figure 8 and Figure 9).

   To move the bubble to the left, unscrew the left set screw and tighten the right set screw. When the bubble is centered, tighten the left screw until the bubble is stationary – **don't over-tighten the set screw**. Check your work by repeating these steps and ensuring that the level is calibrated to within the specified tolerances.



Note: *Tighten the set screws just firmly enough to hold the window assembly in place. Over-tightening these screws may cause damage.*

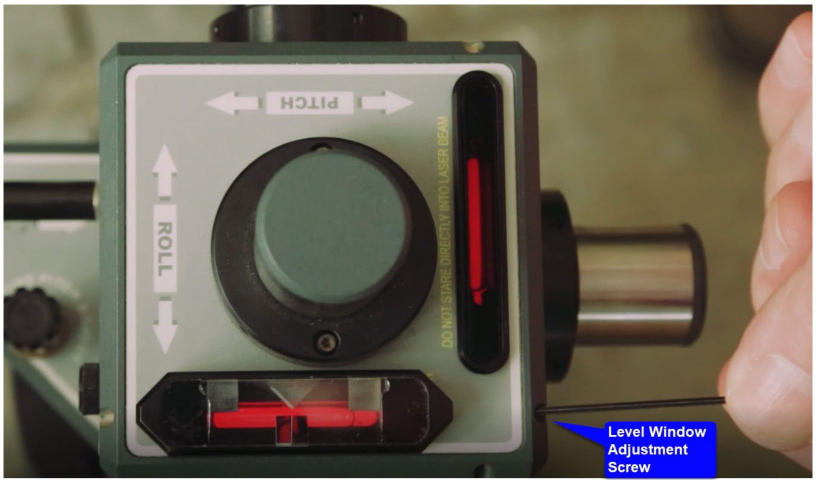


Figure 12 – *L-733 (top view) showing location of Precision Level Vials and corresponding adjustment screws. Also see our YouTube video: How to Calibrate Level Vials.*

Checking the Levels for Accuracy

Ensure that your calculations were correct and redo the calibration procedure to verify the Set Point is still the same within the tolerances outlined above. If it's still out of spec, then calculate a new Set Point and adjust as necessary. In some cases, if the level window requires a lot of adjustment (i.e. the levels were way out of calibration), then it may require a second calibration procedure to get "dialed in".

Calculating the Calibration of the Levels Vials – Pitch Axis

1. **Level the laser.**
   Rotate the entire laser unit 90° to calibrate the *Pitch Axis* level vial. Using the adjustment knobs, level the laser so that *both* the pitch and roll levels are exactly level.
2. **Zero the target in the Near Position.**
   Set the target on the same Near Position as before and re-zero it.
3. **Determine Far Reading 1.**
   Move the target to the same Far Position as before and repeat Step 3 (Roll Axis) above.
4. **Determine Far Reading 2.**
   Rotate the entire laser unit 180°. Re-level the laser using the adjustment knobs so that *both* the pitch and roll levels are exactly level. Return the target to the Near Position, ensuring that it is placed in the exact position as before. Re-zero the target on this point. Move the target back to the Far Position, again ensuring that it is positioned exactly as before. Record the target reading. This is **Far Reading 2**.

5. **Calculate Level Calibration and the Set Point – Pitch Axis**
   Add Reading 1 and Reading 2 and divide by 2 (Set Point). Subtract the Set Point from Reading 1 and divide the result by the D1 (distance between the points). The result is the calibration of the level vial in units of in/ft or mm/m. To be within specifications, the calibration result should be as follows:

Split Prism Vial Assembly:	≤ .00006 in/ft (0.005 mm/m)
Standard Levels:	≤ .00018 in /ft (0.015 mm/m)

   Example:
   15 ft. (D1)
   .000 (Near Reading)

   .035 (Far Reading 1)
   + .010 (Far Reading 2)
   .045 (Sum of the two readings)

   +.045 / 2 = +.0225 (Set Point)

   In/Out of Calibration Calculation = (Far Reading 1 - Set Point) / D1
   (.035 - .0225) / 15 = .0008 in./ft. (out of spec)

   If this value is out of the specification, then you will need to use the Set Point to bring it back into specification. See Step 6 below.

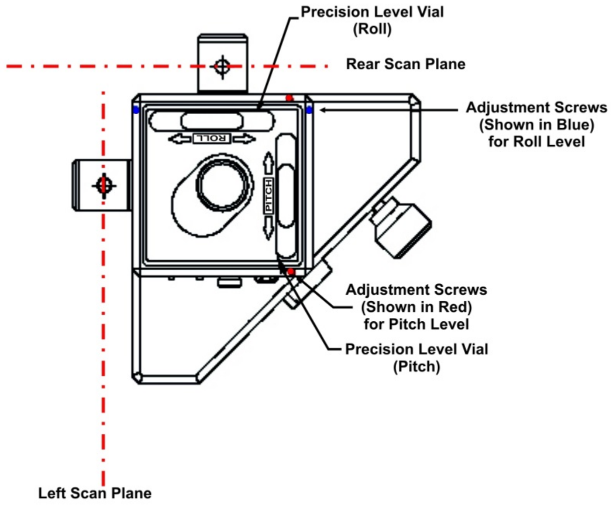
Setting the First Level Vial – Pitch Axis

6. **Tilt the laser to the Set Point**
   Move the target back to the Near Point to verify it still reads zero. If not, re-zero it. Then move the target back to the Far Point and tilt the laser by adjusting the *Pitch Axis* adjustment knob on the laser base until the readout displays the calculated Set Point.

7. **Adjust the level.**
   Locate the two recessed adjustment screws for the Pitch Axis level you are adjusting). Using the wrench provided, adjust the level assembly until the bubble is centered in the window for the Standard Level vials or the two halves of the bubbles line up for the Split Prism Level vial (see Figure 8 and Figure 9).

   For example, to move the bubble to the left, loosen the left screw and tighten the right screw. When the bubble is centered, tighten the left screw until the bubble is stationary. Check your work by repeating these steps and ensuring that the level is calibrated to within the specified tolerances.

   Note: *Tighten the set screws just firmly enough to hold the window assembly in place. Over- tightening these screws may cause damage.*



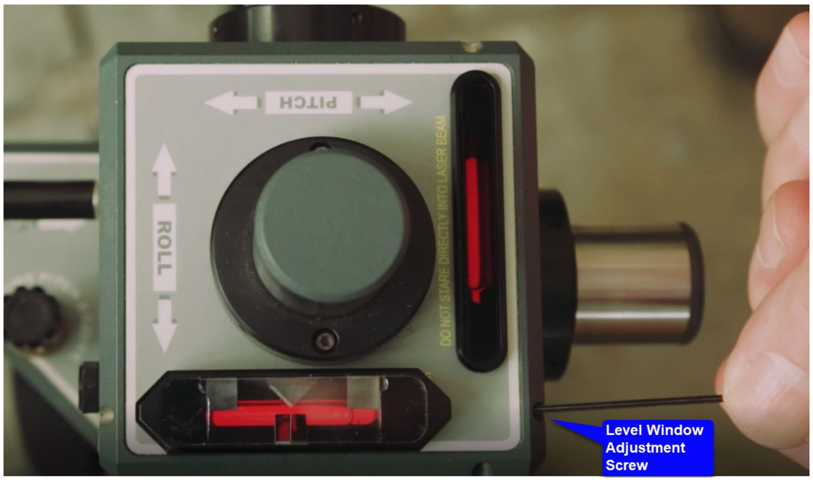


Figure 13 – *L-733 (top view) showing location of Precision Level Vials and corresponding adjustment screws. Also see our YouTube video: How to Calibrate Level Vials.*

Checking the Levels for Accuracy

It's best to make sure that your calculations were correct and redo the calibration procedure to verify the Set Point is still the same within the tolerances outlined above. If it's still out of spec, then calculate a new Set Point and adjust as necessary. In some cases, if the level window requires a lot of adjustment (i.e. the levels were way out of calibration), then it may require a second calibration procedure to get "dialed in".

Laser Buck-in

Laser buck-in refers to the adjustment of a laser plane or line to be parallel to the surface being measured (a tabletop, a surface plate, or a way surface). Three points are required to buck-in a laser plane to a reference surface. Two points are needed to buck-in a straight-line laser to a reference line (i.e., centerline).

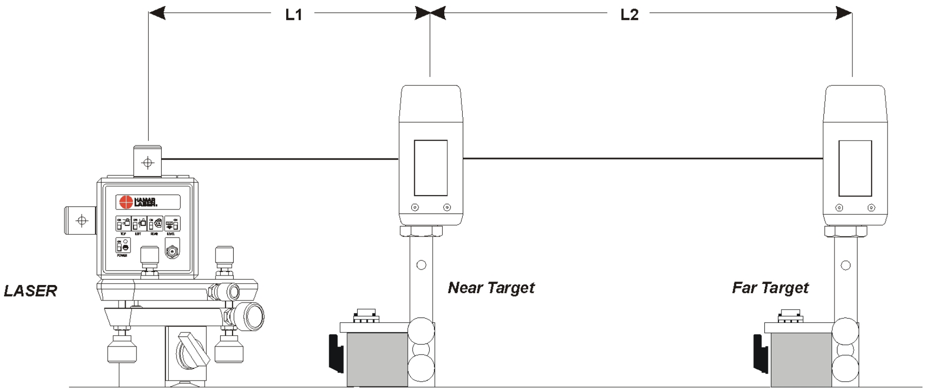
Normal versus Remote Buck-In

There are two procedures for bucking-in the laser:

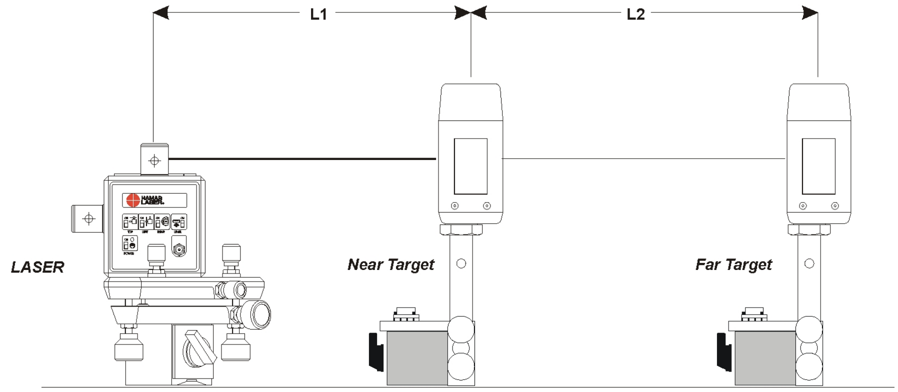
- Close Buck-in
- Remote Buck-in

The procedure used depends on the relationship of two distances: the distance between the laser unit and the first target, and the distance between the first and second targets. The normal buck-in is easier; the remote buck-in is useful in situations where the normal method would be nearly impossible.

Figure 14 illustrates the general rule for determining the buck-in method to use. L1 is the distance from the Laser to the first Target location. L2 is the distance between the 2 targets. If L1 < 1/10 * L2, the Close (normal) Buck-In procedure is used. If L1 > 1/10 * L2, the Remote Buck-In procedure should be used. When in doubt, or if the close procedure is not producing good results, use the remote procedure.



If L1<10% of L2, use the Close Buck-in Method



If L1>10% of L2, use the Remote Buck-in Method

Figure 14 – *Close vs. Remote Buck-in*

Note: *Read15 and Read16 PDA software programs now have a 2-Point Buck-In Wizard to aid you in doing a remote buck-in. Please see those manuals for the procedure.*

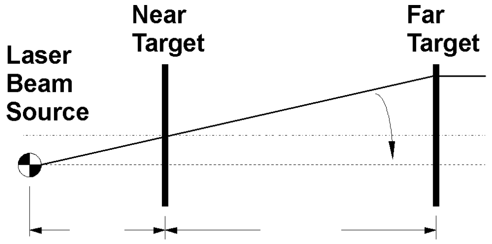
Normal Buck-In

The normal buck-in procedure can be remembered by the rule, "*Zero Near, Tilt Far.*" Buck in the laser beam by zeroing the target on *near* reference point, and then "point" (tilt) the laser beam using the appropriate pitch/roll/yaw adjustment knobs on the laser base so the reading on the far target is zero. The two steps are repeated until both targets show zero readings.

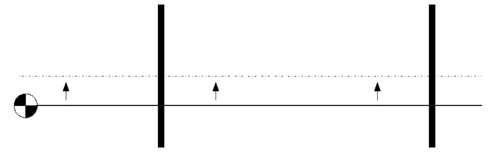
Remote Buck-In

As the distance between the laser and the near target increases with respect to the distance between the two targets, bucking in by the close method becomes nearly impossible. A special Remote Buck-In Procedure has been developed for these situations. The Remote Buck-In uses simple geometry to make the laser beam parallel to the centerline of the two targets, and then centers the beam on that line. Figure 15 illustrates how the remote method works.

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



Make the beam parallel to the target centerline.



Center the beam on the target centerline.

Figure 15 – *Remote Buck-in*

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

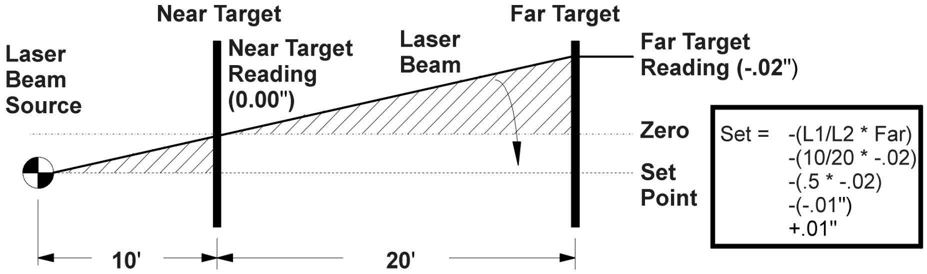


Figure 16 - *Calculating the Set Point*

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

***Set Point*/L1 = Far/L2**

If L1, L2, and the far reading are known, the set can then be determined by the following formula:

***Set Point* = -(Far reading * L1/L2)**

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

In Remote Buck-Ins, steer/tilt the laser plane ***through*** zero until the display reading is equal to the Set Point. This means moving the laser until it reads the set amount on the ***other side*** of zero from the starting point. In doing so, the sign of the number (negative or positive) will be reversed. Figure 16 illustrates this by taking sample readings and showing how the Set Point is derived. Notice the far reading is a negative number and the Set Point is positive as you go "through zero," resulting in a laser beam parallel to the target centerline but offset by the set distance.

If the calculated Set Point exceeds the linear range of the target, (for example, the A-1519 target has a range of 1.0 in. or 25 mm) ***then the target must be moved*** by the Set Point amount. New measurements must then be retaken for both targets, and a new Set Point calculated. Figure 16 shows how to move the laser depending upon the sign of the calculated set point.
Note: *If the laser is mounted on an L-106A screw lift stand, each full turn of the knob lifts or lowers the stand .125 in. or 3 mm).*

The target should give the same reading, both number and sign, at the near and far point positions. If not, recalculate the Set Point and buck in again. In most cases, remote buck-in can be accomplished in two or three passes. This method will work even when L1 is much greater than L2, or when the beam does not even hit the target (in such cases the far reading can be taken by using a ruler to measure the beam's distance from the target center). Once the laser beam is parallel to but offset from the target centerline, you can then zero the reading on the near target position.

Three-Point Buck-In (Flatness)

The 3-Point Buck-In procedure requires adjusting the laser plane to be parallel to three points on the surface being measured; for example, a tabletop, a surface plate, or a way surface. *Any* three points on a surface may be used, however Hamar Laser recommends the setup illustrated in Figure 17.

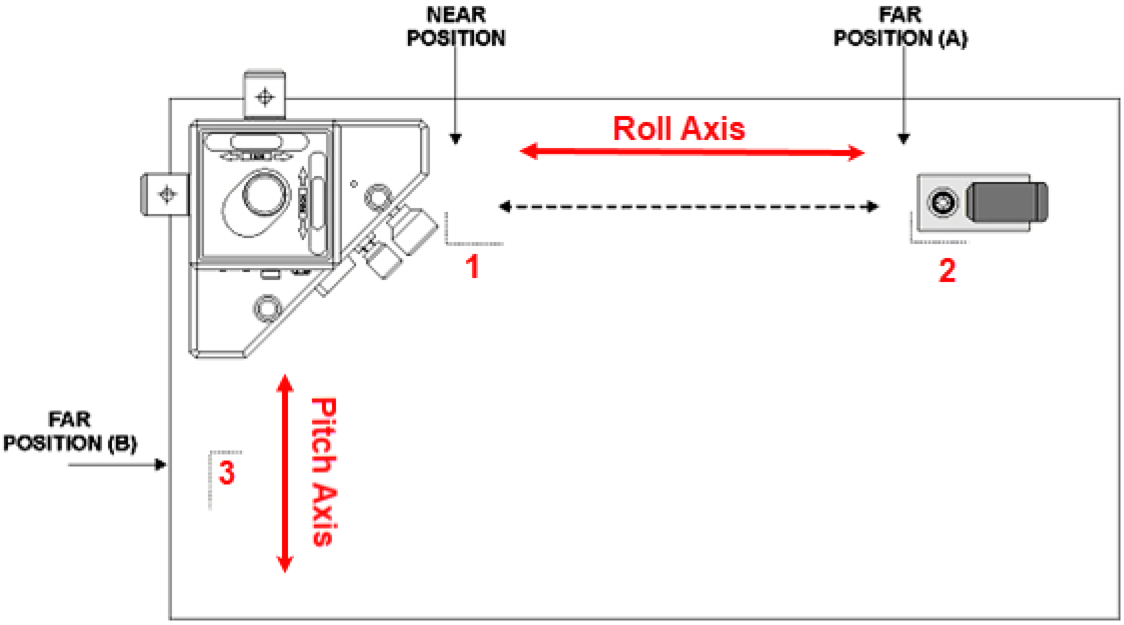


Figure 17 – *3-Point Buck-in Using One Target (recommended setup)*

When performing this procedure, it is best to place the laser source in a position that is as close to the Near Target Position as possible. The Far Target Position B **(3)** should be approximately 90° to these two points. This is not always possible, but this is the easiest configuration for this procedure.

3-Point Buck-In Procedure Using One Target

Setting up the Equipment

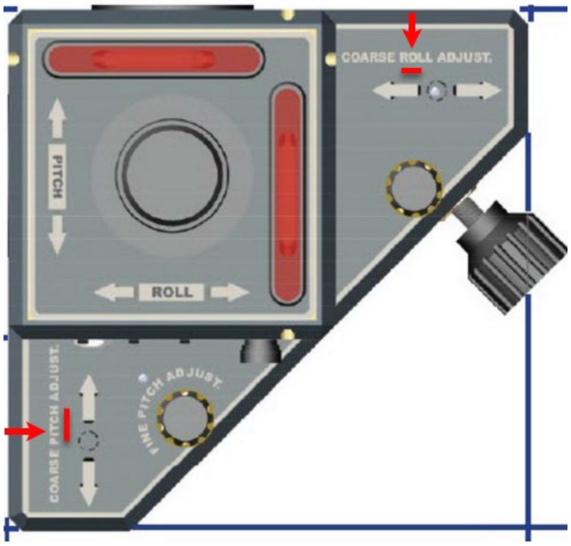
1. **Position and secure the laser.**
   Position the laser as shown and turn the lever on the magnetic base to ON to lock it securely to the metal surface.

2. **Coarse level the laser.**
   Power on the laser and use the speed control knob on the control panel slow the scanner spin until you can see the laser beam pass over the target (the farther away the target is located, the slower the scanner must spin). Turn the light switch for the bubble level vials ON. Using the adjustment knobs and observing the position of the precision level vials, coarse-level the laser so that the laser plane is approximately parallel to the surface.

3. **Position and secure the target.**
   Place the target in the *Near Position* (**1** – see Figure 17). Move the target in its magnetic base until the laser beam roughly hits the mid-position of the target and turn the lever on the magnetic base to ON to lock it securely to the metal surface.

   Note: *As you move the target to the Near Position (1), Far Position A (2) and Far Position B (3), mark where the base of the target sits on the surface so that it may be repositioned in the same place each time.*

4. **Set the readout.**
   If you are using the A-1519 or A-1520 Wireless Targets with the R-1356-2.4ZB PDA Readout or with Hamar Laser's alignment programs, set the readout display through the software. You may also need to adjust the sampling rate to dampen the effects of atmospheric turbulence in the Read15 software (or in the Hamar Laser alignment program you are using).



Performing the 3-Point Buck-In Using One Target

1. **Center the target in the Near Position.**
   With the target in the Near Position, zero the target on the PDA (see the Read15, Plane5 or Machine Tool Geo Manuals).

2. **Move the target to Far Position A and tilt PRY Base *Roll Axis* until the readout reads zero.**
   With the target in Far Position A, tilt the *Roll Axis* of *laser's* PRY Base using the adjustment knobs until the readout reads zero. Be sure to use *only* the *Roll Axis* adjustment knobs (in the setup displayed above, this would be the adjustment knob marked Roll).

   Note: *When the target is in the Near Position, always use the appropriate zero function in the software. When the target is in the Far Position, always use the laser adjustment knobs to tilt the laser beam. This is easily remembered by the phrase, "Zero Near, Tilt Far."*

3. **Repeat Steps 1 and 2 until the readout reads zero at both locations.**
   Continue to move the target between the *Near Position* and *Far Position A*, zeroing the target at the *Near Position* and tilting the laser plane using the *Roll Axis* adjustment knobs at the *Far Position A* until the readout reads zero at both locations.

4. **Move the target to Far Position B and tilt the Pitch Axis of the laser until the readout reads zero.**
   Be sure to use only *Pitch Axis* adjustment knobs that face the target when tilting the laser beam (in the setup displayed in Figure 18, this would be the PITCH adjustment).
5. **Recheck the readings at the Near Position and at Far Positions A and B and adjust to zero if necessary.**
   When the target reads zero at all three locations, the laser plane is parallel to the surface.

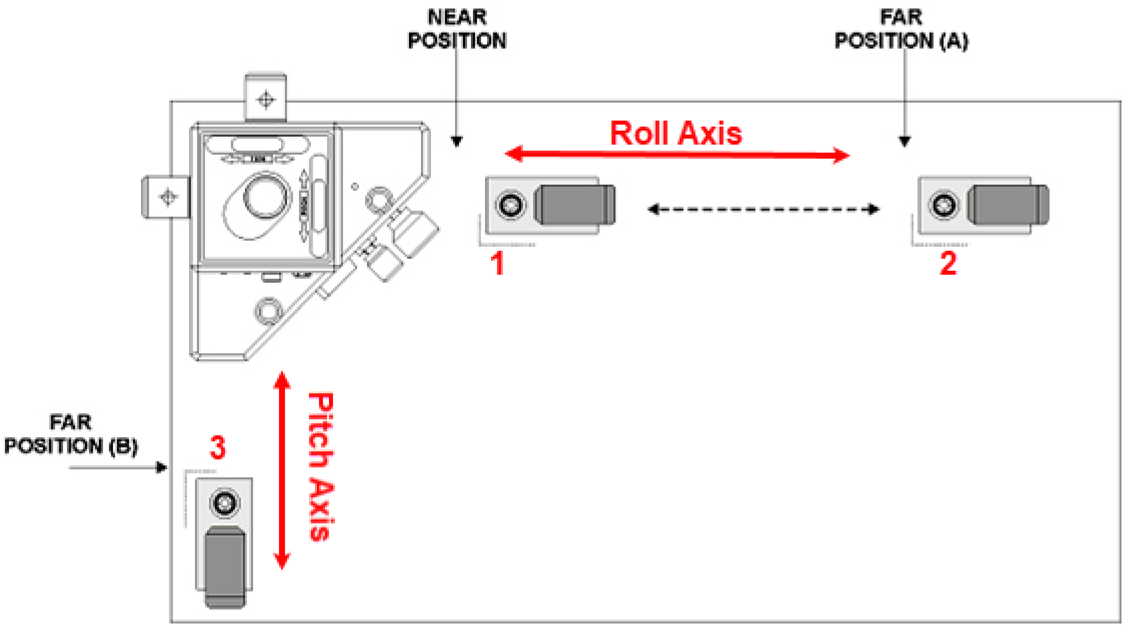


Figure 18 – 3-*Point Buck-In*

3-Point Buck-In Procedure Using Multiple Targets

This method requires three targets. The procedure is basically the same as with one target, but it saves the time required to move a single target to the three different footprints.

1. **Zero all three targets on the near footprint (1)–** see Figure 18**.**
2. **Place two of the targets on the other two footprints (two and three).**
3. **Tilt or aim the laser until all three readouts read the same numbers and the same sign.**
4. **When all three readouts read the same, the laser plane is then parallel to all three points.**

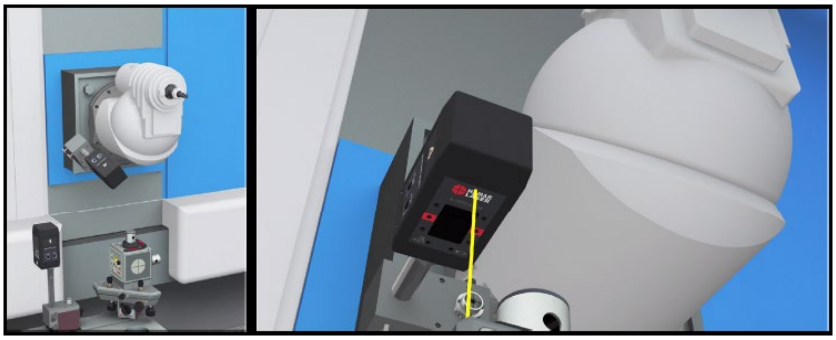
2-Point Buck-In on Machine Tool Axis (Straightness)

A laser beam is often used as a "straight edge" to measure straightness. Examples are machine tool ways or bore straightness measurement. The laser beam must be adjusted to be parallel to or coincident with an edge or centerline. The process of making that adjustment is called "bucking in." This section describes two types of buck-in methods: close (simple) and remote (more difficult).

Two points in space define a unique straight line; therefore, two reference points are needed in order to relate the position of a laser beam to a surface or centerline. Any two points may be chosen (the suitability of the points cannot be judged until after the measurement has been done). The points are usually selected near the extreme ends of the job for the sake of convenience. A 2-Point Buck-In makes the laser beam parallel with these two points. It is best to place the laser source in a position that is as close to the near target position as possible. Orient the laser so that either the long axis of the base or the short axis of the base is parallel to the near and the far target positions.

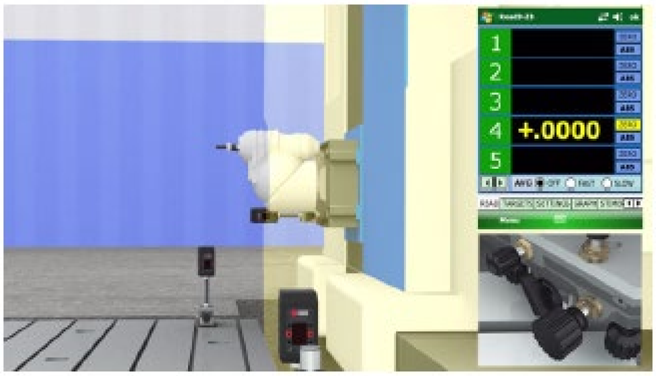
Aligning the Laser to the X-Axis Travel

1. Mount Target #4 on the ram, move the spindle and adjust the target height.



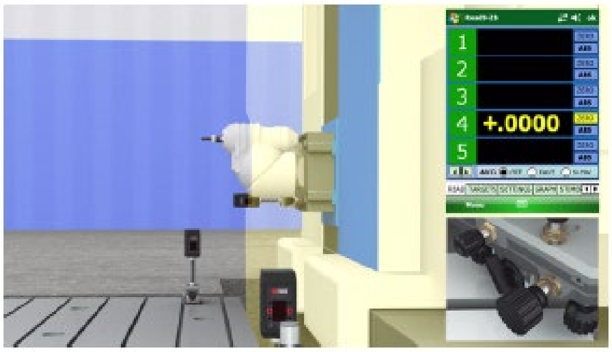
2. Power on the laser and zero the target in the Read9 PDA. Move the column down to the end of the X-Axis travel and rotate the target head to point towards the laser.

3. Turn the Yaw-Axis adjustment knob to center the laser to zero on the target.



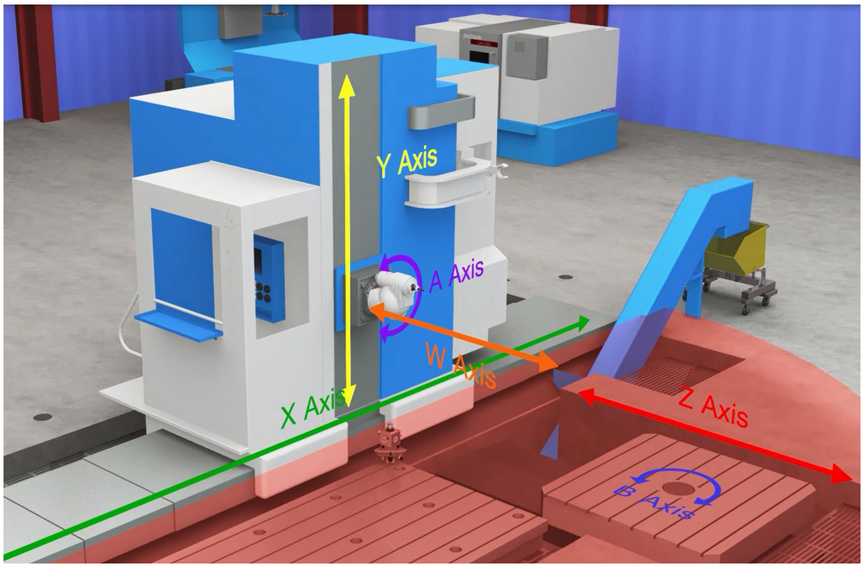
4. Return the column to its starting position and rotate the target toward the laser. Zero the target.

5. Send the column back to the far end of travel and tweak the Yaw-Axis adjustment knob to zero the laser.



6. When the target reads zero at both ends, the laser is aligned to the X-Axis.

Measuring a Machining Center



The following section describes how the laser is used to measure straightness, flatness, squareness, levelness and parallelism on a 6-axis horizontal floor mill. Note that if a machine is going to be aligned, rather than just measured, it is important to put the laser on an instrument stand. If the laser is on the machine bed or table, adjustments will likely move the laser and affect the setup.

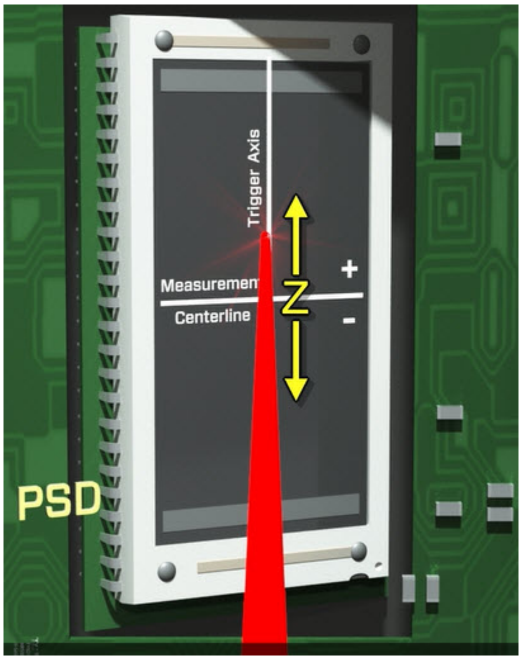
Setting Up (Bucking-in) the Laser

When setting up the laser to measure either straightness or flatness, you must first position the laser plane(s) so that they are parallel to the reference points on the machine. This process is called "bucking in" the laser. To speed up the setup process, the use of three reference targets is highly recommended.

- For measuring straightness, two reference points are needed.
- For measuring flatness, three reference points are needed.
- For measuring the flatness, straightness and squareness of a machining center, five reference points are needed.

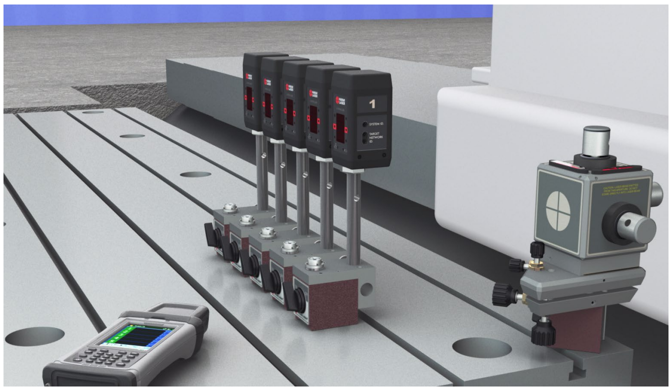
In this procedure, we'll use three targets for the initial 3-point setup and one target for the 2-point setup.

Once the laser has been set up to its reference points, the targets can be repositioned to measure the various surfaces or lines of motion for deviation from the references. A plus (+) reading indicates a target is higher than the reference points, and a minus (-) reading indicates it is lower.

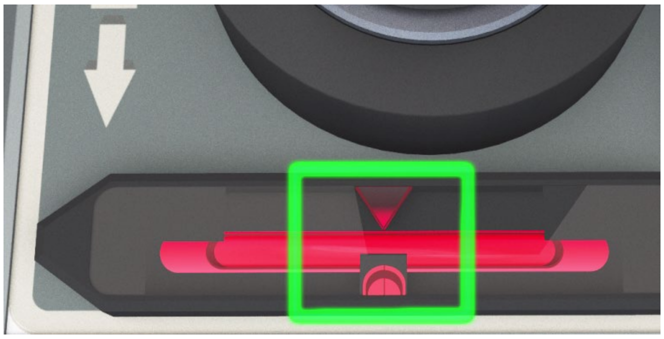


Procedure

1. Place the laser on the table at a spot that provides the ability to measure all the axes from the same setup.



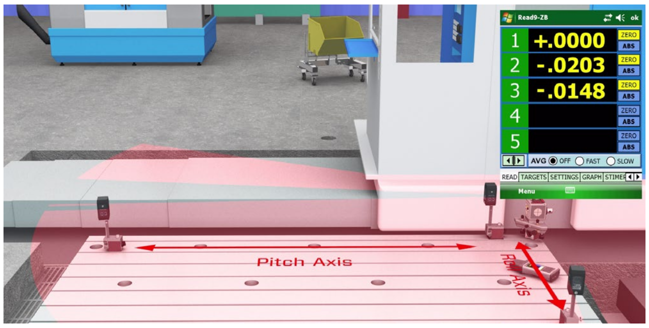
2. Level the Pitch-Axis level via by using the coarse and fine adjustments to line up the edges of the bubble. Repeat the process with the Roll-Axis level vial. Now the red laser plane is level to earth



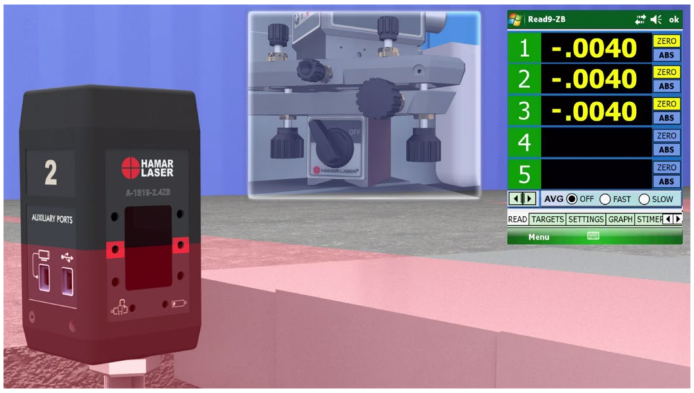
3. Place Target #1 at a location next to the laser and mark the outline of the magnetic base for good repeatability. Point the laser at the target window and adjust the target height until the laser beam is centered.

4. Turn on the laser rotation (which also turns on the targets). Target #1 data displays in the Read9 software on the PDA. Zero the display. Remove Target #1 and replace it with Target #2. Zero the Read9 display for Target #2. Repeat the process for Target #3.

5. Spread out the targets on the table on three reference points, two along the Pitch Axis and one on the Roll Axis.

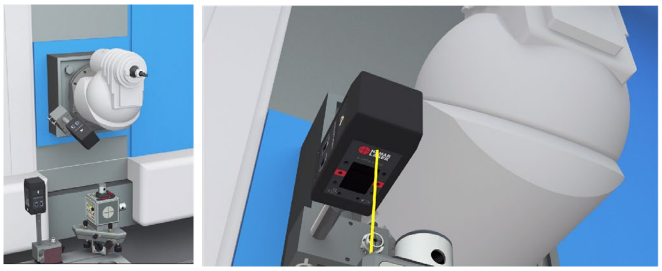


6. Looking at the data for Targets #1 and #2, adjust the Pitch-Axis knobs on the laser until the two values are equal. Switch to Targets #1 and #3 and adjust the Roll-Axis knobs on the laser until those two values are equal. Now the target values for all three targets are equal and the laser plane is aligned to the table.

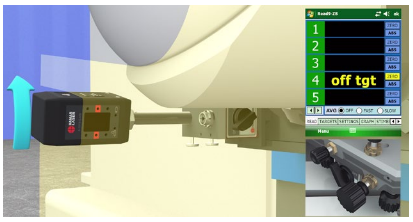


Aligning the Laser to the X-Axis Travel

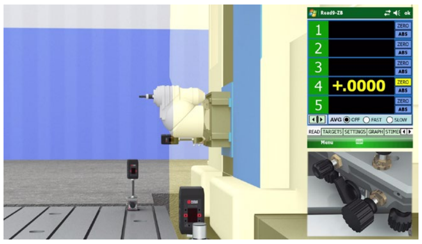
1. Mount Target #4 on the ram, move the spindle and adjust the target height.



2. Power on the laser and zero the target in the Read9 PDA. Move the column down to the end of the X-Axis travel and rotate the target head to point towards the laser.

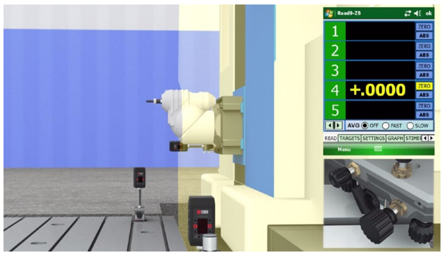


3. Turn the Yaw-Axis adjustment knob to center the laser to zero on the target.

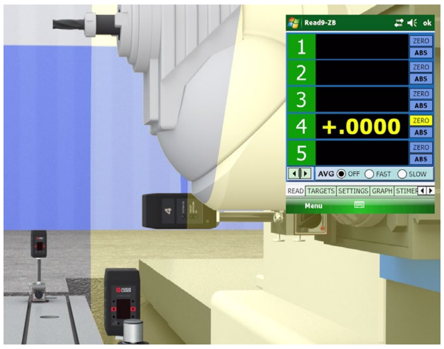


4. Return the column to its starting position and rotate the target toward the laser. Zero the target.

5. Send the column back to the far end of travel and tweak the Yaw-Axis adjustment knob to zero the laser.



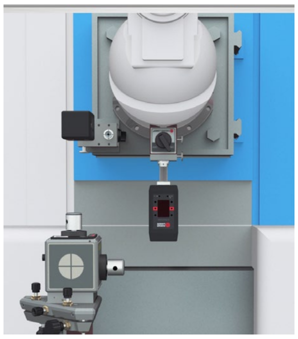
6. When the target reads zero at both ends, the laser is aligned to the X-Axis.



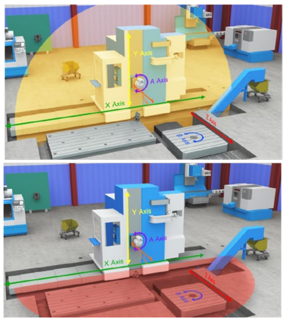
Measuring X-Axis Straightness and Flatness Simultaneously

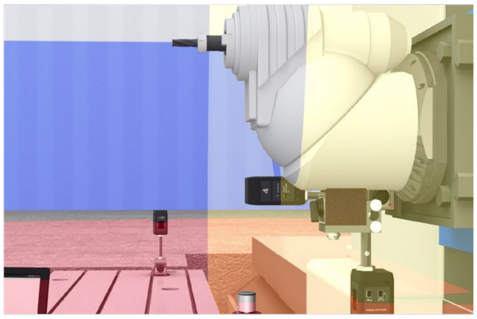
The straightness and flatness for X can be measured simultaneously by adding a second measuring target to the bottom of the spindle ram. The targets come with a 3-piece post set, so a shorter post may be used to adjust the target height to pick up the red laser.

1. Attach a second measuring target to the bottom of the spindle ram with a short post. Adjust the target height to pick up the red laser.

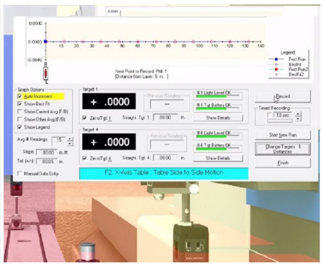


2. Turn on the rotation for both laser planes. The Gold Laser (top left) measures X-Axis Straightness and the Red Laser (bottom left) measures Flatness.

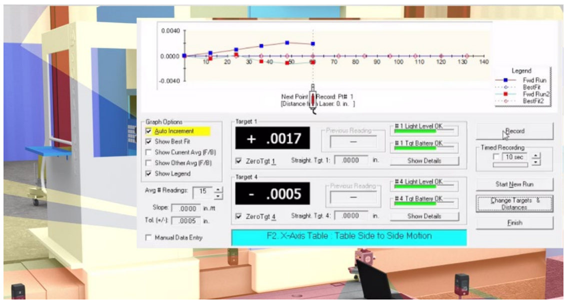




3. The target readings are sent wirelessly to a laptop computer, where our Machine Tool Geometry software records them. Select the axis, enter the length of travel and number of points, and ensure the targets are pointed at the laser. Hit the **RECORD** button and the Machine Tool Geometry software records both targets' data simultaneously and plots out straightness.



4. Continue to move the column to each point and hit Record. After the data has been taken, return the column to the home position.



Next Point | Record: Pt# 1
[Distance from Laser: 0. in.]

Graph Options
☑ Auto Increment
☑ Show Best Fit
☐ Show Current Avg (F/B)
☐ Show Other Avg (F/B)
☑ Show Legend

Avg # Readings: 15
Slope: .0000 in./ft
Tol. (+/-): .0005 in.
☐ Manual Data Entry

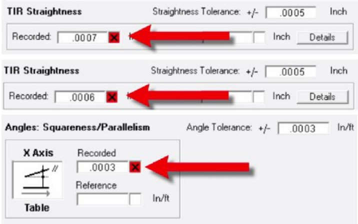
Target 1: + .0017
Previous Reading: —
#1 Light Level OK
#1 Tgt Battery OK
☑ ZeroTgt 1
Straight. Tgt. 1: .0000 in.

Target 4: - .0005
Previous Reading: —
#4 Light Level OK
#4 Tgt Battery OK
☑ ZeroTgt 4
Straight. Tgt. 4: .0000 in.

Timed Recording: ☐ 10 sec

F2. X-Axis Table : Table Side to Side Motion

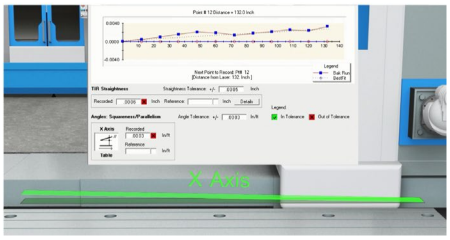
5. The X-Axis results show a Straightness error of .0007 in. TIR and a Flatness error of .0006 in. TIR. The slope of the Best Fit line is .0003 in/ft, which means the X-Axis is sloping UP relative to the table.



TIR Straightness
Straightness Tolerance: +/- .0005 Inch
Recorded: .0007 ☒ Inch

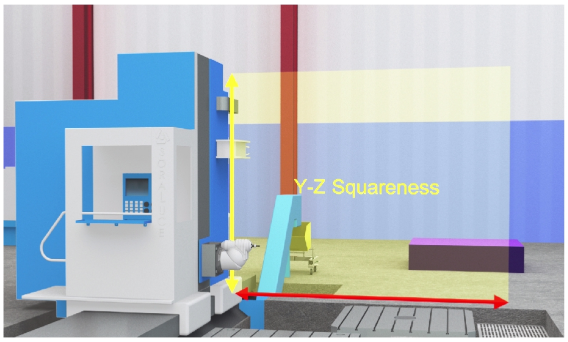
TIR Straightness
Straightness Tolerance: +/- .0005 Inch
Recorded: .0006 ☒ Inch

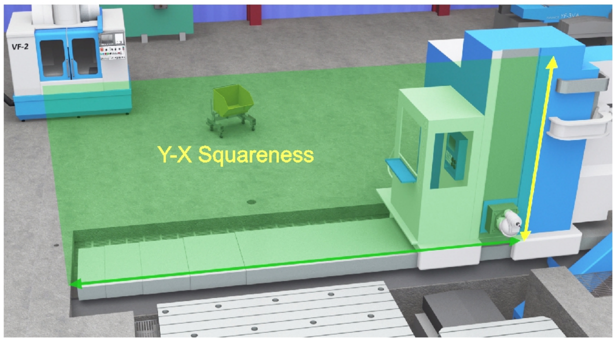
Angles: Squareness/Parallelism
Angle Tolerance: +/- .0003 In/ft
X Axis / Table
Recorded: .0003 ☒
Reference: In/ft

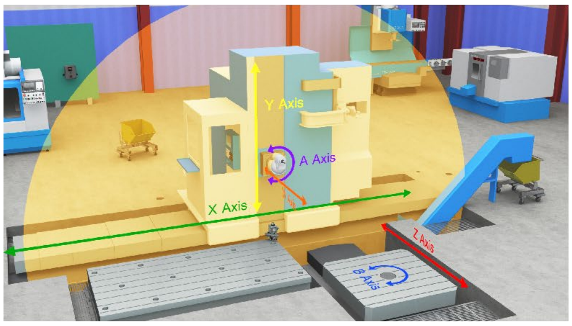


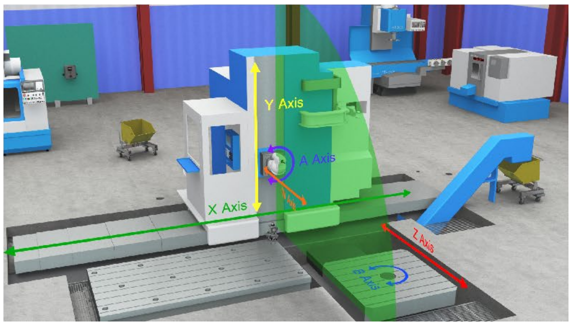
Y-Axis Flatness and Straightness and Y-Z / Y-X Squareness

After measuring the Y-Axis flatness and straightness, the Machine Geometry software calculates the Y-Z and Y-X Squareness. The Gold Plane (bottom left) measures Y Flatness and the Green Plane (bottom right) measures Y Straightness.

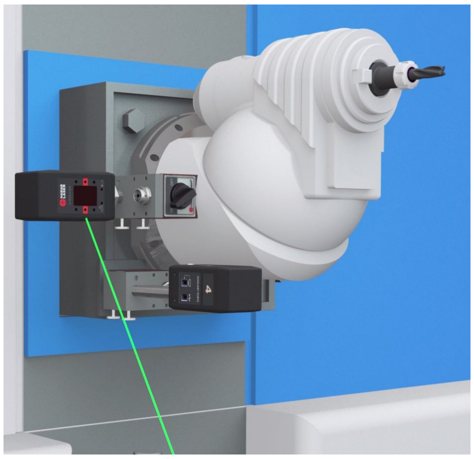




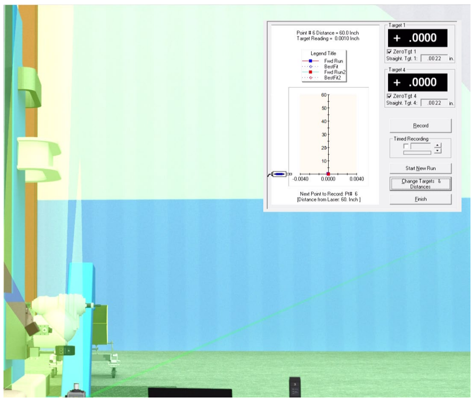




1. To measure the Y-Axis, move the second target to the side of the spindle and adjust the column and target height to center the laser in the window.



2. Turn on the laser rotation and zero the targets.



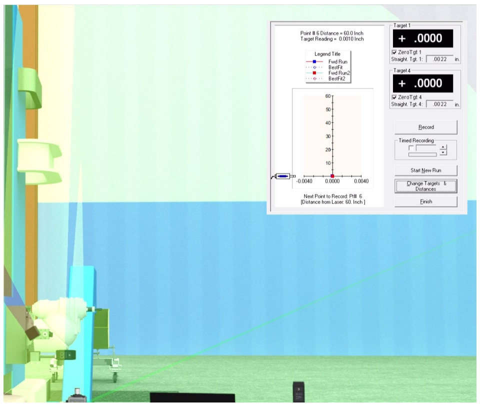
Point # 6 Distance = 60.0 Inch
Target Reading = 0.0010 Inch

Target 1: + .0000
☑ ZeroTgt 1
Straight. Tgt. 1: .0022 in.

Target 4: + .0000
☑ ZeroTgt 4
Straight. Tgt. 4: .0022 in.

Next Point to Record: Pt# 6
[Distance from Laser: 60. Inch]

3. Move the column, pause a few seconds, and click **Record**. Repeat for each point.



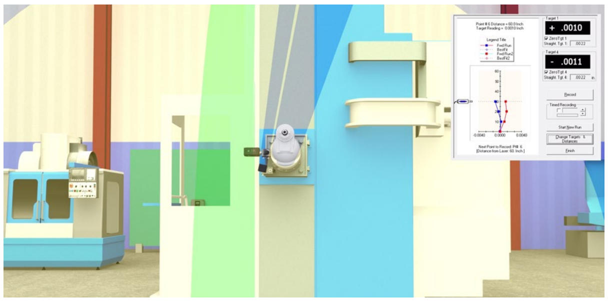
Point # 6 Distance = 60.0 Inch
Target Reading = 0.0010 Inch

Target 1: + .0000
☑ ZeroTgt 1
Straight. Tgt. 1: .0022 in.

Target 4: + .0000
☑ ZeroTgt 4
Straight. Tgt. 4: .0022 in.

Next Point to Record: Pt# 6
[Distance from Laser: 60. Inch]

4. The Gold Plane measures the squareness of the Y-Axis to Z and the Green Plane measures Y to X squareness.



Point # 6 Distance = 60.0 Inch
Target Reading = 0.0010 Inch

Target 1: + .0010
☑ ZeroTgt 1
Straight. Tgt. 1: .0022

Target 4: - .0011
☑ ZeroTgt 4
Straight. Tgt. 4: .0022 in.

Next Point to Record: Pt# 6
[Distance from Laser: 60. Inch]

As before, the Machine Tool Geometry software does the straightness and squareness calculations. The results show .0010" TIR for flatness and .0008" TIR for straightness.

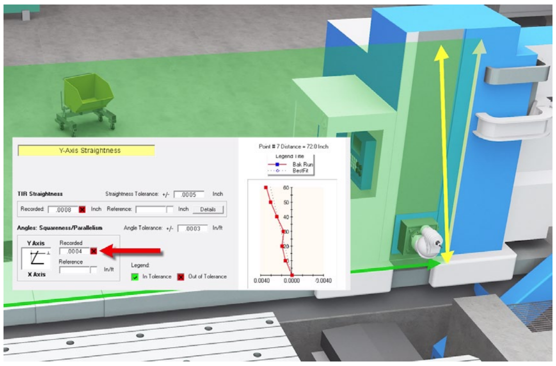
TIR Straightness Straightness Tolerance: +/- .0005 Inch

Recorded: .0010 ☒ Inch

TIR Straightness Straightness Tolerance: +/- .0005 Inch

Recorded: .0008 ☒ Inch

6. The X-Y Squareness is .0004 in/ft, meaning the column is leaning to the left.



Y-Axis Straightness

TIR Straightness Straightness Tolerance: +/- .0005 Inch

Recorded: .0008 ☒ Inch Reference: ☐ Inch

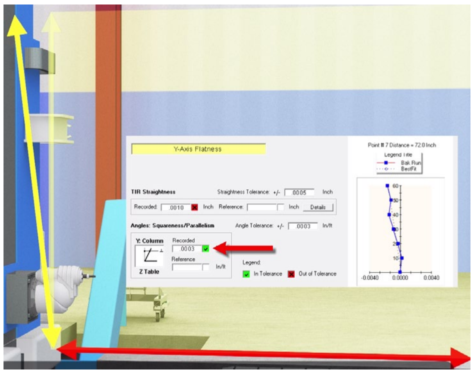
Angles: Squareness/Parallelism Angle Tolerance: +/- .0003 In/ft

Y Axis / X Axis — Recorded: .0004 ☒ Reference: ☐ In/ft

Legend: ✓ In Tolerance ☒ Out of Tolerance

Point # 7 Distance = 72.0 Inch

7. The squareness of Y to the tables is .0003 in/ft, meaning the column is leaning back.



Y-Axis Flatness

TIR Straightness Straightness Tolerance: +/- .0005 Inch

Recorded: .0010 ☒ Inch Reference: ☐ Inch

Angles: Squareness/Parallelism Angle Tolerance: +/- .0003 In/ft

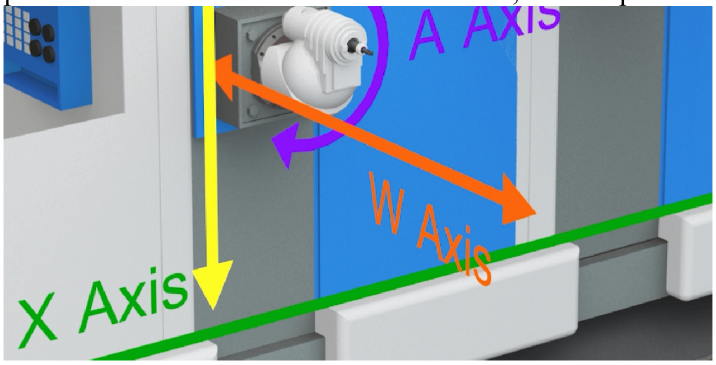
Y: Column / Z Table — Recorded: .0003 ✓ Reference: ☐ In/ft

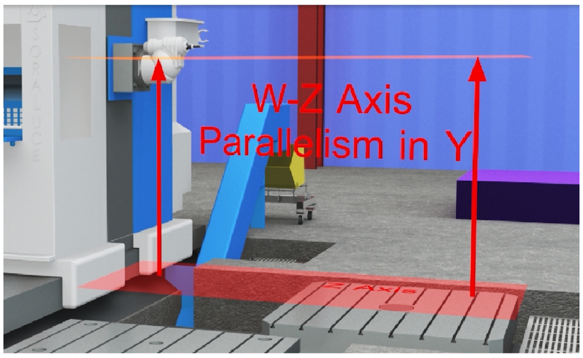
Legend: ✓ In Tolerance ☒ Out of Tolerance

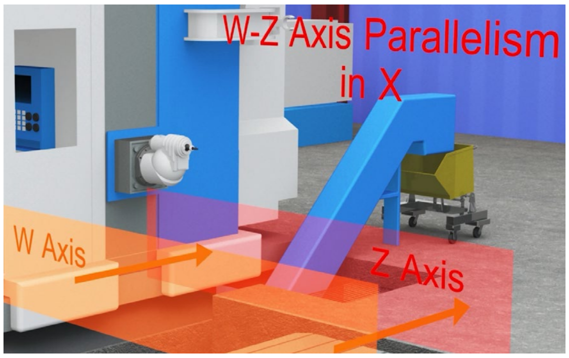
Point # 7 Distance = 72.0 Inch

W-Axis Flatness and Straightness, W-Z (in X) Parallelism, W-Z (in Y) Parallelism

Without changing the L-743 setup, the W-Axis can be measured for flatness and straightness and parallelism to the Z-Axis in the Y direction, and the parallelism to the Z-Axis in the X direction.







1. To set up for W, change the target position, turn on the laser rotation and adjust the spindle to center the laser.

Next Point to Record: Pt# 1
[Distance from Laser: 0. in.]

☑ Auto Increment
☑ Show Best Fit
☐ Show Current Avg (F/B)
☐ Show Other Avg (F/B)
☑ Show Legend
Avg # Readings: 15
Slope: .0000 in./ft
Tol. (+/-): .0005 in.
☐ Manual Data Entry

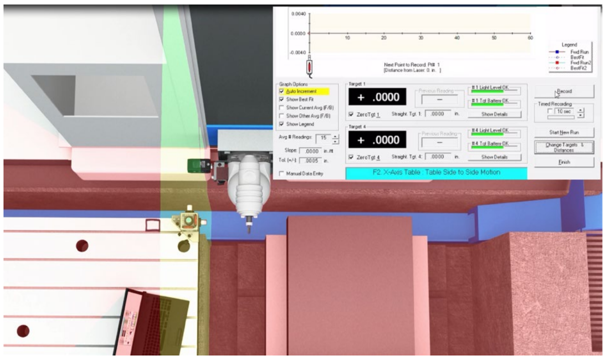
Target 1: off tgt
☐ ZeroTgt 1 Straight. Tgt. 1: .0000 in.
1 Light Level OK
1 Tgt Battery OK

Target 4: off tgt
☐ ZeroTgt 4 Straight. Tgt. 4: .0000 in.
4 Light Level OK
4 Tgt Battery OK

☐ 10 sec

F2. X-Axis Table : Table Side to Side Motion

2. Zero Targets #1 and #4. The green plane measures the straightness of W, W-X squareness and parallelism to Z (in X).



Next Point to Record: Pt# 1
[Distance from Laser: 0. in.]

☑ Auto Increment
☑ Show Best Fit
☐ Show Current Avg (F/B)
☐ Show Other Avg (F/B)
☑ Show Legend
Avg # Readings: 15
Slope: .0000 in./ft
Tol. (+/-): .0005 in.
☐ Manual Data Entry

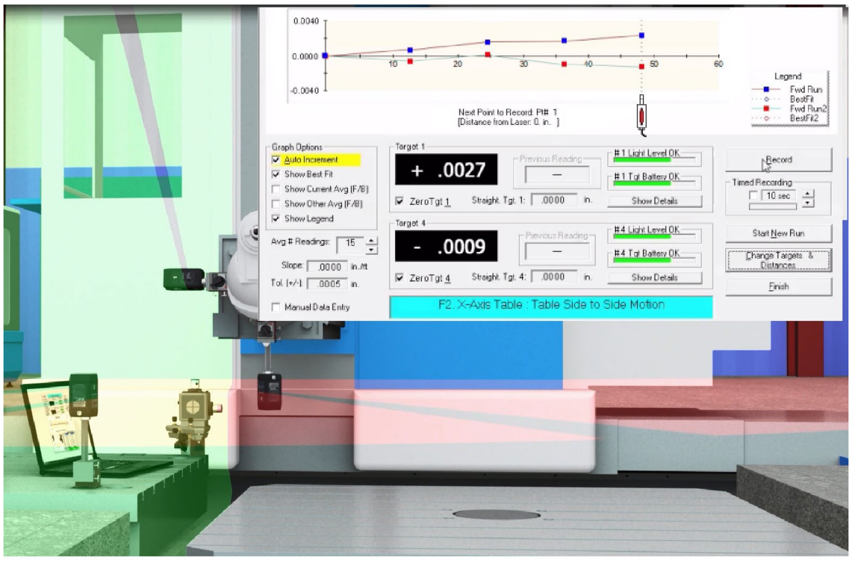
Target 1: + .0000
☑ ZeroTgt 1 Straight. Tgt. 1: .0000 in.
1 Light Level OK
1 Tgt Battery OK

Target 4: + .0000
☑ ZeroTgt 4 Straight. Tgt. 4: .0000 in.
4 Light Level OK
4 Tgt Battery OK

☐ 10 sec

F2. X-Axis Table : Table Side to Side Motion

3. The red plane measures the flatness of W, W-Y squareness and parallelism to Z (in Y). The software records the straightness of W and calculates the squareness and parallelism to the other axes. The results show .0003 in. for straightness and .0011 in. for flatness.



Next Point to Record: Pt# 1
[Distance from Laser: 0. in.]

Graph Options
☑ Auto Increment
☑ Show Best Fit
☐ Show Current Avg (F/B)
☐ Show Other Avg (F/B)
☑ Show Legend

Avg # Readings: 15
Slope: .0000 in./ft
Tol. (+/-): .0005 in.
☐ Manual Data Entry

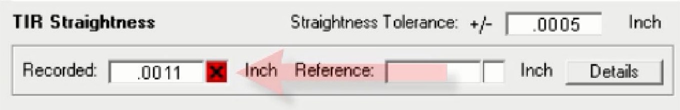
Target 1: + .0027
Previous Reading: —
#1 Light Level OK
#1 Tgt Battery OK
☑ ZeroTgt 1 Straight. Tgt. 1: .0000 in.

Target 4: - .0009
Previous Reading: —
#4 Light Level OK
#4 Tgt Battery OK
☑ ZeroTgt 4 Straight. Tgt. 4: .0000 in.

Timed Recording: ☐ 10 sec

F2. X-Axis Table : Table Side to Side Motion

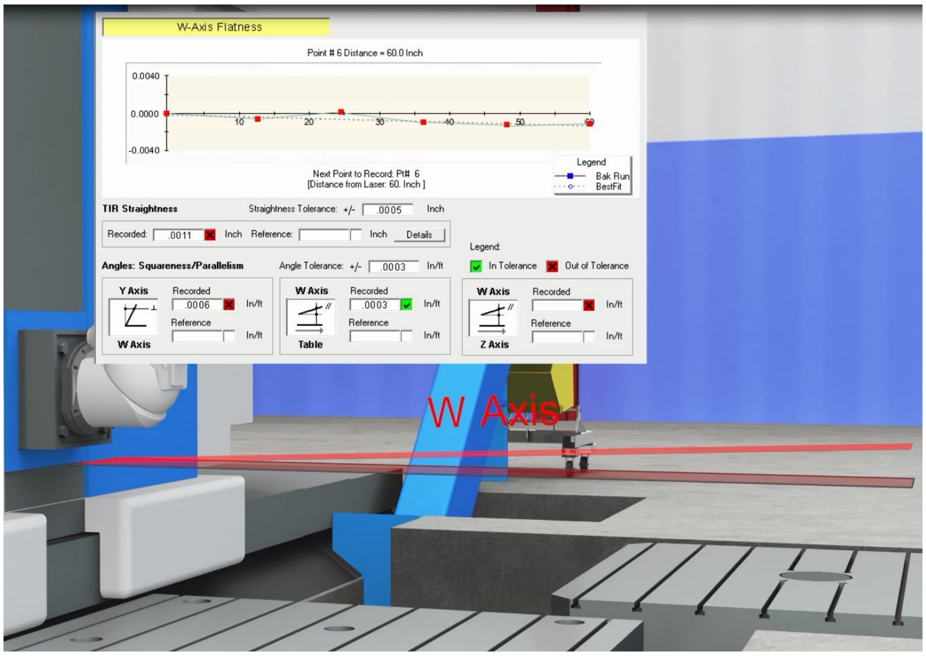
TIR Straightness Straightness Tolerance: +/- .0005 Inch
Recorded: .0003 ✓ In Inch



TIR Straightness Straightness Tolerance: +/- .0005 Inch
Recorded: .0011 ☒ Inch Reference: Inch

4. The slope of the vertical Best-Fit line is .0003 in/ft, meaning the W-Axis is sloping up from left to right relative to the table.

   For Z-W parallelism, Z must be measured first.



W-Axis Flatness

Point # 6 Distance = 60.0 Inch

Next Point to Record: Pt# 6
[Distance from Laser: 60. Inch]

TIR Straightness Straightness Tolerance: +/- .0005 Inch
Recorded: .0011 ☒ Inch Reference: Inch

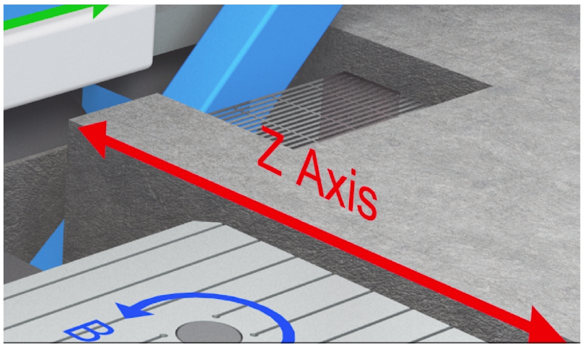
Angles: Squareness/Parallelism Angle Tolerance: +/- .0003 In/ft

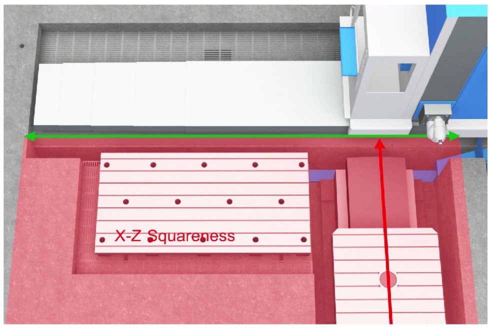
Legend: ☑ In Tolerance ☒ Out of Tolerance

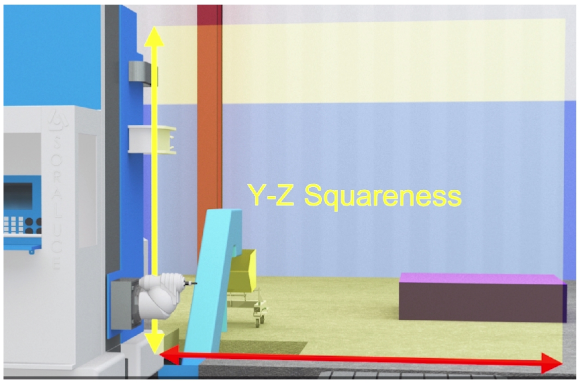
Y Axis / W Axis: Recorded .0006 ☒ In/ft; Reference In/ft
W Axis / Table: Recorded .0003 ☑ In/ft; Reference In/ft
W Axis / Z Axis: Recorded ☒ In/ft; Reference In/ft

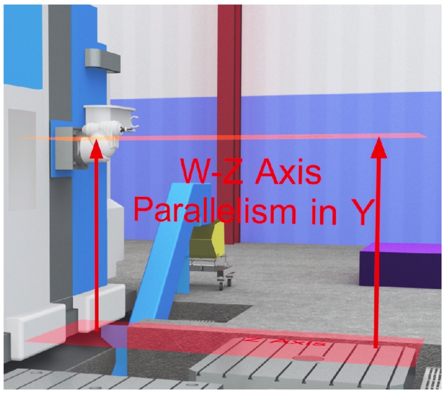
Z-Axis Flatness and Straightness, Z-X and Z-Y Squareness, Z-W (in X) Parallelism, Z-W (in Y) Parallelism

The final axis check is Z-Axis flatness and straightness, which provides the squareness to the X-Axis and the squareness to the Y-Axis. In addition, the parallelism for Z-W (in Y) and Z-W (in X) can be determined.

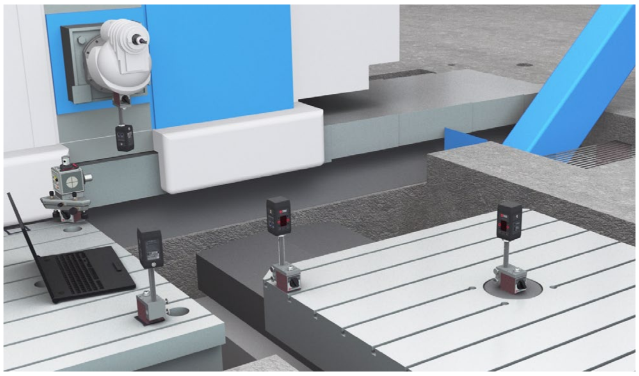






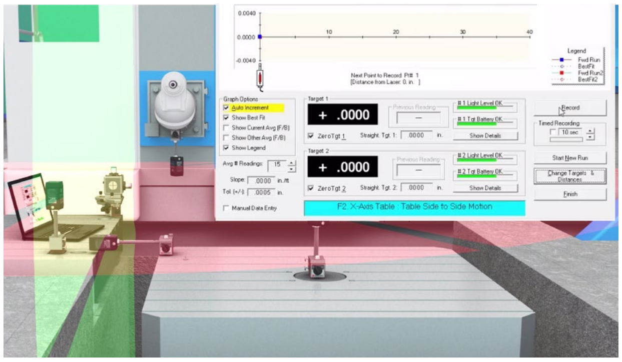


1. Leave the laser in position and re-position the targets. To measure Z-Axis flatness, use the red laser plane with Target #1 on the table.



2. For straightness, mount Target #2's post into the side hole in the magnetic base to pick up the green laser plane. Adjust the pole length for Target #2, turn on the green laser and zero the display.

   Repeat for Target #1 and the red laser plane. Now you're ready to measure.



Next Point to Record: Pt# 1
[Distance from Laser: 0. in.]

☑ Auto Increment
☑ Show Best Fit
☐ Show Current Avg (F/B)
☐ Show Other Avg (F/B)
☑ Show Legend
Avg # Readings: 15
Slope: .0000 in./ft
Tol (+/-): .0005 in.
☐ Manual Data Entry

Target 1
+ .0000
# 1 Light Level OK
# 1 Tgt Battery OK
☑ ZeroTgt 1 Straight. Tgt. 1: .0000 in.

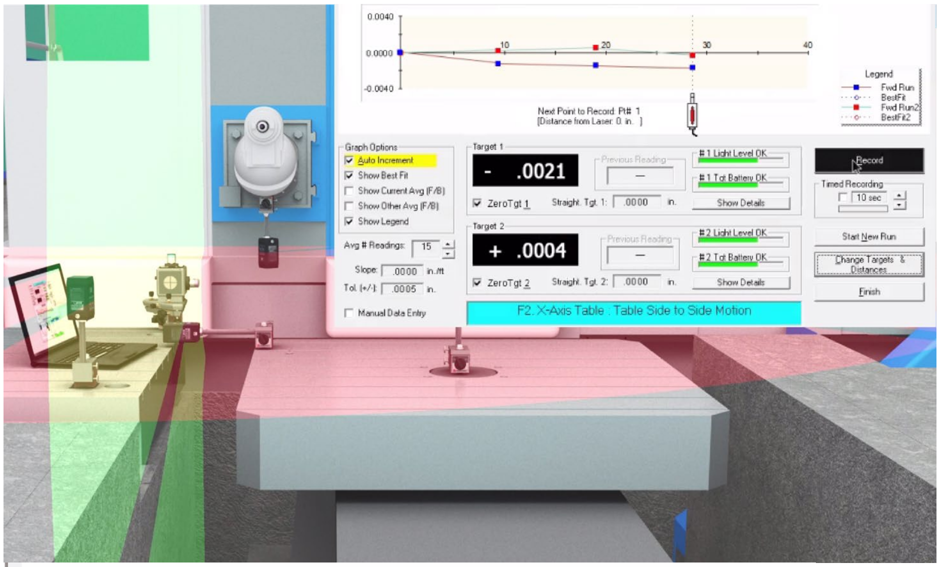
Target 2
+ .0000
# 2 Light Level OK
# 2 Tgt Battery OK
☑ ZeroTgt 2 Straight. Tgt. 2: .0000 in.

☐ 10 sec

F2. X-Axis Table : Table Side to Side Motion

3. Record the data in the Machine Tool Geometry program and the parallelism and squareness are automatically calculated.

   The Z-Axis results show errors of .0005 in. for straightness and .0008 in. for flatness.



Next Point to Record: Pt# 1
[Distance from Laser: 0. in.]

Graph Options
☑ Auto Increment
☑ Show Best Fit
☐ Show Current Avg (F/B)
☐ Show Other Avg (F/B)
☑ Show Legend

Avg # Readings: 15
Slope: .0000 in./ft
Tol. (+/-): .0005 in.
☐ Manual Data Entry

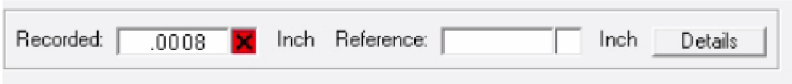
Target 1: - .0021
Previous Reading: —
☑ ZeroTgt 1
Straight. Tgt. 1: .0000 in.
#1 Light Level OK
#1 Tgt Battery OK

Target 2: + .0004
Previous Reading: —
☑ ZeroTgt 2
Straight. Tgt. 2: .0000 in.
#2 Light Level OK
#2 Tgt Battery OK

Timed Recording
☐ 10 sec

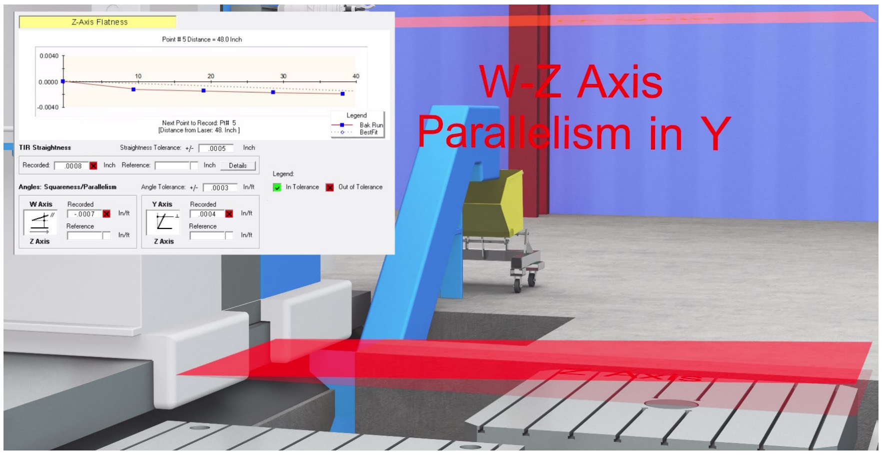
F2. X-Axis Table : Table Side to Side Motion

TIR Straightness
Straightness Tolerance: +/- .0005 Inch
Recorded: .0005 ✓ Inch



Recorded: .0008 ☒ Inch Reference: Inch

4. The slope of the vertical Best-Fit line is -.0007 in/ft, which means the Z-Axis is sloping up toward Y relative to W.



Z-Axis Flatness

Point # 5 Distance = 48.0 Inch

Next Point to Record: Pt# 5
[Distance from Laser: 48. Inch]

TIR Straightness
Straightness Tolerance: +/- .0005 Inch
Recorded: .0008 ☒ Inch Reference: Inch

Angles: Squareness/Parallelism
Angle Tolerance: +/- .0003 In/ft

W Axis / **Z Axis**
Recorded: -.0007 ☒ In/ft
Reference: In/ft

Y Axis / **Z Axis**
Recorded: .0004 ☒ In/ft
Reference: In/ft

Legend: ✓ In Tolerance ☒ Out of Tolerance

5. The horizontal Best-Fit slope is -.0003 in/ft, which means Z is sloping toward X relative to W.

Z-Axis Straightness

Point # 5 Distance = 48.0 Inch

Next Point to Record: Pt# 5
[Distance from Laser: 48. Inch]

TIR Straightness
Straightness Tolerance: +/- .0005 Inch
Recorded: .0005 ✓ Inch Reference: Inch

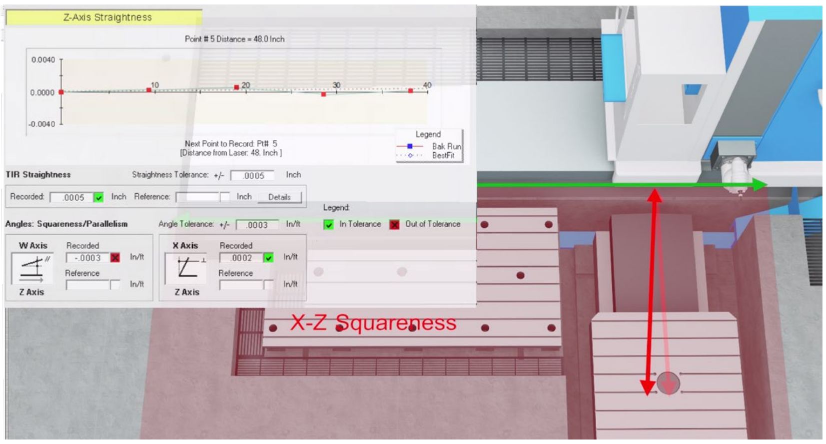
Angles: Squareness/Parallelism
Angle Tolerance: +/- .0003 In/ft

W Axis / **Z Axis**
Recorded: -.0003 ☒ In/ft
Reference: In/ft

X Axis / **Z Axis**
Recorded: .0002 ✓ In/ft
Reference: In/ft

Legend: ✓ In Tolerance ☒ Out of Tolerance

6. For Z squareness to X and Y, the Machine Tool Geometry program subtracts the Best-Fit slope of Z from the Best-Fit slopes of Y and X and calculates the squareness. Therefore, the result for the squareness of Z to X is .0002 in/ft, which means the Z-Axis is tilting to the left.


Z-Axis Straightness

Point # 5 Distance = 48.0 Inch

Next Point to Record: Pt# 5
[Distance from Laser: 48. Inch]

TIR Straightness — Straightness Tolerance: +/- .0005 Inch

Recorded: .0005 ☑ Inch — Reference: ☐ Inch — Details

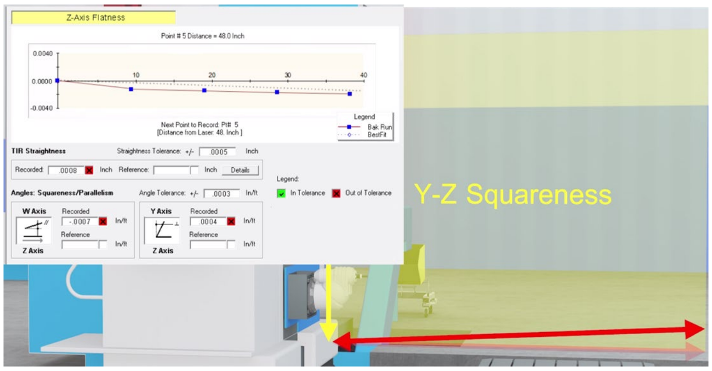
Angles: Squareness/Parallelism — Angle Tolerance: +/- .0003 In/ft

Legend: ☑ In Tolerance ☒ Out of Tolerance

W Axis / Z Axis — Recorded: -.0003 ☒ In/ft — Reference: ☐ In/ft

X Axis / Z Axis — Recorded: .0002 ☑ In/ft — Reference: ☐ In/ft

7. The squareness of Z to Y is .0004 in/ft, which means the Z-Axis is sloping up relative to Y.


Z-Axis Flatness

Point # 5 Distance = 48.0 Inch

Next Point to Record: Pt# 5
[Distance from Laser: 48. Inch]

TIR Straightness — Straightness Tolerance: +/- .0005 Inch

Recorded: .0008 ☒ Inch — Reference: ☐ Inch — Details

Angles: Squareness/Parallelism — Angle Tolerance: +/- .0003 In/ft

Legend: ☑ In Tolerance ☒ Out of Tolerance

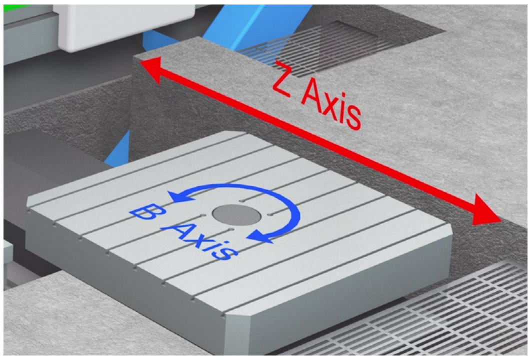
W Axis / Z Axis — Recorded: -.0007 ☒ In/ft — Reference: ☐ In/ft

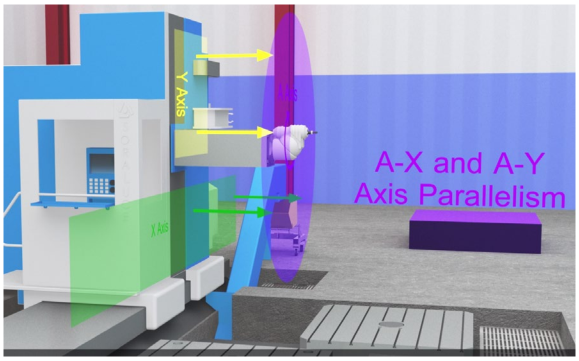
Y Axis / Z Axis — Recorded: .0004 ☒ In/ft — Reference: ☐ In/ft

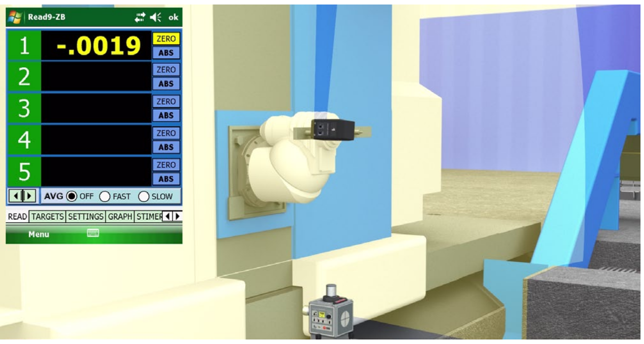
Additional Capabilities of the L-743 Machine Tool Alignment System

(Checking the A and B Rotary Axes and Tramming the Spindle)

- Rotation Flatness of Each Axis
- Squareness and Parallelism to Main Axes
  - A-X (in Z) Parallelism
  - A-Y (in Z) Parallelism
  - B-Z (in Y) Parallelism
  - B-X (in Y) Parallelism
  - Measuring the "tram," or squareness of A's spindle axis to X and Y






Read9-ZB

1 -.0019

2

3

4

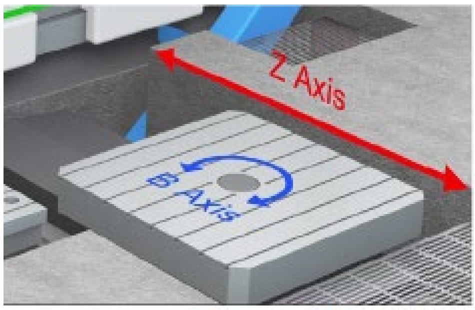
5

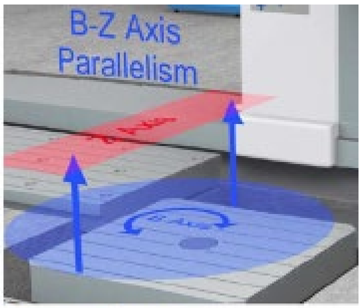
Measuring Rotary Axes

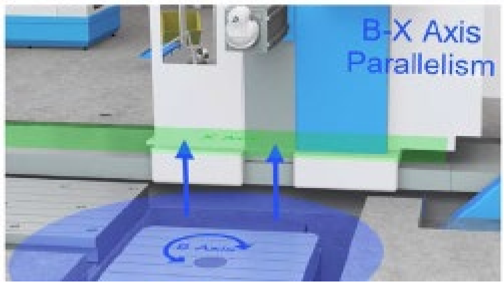
Checking A and B Rotary Axes and Tramming the Spindle

This section includes:

- Rotation flatness of each axis
- Squareness and parallelism to main axes
  - A-X (in Z) Parallelism
  - A-Y (in Z) Parallelism
  - B-Z (in Y) Parallelism
  - B-X (in Y) Parallelism
  - Measuring the "tram" or squareness of the A spindle axis to X and Y



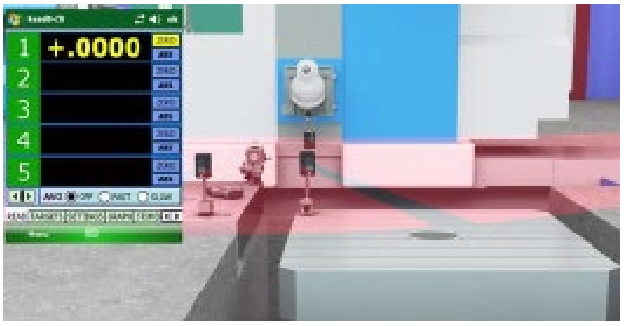




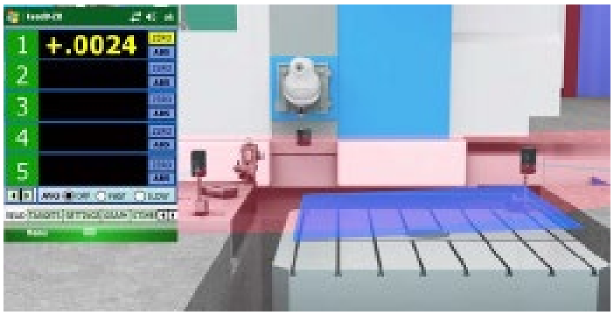
Please see Page 30 for details on how the L-743 is set up on the floor mill. In that section, we checked the flatness, straightness and squareness of the X, Y, W and Z axes. This section continues the alignment check (assuming the laser is still bucked-in to the five points, as shown in Part 1) to show how to check the rotary axes for alignment.

Checking the B-Axis Flatness of Rotation, B-Z (in Y) Parallelism and B-X (in Y) Parallelism

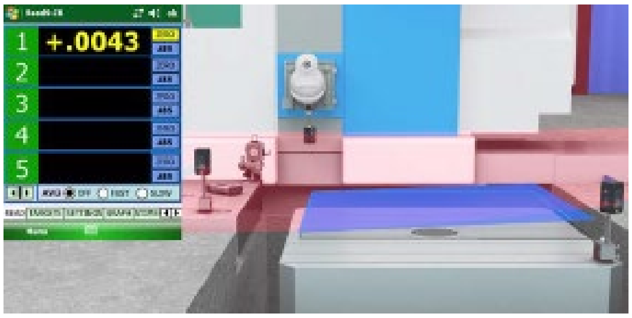
1. To check the B rotation, move the target to one of the corners of the table. Zero the display and then rotate the table 90 degrees.



2. The display shows +.0024, indicating that the table rose by .0024 as it rotated. Therefore, the rotation plane is sloping up from left to right relative to the main table (recall that the main table was the reference for the horizontal red laser plane).

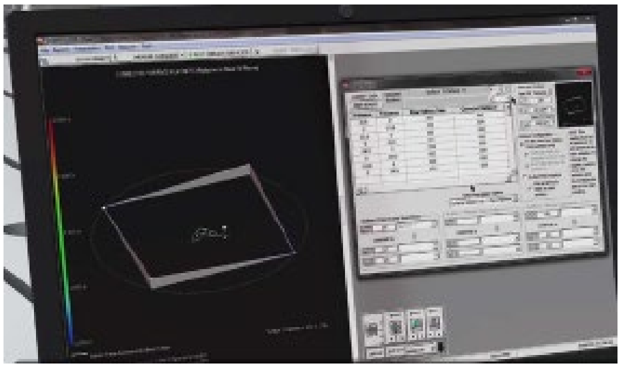


3. Rotate the table 90 degrees. The target now reads .0043, which is higher than the previous point and means the rotation plane is also sloping up and away from the spindle relative to the main table.

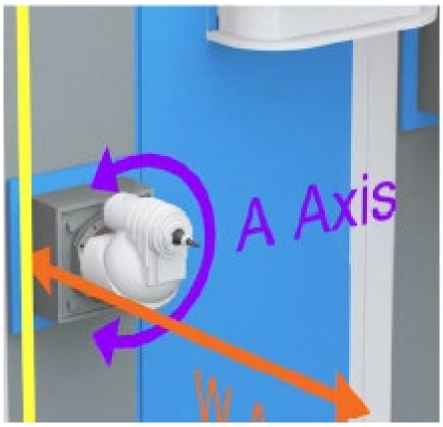


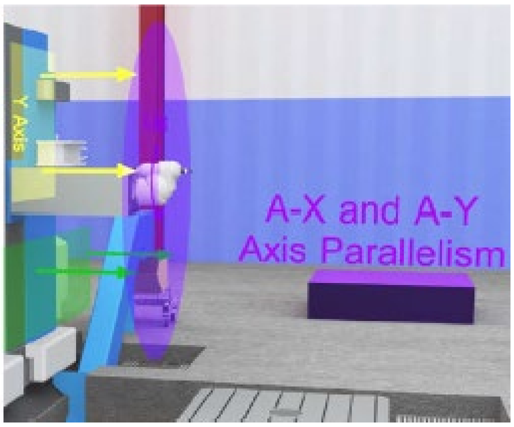
4. The last reading is .0031 and the data is uploaded to Plane 5 for analysis.

5. Plane5 analyzed the data and found that the flatness of rotation is .0010 in. TIR and the parallelism to X is .0011 in/ft and .002 in/ft to Z.



Checking the A-Axis Flatness of Rotation, A-X (in Z) Parallelism and A-Y (in Z) Parallelism



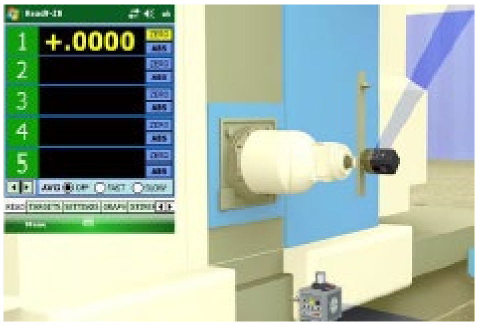


1. To measure the A rotation, use the gold laser plane and a target mounted on the spindle. For both the A-axis and the Tram measurements, a simple tram bar can be inserted into the spindle with a target attached.

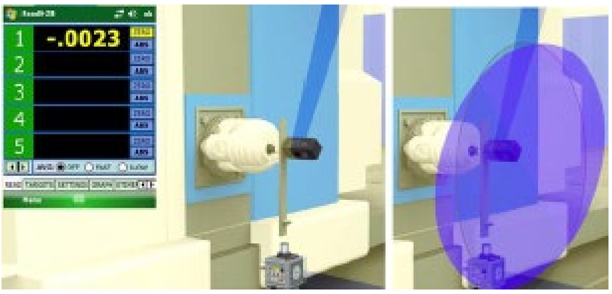
2. Adjust the ram and zero the target.

3. Rotate the A-axis 180 degrees. In this case, the reading is -.0011, which means the A rotation axis is tilting forward relative to the Y-axis by .0011 in 18 in.
   Note: *In Steps 3 and 5, the purple ellipse represents the measured plane. The transparent ellipse behind it represents the reference plane.*

4. Rotate to 90 degrees and zero the target.



5. Rotate to 270 degrees. This reading is -.0023, which means the A rotation axis is tilting toward the X-axis by .0023 in 18 in.
   Note: *In Steps 3 and 5, the purple ellipse represents the measured plane. The transparent ellipse behind it represents the reference plane.*



6. The last A-axis check is to measure the flatness of the rotation. Take measurements every 45 or 90 degrees and use Plane5 to calculate the flatness.

Tramming the Spindle

1. To measure the "tram" (squareness of the A spindle axis to X and Y), move the target to the end of the tram bar and rotate the spindle.

2. As with the A-axis, begin at 0 degrees, zero and rotate 180 degrees. The .0031 reading indicates the spindle axis is pointing upward relative to the Y-axis.

3. To compare the X-axis, start at 90 degrees and zero the PDA. Rotate to 270 degrees. The -.0019 reading indicates that the spindle axis is pointing to the left relative to the X-axis.

Measuring Sawmills

The critical alignments for a sawmill ensure that the log carriage is traveling straight and flat, is perpendicular to the blade, where the mill is cutting specific board lengths, and parallel to the blade, where the mill is cutting/shaping board lumber.

The L-733/L-743 Triple Scan Laser systems offer the fastest and most accurate way to align sawmills on the market today. They are easy to learn and quick to set up. Here is a rough procedure outlining how it's used.

Checking Log Carriage Straightness and Flatness/Level

1. The L-743 or L-733 is positioned at the end of the mill and is leveled, using the built-in level vials.

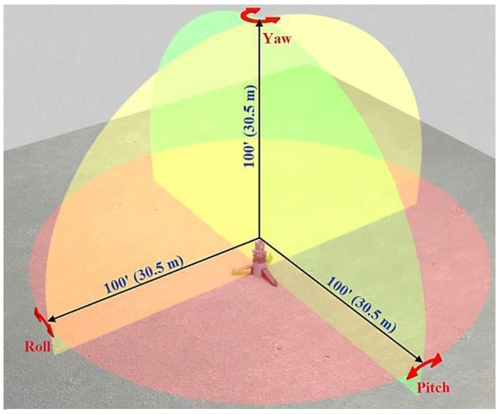


Figure 19 – *L-743 Triple Scan's three mutually perpendicular laser planes*

2. Two reference points are needed to align the laser to the machine centerline. Typically, a fixture is made to hold two A-1519-2.4ZB Targets to pick up the tight wire centerline mounting points. The fixturing positions the center of the targets to within .001 in. (0.025 mm) of the centerline jig location.
3. Each A-1519-2.4ZB is placed at end point of the machine and the L-733/L-743 is placed near one end of the mill. Then using the yaw adjustment on the L-743/L-733 laser base, the laser is adjusted so the targets in the far position and the near positions both read the same value. This means the laser is parallel to the reference points.

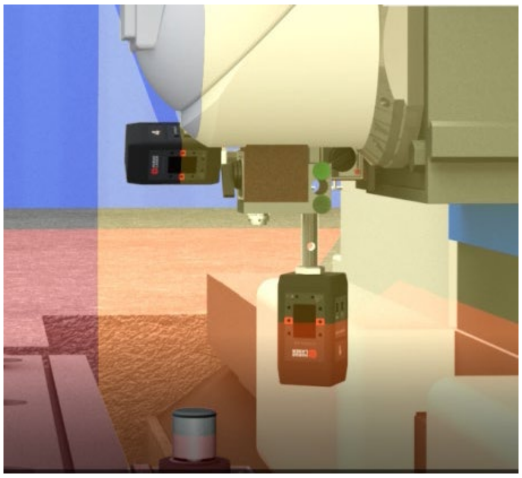
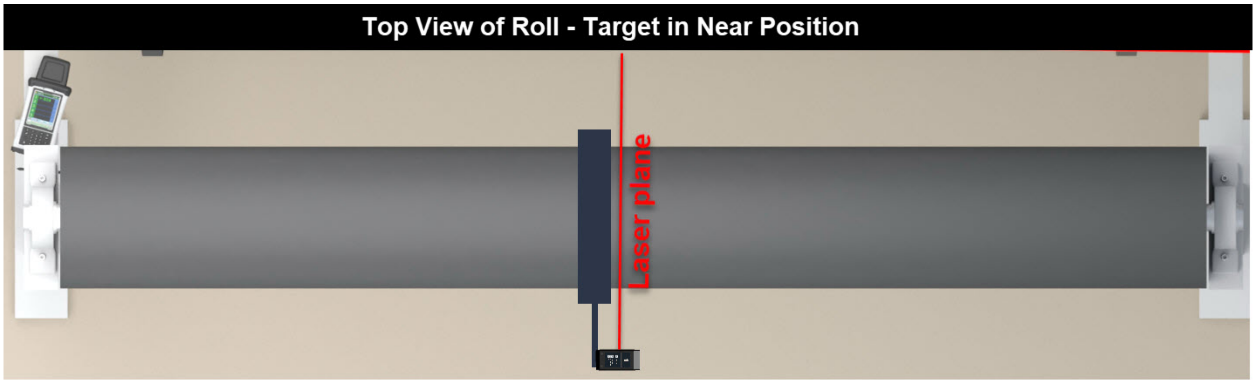


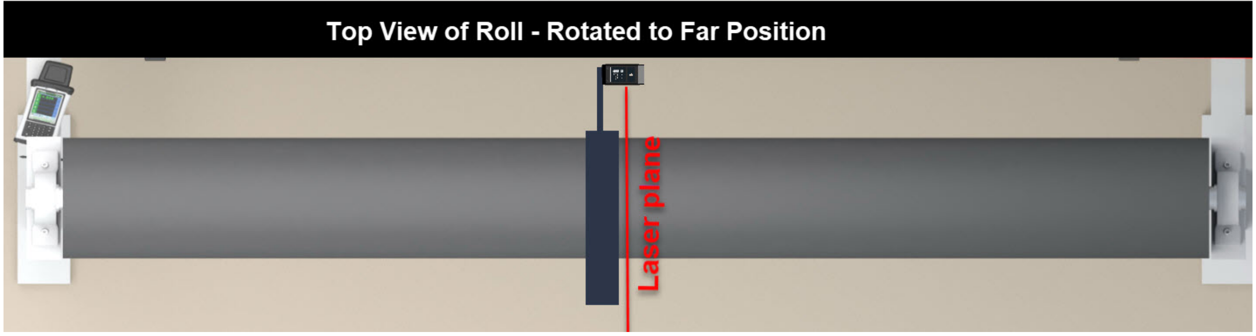
Figure 20 -- *Two A-1519-2.4ZB Targets mounted vertically and horizontally on a machine tool spindle*

4. Then the L-106X Laser Translation Stage is used to translate (move the laser with very little angular change) the laser plane so both targets read close to zero, usually the tolerance is .010 in. (0.25 mm). This means the laser is now on the centerline of the machine.
5. Step 4 may need to be repeated a few times to get the laser aligned (bucked-in) to the reference points.
6. Mount an A-1519-2.4ZB Target on the log carriage (or fixture to simulate the carriage) horizontally and adjust so that it detects the laser beam. A second A-1519-2.4ZB can be mounted vertically on the carriage to measure flatness/level (this setup is similar to the machine tool setup in image shown in Figure 20). Now both A-1519-2.4ZB measuring targets on the carriage are zeroed at a location next to the laser.
7. To measure the straightness, the carriage is moved at user-specified intervals and any deviations from zero are noted or recorded. Since the readings update in real time, the target can be used as a digital indicator and the point can be brought into alignment by adjusting it until the reading is zero.
8. To measure the flatness/level, the vertical target is used in the same manner and at the same time as the horizontal target. Both the flatness/level and straightness can be measured and aligned at the same time.

Figure 21 -- *R-1356-2.4ZB PDA Readout showing data values for Targets #1, 2 and 3*

Checking Support Rollers for Squareness





The goal is to ensure the rollers supporting the logs are perpendicular to the machine centerline to prevent “wandering” of the logs to one side or the other.

With the same setup as above, make up a fixture that is mounted over the roll. It has a post that is approximately 12 in. long and the target is mounted horizontally, which will be used to “sweep the roll” (rotate the fixture/roll to put the target as close to the laser as you can and then sweep it through the arc to the other side).

First, zero the target in the near position. Then rotate the roll so the target/fixture are as far away from the laser as possible (far position). Any deviation from zero is a measure of how far out of square the roll is.

For example, if you take a tape measure and measure how far the target moves when you sweep it and then divide the alignment value at the far location, you have an angular measurement expressed in inches/inch. Therefore, if the sweep distance is 20 in. and you get .030 in. at the far location, the angle is = .030/20 = .0015 in/in. If the roll is 24 in. long, move it 24*.0015 in. = .036 in. to correct the error.

Checking Saw-Blade Squareness

When checking the squareness of a saw blade to the travel of the log carriage, the laser must be moved along the centerline (down the machine) from the initial setup location to within 12 to 18 in. (305 mm to 483 mm) of the blade. Here is how:

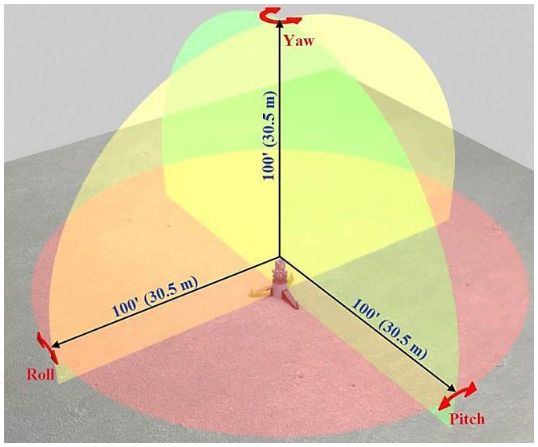


Figure 22 – *L-743 Laser showing three mutually perpendicular laser planes*

1. After roughly aligning the laser to the references, it is then "bucked in" as before to put the laser plane on the machine centerline.
2. Recall that the L-743/L-733 has three laser planes (two vertical and one horizontal) and they are all square to each other. This means that with the first vertical laser (yellow plane in the graphic) plane aligned to the machine's centerline, the second vertical laser plane (green) is perpendicular to it, so to measure squareness of a saw blade, mount a target horizontally on the closest point on the blade and zero it.
3. Rotate the blade 180 degrees and any deviation is how far out of square the blade is to the machine centerline.
4. If the blade is mounted on a carriage where the travel is supposed to be perpendicular to the centerline, you can simply zero the target in a close position and then move the blade carriage to the other end of its travel and any deviation noted in the value is a measure of the squareness error of the travel of the blade carriage.
5. Since the readings update in real time, the blade (or carriage) can be adjusted so that the reading is zero, which means it is perpendicular to the travel of the carriage.

Checking Saw-Blade Parallelism

To check the parallelism of saw blades that cut parallel to the carriage travel, the setup procedure for “straightness” above is followed.

Place the A-1519-2.4ZB target on the blade at the closest point to the laser (3:00) and zero. Rotate the blade 180 degrees so the target is at farthest point on the blade from the laser (9:00). Any deviation from zero is a measure of the parallelism errors of the blade to the carriage travel.

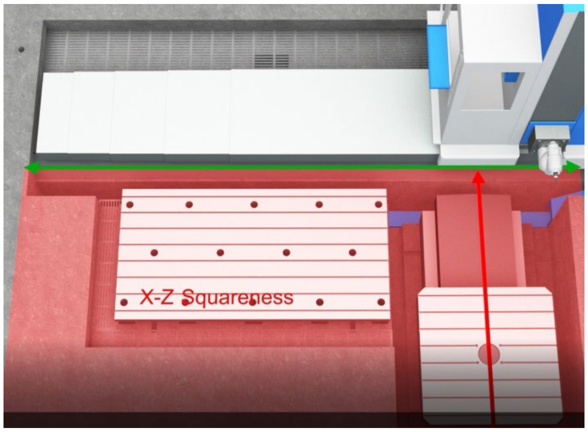


Figure 23 -- *Top View showing the L-743 Laser measuring squareness between the X and Z axes of a horizontal floor mill – similar to measuring a saw blade(Z) squareness to the mill’s centerline (X)*

Checking Plumbness of Blades

With the laser leveled, both vertical laser planes are plumb to earth and the plumbness of the blade can easily be checked.

1. Place a target on the blade at the 12:00 position and zero it.

2. Rotate the blade so the target is at 6:00 (or 3:00 or 9:00). Any deviation in the target reading is a measure of how far out of plumb the blade is.

Roll Alignment Buck-in and Laser Transfer Procedure

When aligning rolls, be they paper mill, printing presses or film lines, the most difficult alignment is the horizontal parallelism. The vertical parallelism or levelness can easily be checked using a machinist level. Hamar Laser provides two systems for roll alignment: The L-742W Ultra-Precision Roll Alignment System for printing presses and paper machines, and the L-732W Precision Roll Alignment System for lower-accuracy roll alignment applications, such as rubber mills and textiles.

Conventional methods of roll alignment usually use floor benchmarks (monuments) at the side of the machine as references. The L-742W (or L-732W) offers the versatility of using these benchmarks or of picking up a reference roll, such as a cooch roll on paper mills. We strongly believe that using a reference roll provides the most accurate reference and results in better alignments.

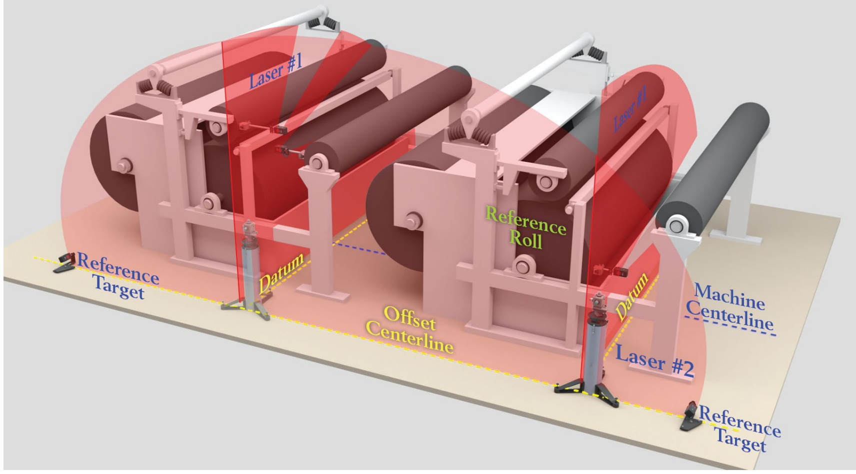


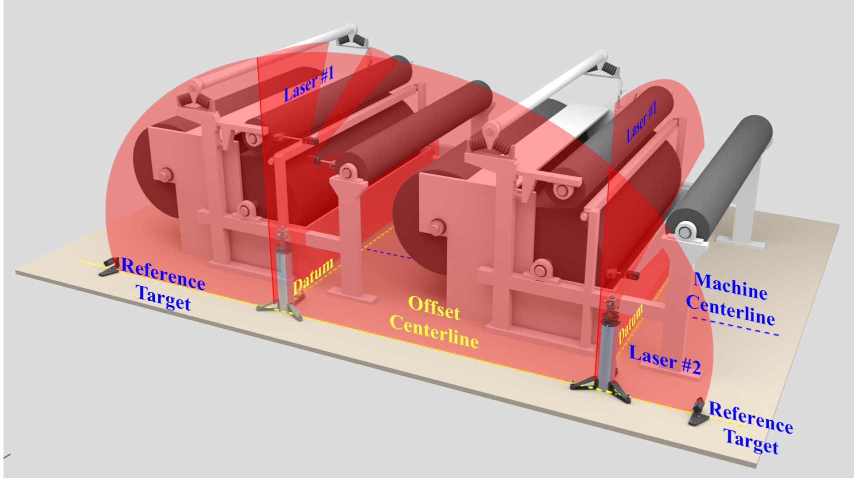
Figure 24 – *Dimensional View of Roll Alignment*

Benchmarks are usually set in a thin concrete floor, are rarely covered, and are routinely run over and nicked. More importantly, they move with the slab of concrete and rarely hold their position relative to the mill itself. Most floors in a typical plant have multiple slabs and are usually cracked throughout, creating instability of the monuments. Unless checked each time they are used, using the benchmarks probably will result in significant alignment errors.

The L-742 Alignment Procedure

Horizontal Roll Parallelism

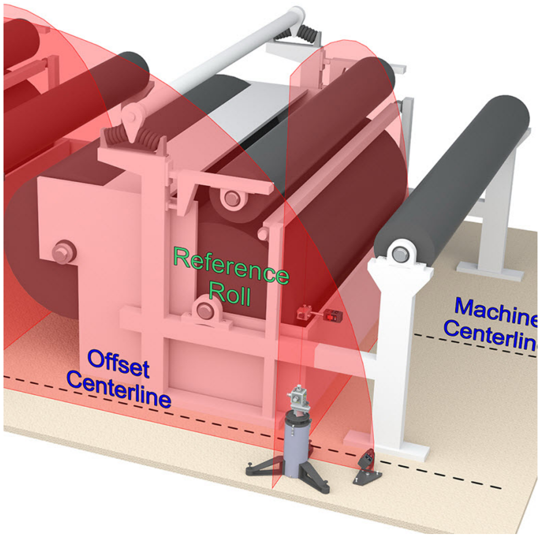
When aligning rolls for paper mills, printing presses or film lines, the most difficult alignment is the horizontal parallelism (vertical parallelism or levelness can easily be checked using a machinist level). The following section provides suggestions for choosing a reference and step-by-step procedures for equipment setup and performing an alignment.



L-742 Roll Alignment System Showing Laser Transfer Method

Choosing a Reference for Roll Alignment

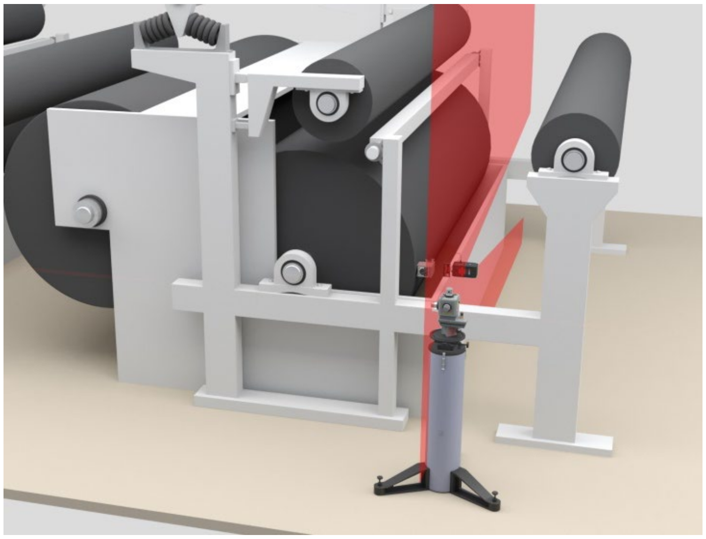
Conventional methods of roll alignment usually use floor benchmarks (monuments) at the side of the machine as references. The L-742/L-732 offer the versatility of using these benchmarks or of picking up a reference roll, such as a cooch roll on paper mills. We strongly believe that using a reference roll provides the most accurate reference and results in better alignments.



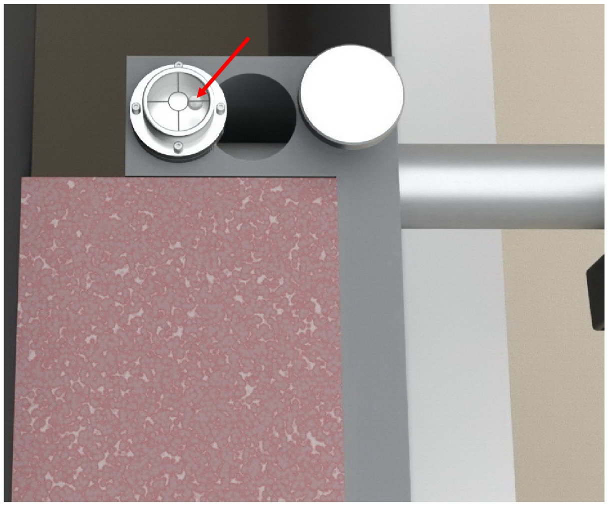
Benchmarks are usually set in a thin concrete floor, are rarely covered, and are routinely run over and nicked. More importantly, they move with the slab of concrete and rarely hold their position relative to the mill itself. Most floors in a typical plant have multiple slabs and are usually cracked throughout, creating instability of the monuments. Unless checked each time they are used, using the benchmarks probably will result in significant alignment errors.

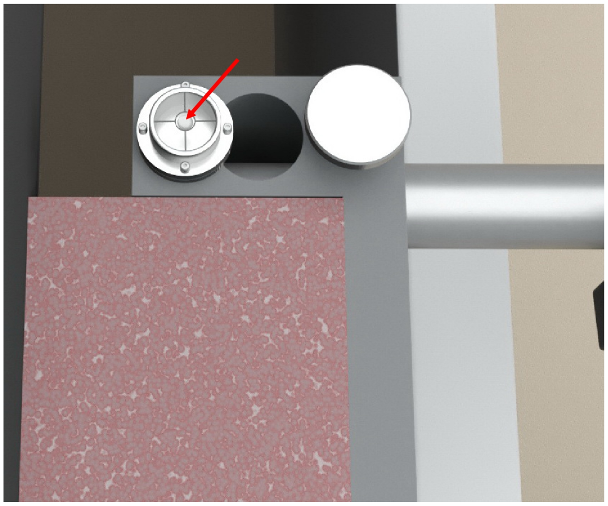
Here's how the process works for picking up a reference roll: (keep in mind that using the L-742W or L-732W is like having two walls, both perpendicular to each other, 100 ft. (30.5 m) in radius and very flat).

1. Place the L-742 on the L-106 stand outside the machine near the reference roll, at the side of the machine and level it. The L-742 Laser Plane #1 (LP#1) should be about 5 in. from the side of the roll to allow space for the A-1519-2.4ZB Targets to measure the roll.

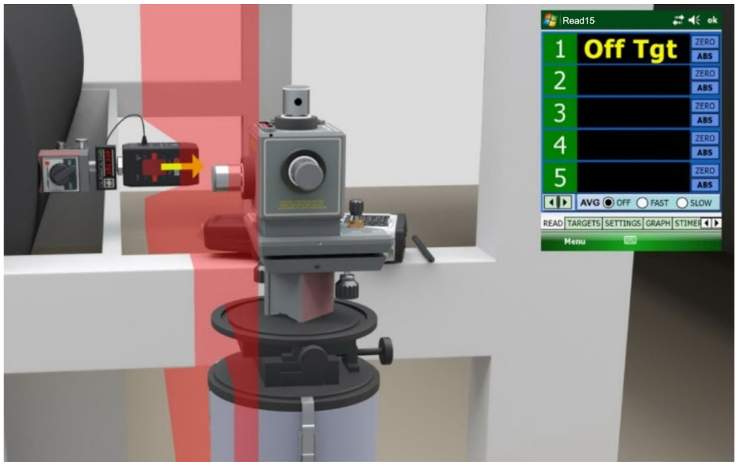


2. Place A-1519-2.4ZB Target #1 on the reference roll horizontally at the closest point to the laser and mark the location on the roll. Slide the magnetic base slowly up/down (or rotate the roll) until the bubble is centered on the bulls-eye level. This puts the target at the Top Dead Center (TDC) of the roll.



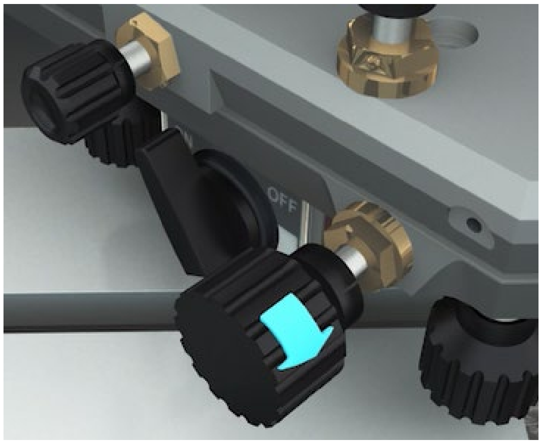


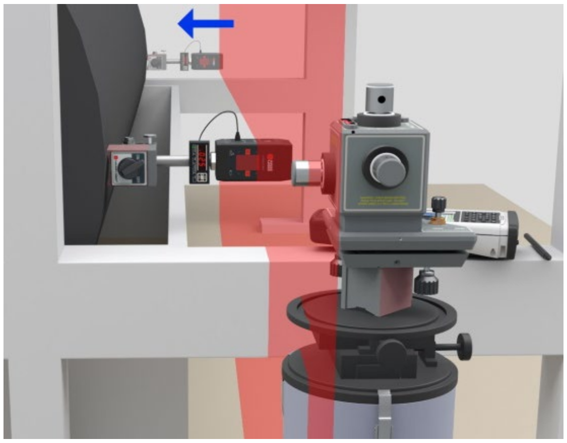
3. Adjust the height of the target by loosening the thumb screw and sliding the post in/out of the magnetic base until the target detects the laser plane.

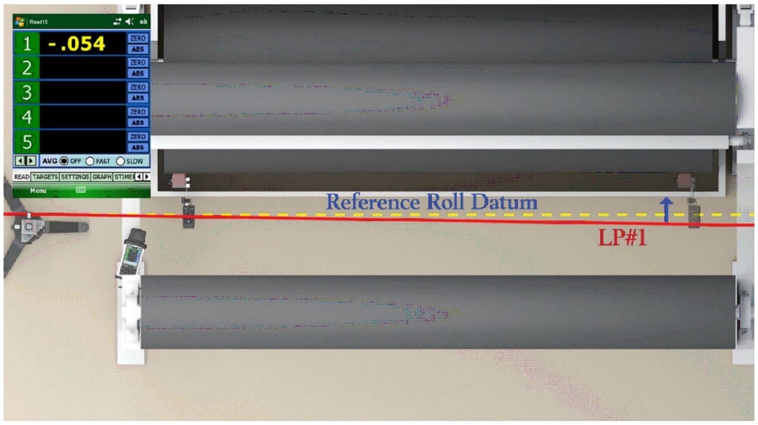


4. Zero the value for Target 1 using Read15 in the R-1356-2.4ZB PDA Readout and move the target to the far end of the roll. **Note:** *See **Using Read15 for Remote Buck-ins on Rolls** on Page 59 instead of following the manual buck-in method in Steps 4 through 6.*

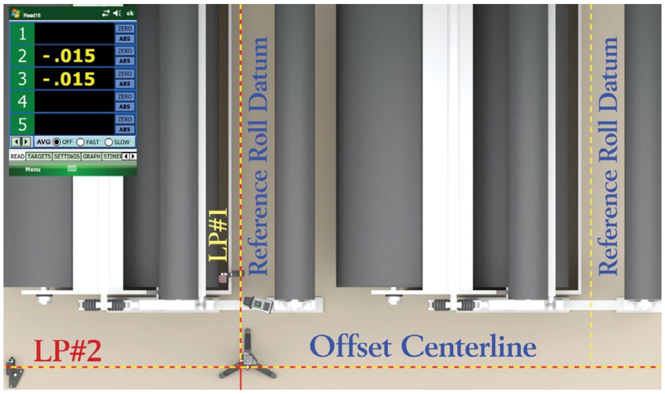
5. “Buck in” or tilt Laser Plane #1 (LP#1) using the Yaw Adjustment until Target #1 reads zero at the Far Point. Move Target #1 back to the Near Point, re-zero, and repeat the process until the target reads zero at both locations, which usually takes 2-3 tries. If using the Remote Buck-in Formula (see Page 63), this process can be done in one pass.





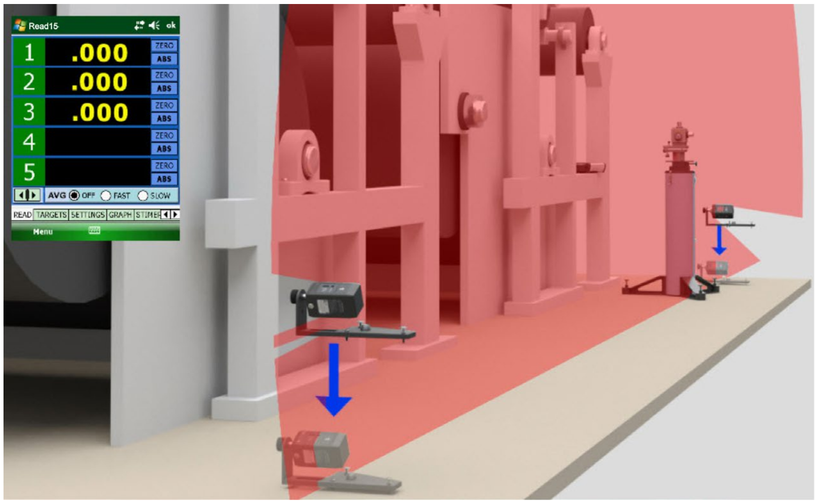


6. The laser plane is now parallel to the reference roll.

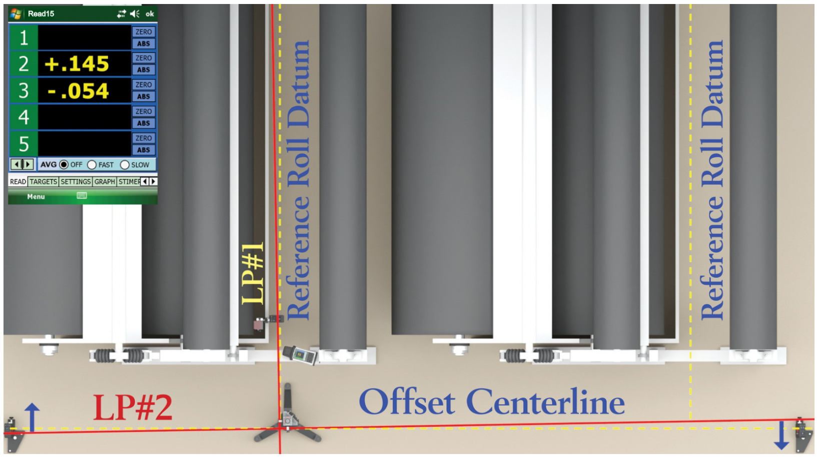


7. Since the LP#2 is perpendicular to LP#1, LP#2 becomes the offset centerline of the mill. This offset centerline has a range of 100 ft. (30.5 m) on either side of the laser.

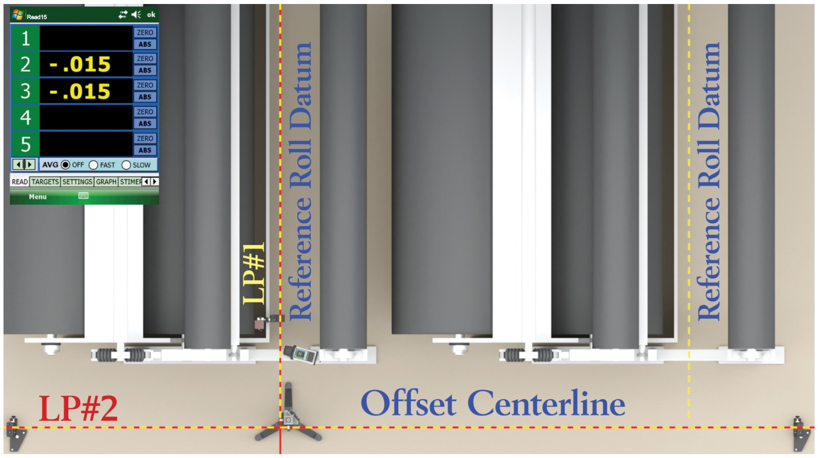
8. Place Target #2 and #3 on floor fixtures at both ends of the machine and adjust until the laser beam hits the middle of the target windows. Turn on LP#2 and the values for targets are then zeroed in Read15, establishing the offset centerline. These targets are *not* touched during the remainder of the alignment.



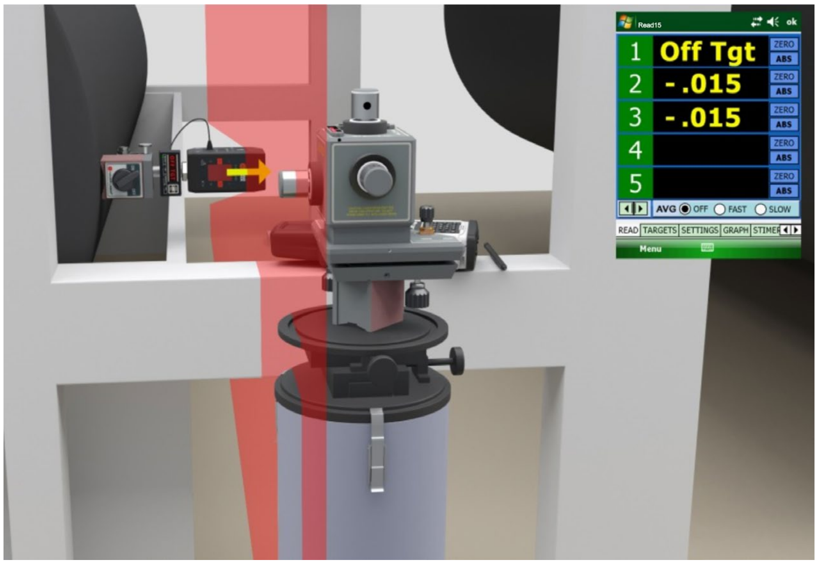
9. To check the parallelism of a section of rolls, move the L-742 and L-106 stand along the offset centerline to the desired machine section and position the laser so LP#1 is about 4-5 in. from the roll to be measured. Level the L-742.



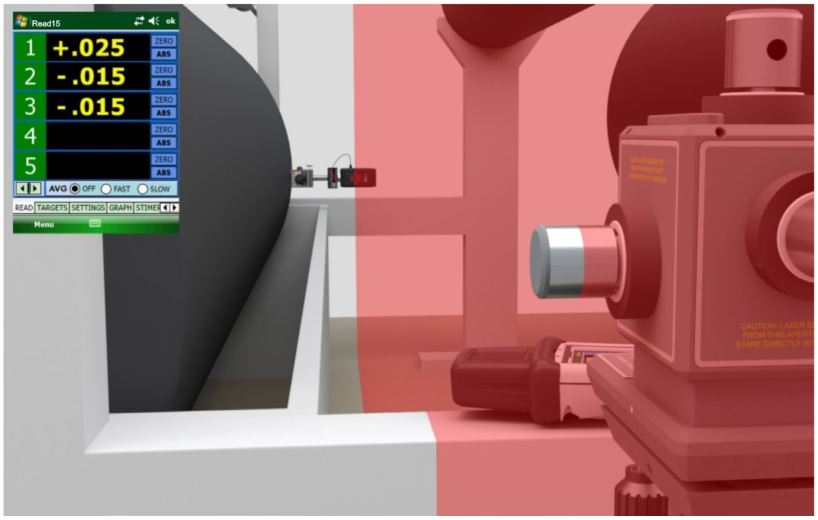
10. Adjust the yaw adjustment on the laser base so that LP#2 is tilted until both Target #2 and #3 show the same readings. LP#2 is now parallel to the offset centerline.
Note: ***Note:** The readings do not have to be zero, but just the same number and same sign.*



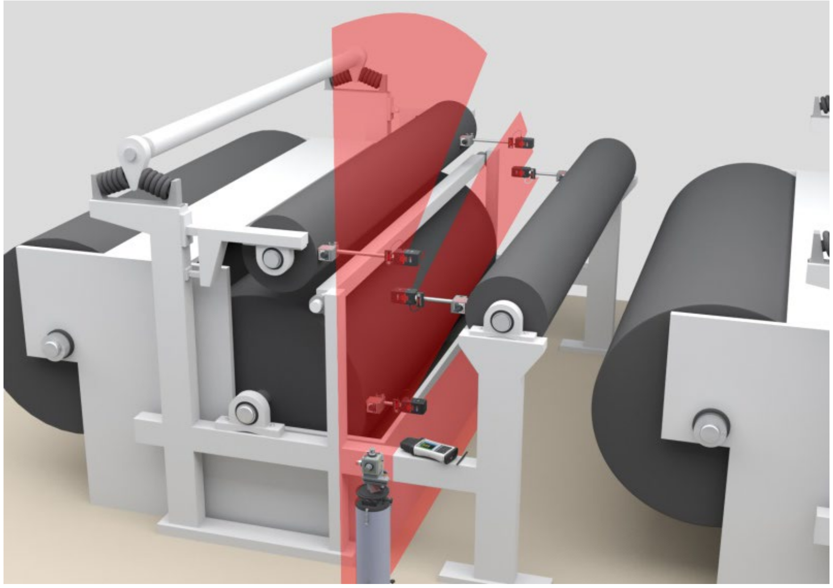
11. To measure one of the rolls for parallelism, place Target #1 horizontally on the roll closest to the laser. Adjust the post so the laser plane is near the center of the target. Move the magnetic base up/down the roll until the bubble is level. Zero Target #1 in Read15.



12. Move Target #1 to the far end of the roll. The resulting value is a measure of the parallelism of this roll relative to the reference roll. In this case, a plus (+) reading means the far end of the roll is pointing to the right by .025 in. To align it, adjust the roll until the readout shows zero, which means the roll is aligned and parallel to the reference roll.



13. Since the laser generates a plane, rolls at any elevation in that section that are within 2 ft. (610 mm) horizontally of the laser plane can be measured for parallelism without changing the setup of the laser.

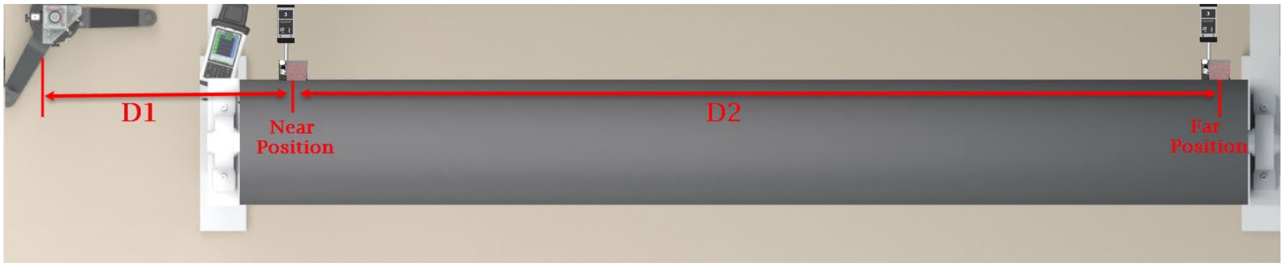


Remote Buck-in Formula

Often in Roll Alignment, the laser has to be far from the edge of the machine. In this case, the normal buck-in process does not work very well. To circumvent this, we use the Remote Buck-in Formula:

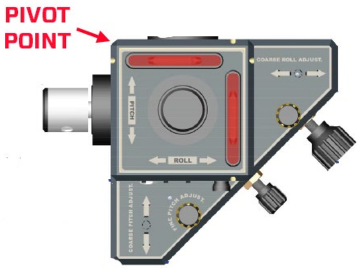
Set Point = -1 * (D1/D2) * Far Reading, where:
D1 = distance from laser base to Near Point target location on the roll.
D2 = distance from the Near Point target location to the Far Point target location on the roll.
Far Reading = the value in the PDA with the target zeroed at the Near Point and moved to the Far Point.

After calculating the Set Point, put the target back on the Far Point. Then adjust the L-742 Yaw Axis until the target value equals the Set Point. When you move the target back to the Near Point, you will see the reading is the same as the Set Point. This means it's bucked in. Taking care with the dimension measurements will result in doing the buck-in in one pass.



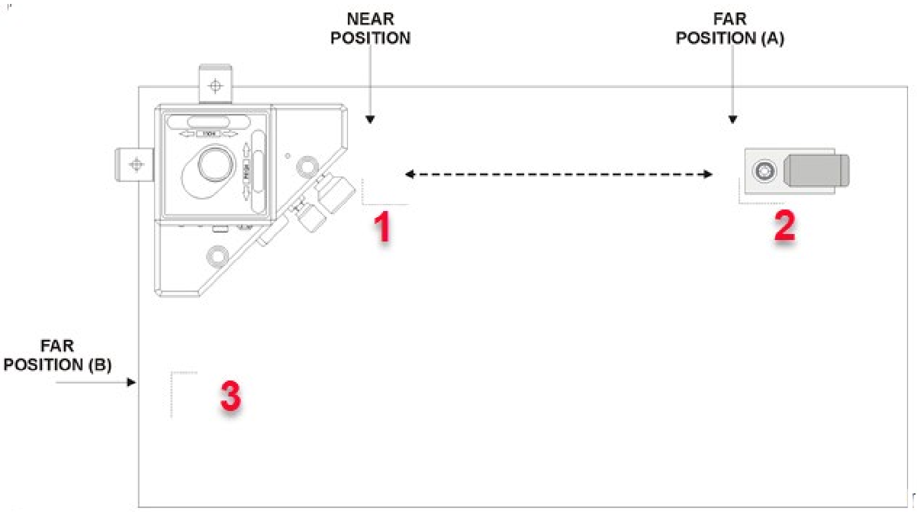
Using Read15 for Remote Buck-Ins on Rolls

The **Two-Point Buck-in** tab is used to make the process of making the laser parallel (bucked-in) to two reference points easier. There is a short procedure to follow that requires measuring the dimensions between the target and laser. When done with this procedure, the laser will be “bucked-in” (made parallel to) two points on a surface.



Step 1 – Setup

a. Select the Target ID to use by using the dropdown menu.
b. Select a location to place the laser.
c. Select the *Near* and *Far* reference point locations on the surface to be measured (see Figure 25).
d. Measure the D1 dimension from the laser’s Pivot Point to the center of the target post on the *Near* reference point.
e. Measure the D2 dimension from the center of the target post on the *Near* reference point to the center of the target post on the *Far* reference point.
f. Enter the two dimensions in the entry boxes and click **Next**.



1 -.06992

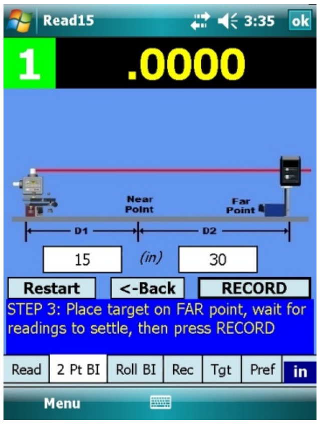
Target: ID = 1

15 (in) 30

Figure 25 -- *Recommended Buck-in points to measure the flatness of a surface.*

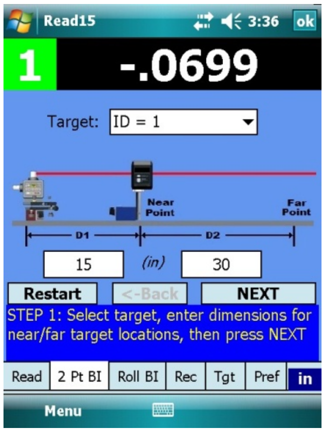
Step 2 – Zero Target and Record Data

a. Place the target on the Near point, and when the displayed readings settle down, tap the yellow ZERO button.



STEP 3: Place target on FAR point, wait for readings to settle, then press RECORD

b. Place the target on the *Far* point, and when the displayed readings settle down, press **RECORD**.



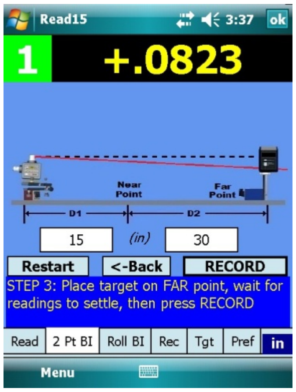
Target: ID = 1

15

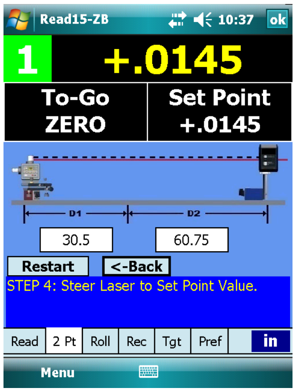
30

STEP 1: Select target, enter dimensions for near/far target locations, then press NEXT

c. Read15 calculates a Set Point, which is the value that you want the target to read when you finish tilting the laser beam. This bucks-in the laser to the two reference points.



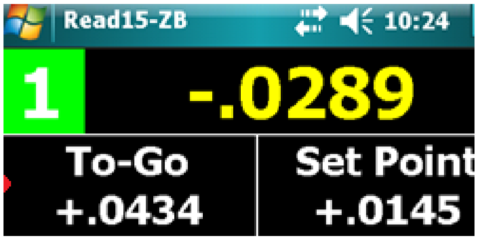
STEP 3: Place target on FAR point, wait for readings to settle, then press RECORD



STEP 4: Steer Laser to Set Point Value.

Step 3 – Tilt Laser to be Parallel to Reference Points

a. There are two ways to use the Set Point:
  - To Go – This is the amount the laser beam needs to be tilted until the Far point value is equal to the Near point value. Here you will tilt the laser until the To Go value is zero.
  - Set Point - This is the value you want the main display value to be set to. The laser is bucked-in when the display value equals the Set Point.



1 -.0289

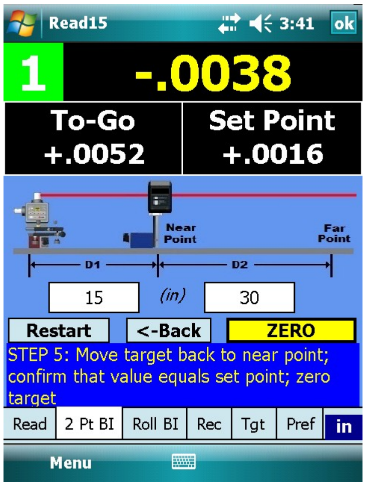
To-Go +.0434

Set Point +.0145

b. Tilt the laser until either the To Go value is zero or the display (yellow) value equals the Set Point.

c. Move the target back to the Near Point and the value should be equal to the Set Point.

d. If not, then repeat Steps 2 and 3 until the display values are zero at both the Near and Far points. The laser is now bucked-in to the two reference points for a line on a surface.



1 -.0038

To-Go +.0052

Set Point +.0016

D1: 15 (in) D2: 30

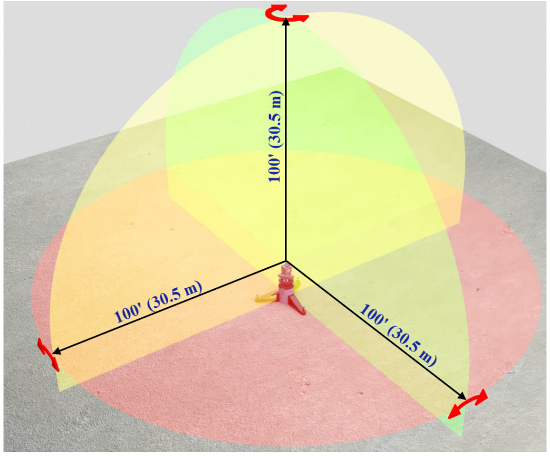
STEP 5: Move target back to near point; confirm that value equals set point; zero target

To measure the flatness (vertical straightness) in a *line* between the *Near* and *Far* points, move the target to another point on the surface and the display value will be a measure of that point's alignment relative to the reference points.

To measure a surface *plane*, you will need to find a third reference point and repeat Steps 1, 2 and 3 until the target reads zero on *all three* reference points (see Figure 25). When the laser is bucked-into three points, the entire surface can be measured (rather than just one line on the surface).

Leveling Rolls

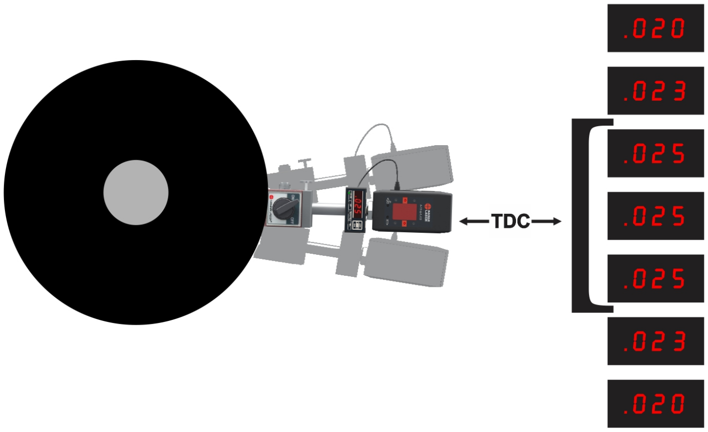
For checking level on applications with multiple rolls in the same horizontal plane, the L-743 or L-733 must be used since they have a horizontal laser plane in addition to the two vertical planes of the L-742W or L-732W. Level the laser, place a target on one end of the roll and zero. Move the target to the other end of the roll and measure the deviation from level. If both readings are zero, then the roll is level. If not, it can be adjusted using the target as an electronic indictor.



Arc Measurement Method - Sweeping Through the Arc

For hard-to-reach rolls that are farther than 2 ft. (610 mm) from the laser, or where the roll radius is greater than 2 ft., the Arc Measurement Method must be used to get accurate results. In this method, instead of using the bullseye level, the target is swept through an arc to find the Top Dead Center (TDC), or the highest point on the arc that is tangent to the laser plane. To do this, the target is attached to the roll and it is slowly rotated (or slid around it) until the highest value is determined (see procedure below).

Arc Measurement
Sweeping Through the Arc

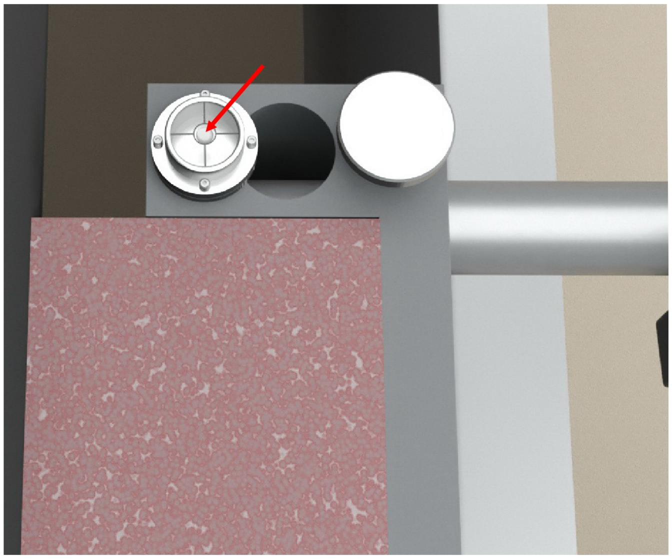


Slowly rotate the roll (or slide the V-block mag base or T-1600 Fixture around the roll) and watch the display on the R-1356 Readout. The highest number (most +) will be at TDC and this is the measurement value to record

When readings on the R-1356 stay the same as you rotate, you are at TDC

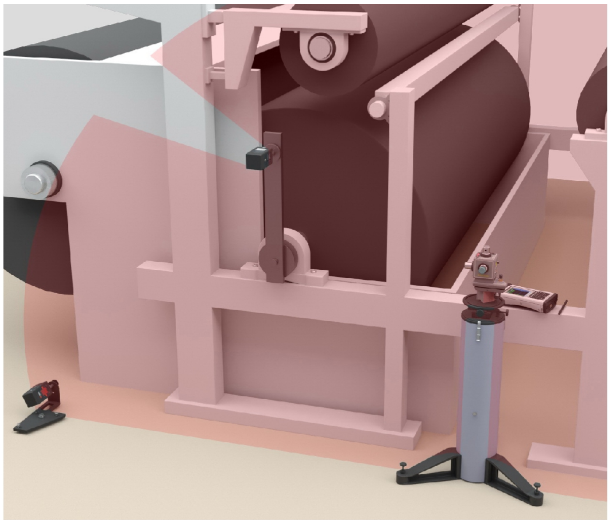
Arc Measurement Method Procedure

1. Set up the A-1519-2.4ZB Target magnetic base (or use the T-1600 as described below). Ensure that the level on the magnetic base or fixture is centered, indicating you are close to TDC.
2. Slowly slide (or rotate the roll) the target magnetic base (or T-1600 fixture) around the roll in one direction while watching the R-1356 display. If you see the target reading *decreasing* in value, stop and rotate in the opposite direction. You will then see the target value *increasing*. As you continue to sweep through the arc, you will notice the value stops increasing for a short time, and if you continue to rotate in the same direction, then you will notice the value will start to decrease again.
3. The highest reading (most positive) occurs when the target is at the TDC. This is the value to record as the measurement for that point.
4. This method should work for roll diameters or target rod lengths up to 6 ft. or 2 m.

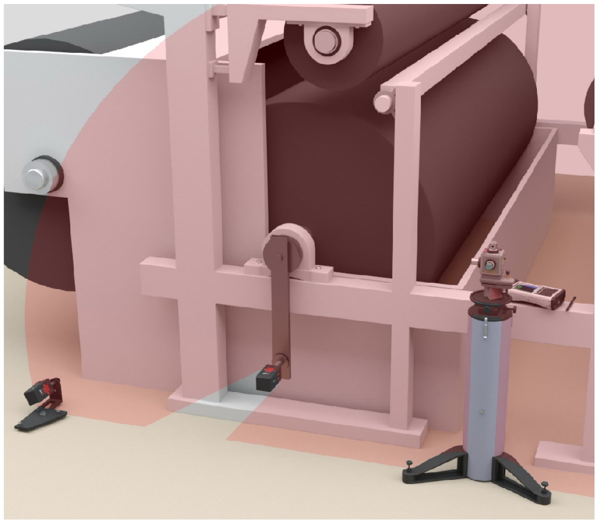


Tramming Method for Hard-to-Reach Rolls

1. There are times when the side of the roll is impossible to reach with the target. In this case, we can attach a tram bar to the end of the shaft and put the A-1519-2.4ZB Target on it. Rotate the shaft to 12:00 and zero it in Read15. Then rotate it to 6:00 and the deviation is a measure of how out of level the roll is *relative* to *earth level.*

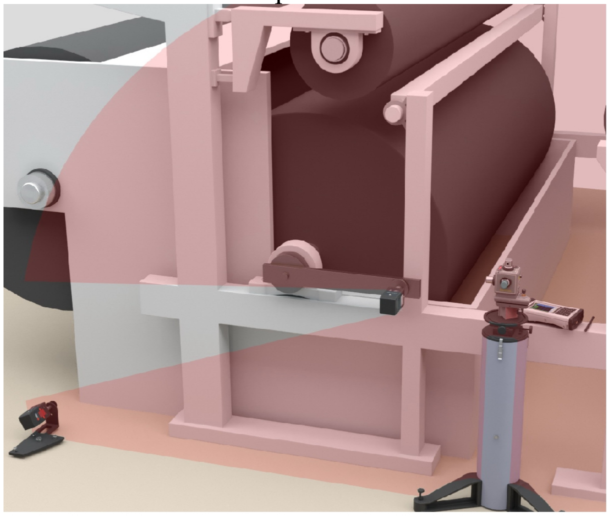


A-1519-2.4ZB Target at 12:00

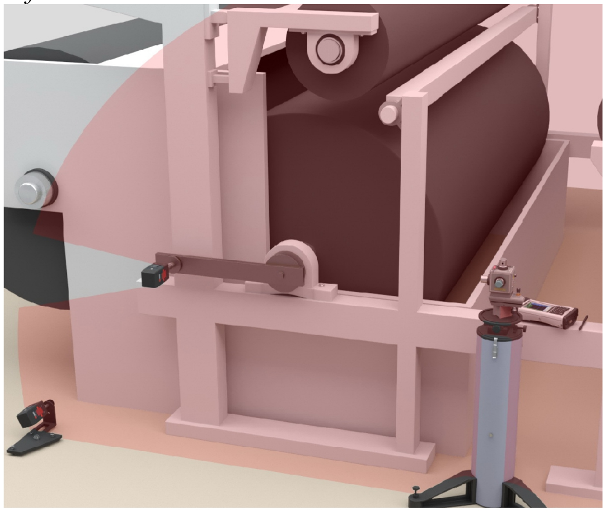


A-1519-2.4ZB Target at 6:00

2. For the horizontal parallelism, rotate the shaft to 3:00 and zero it. Then rotate it to 9:00 and this gives you a measure of how out of parallel the roll is *relative* to the *reference roll*.



A-1519-2.4ZB Target at 3:00

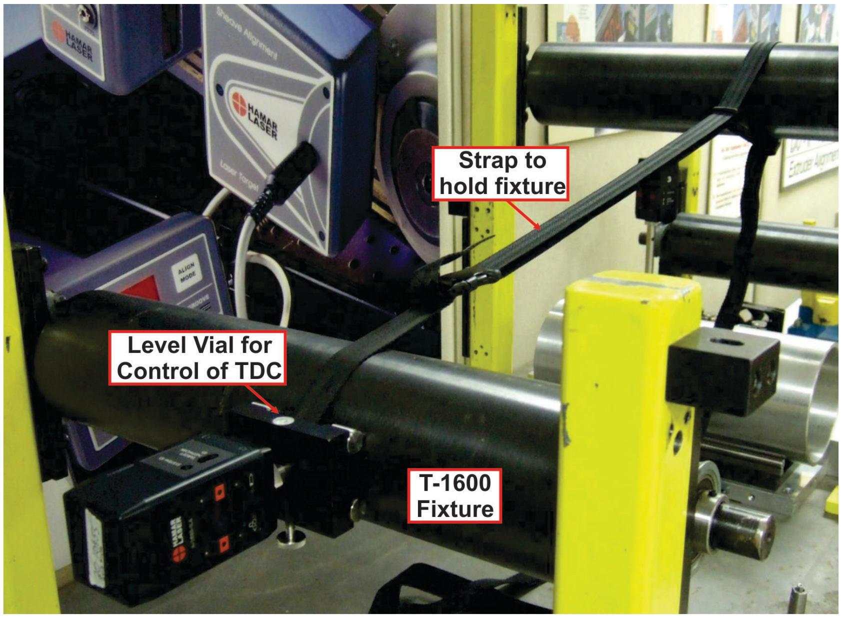


A-1519-2.4ZB Target at 9:00

Note: *If the tram bar radius is 18 in. (500 mm) long and the difference in the reading is .009 in. (0.23 mm), then that equals a parallelism error of .003 in/ft (0.25 mm/m). If the roll is 15 ft. (4.5 m) long, then this means the far end of the roll is out by .045 in. (1.14 mm) relative to the reference roll.*

The T-1600 Non-Magnetic Roll Fixture for the A-1519-2.4ZB Targets

The T-1600 Non-Magnetic Roll Fixture is used for aluminum, rubber and stainless steel rolls. Also available is the T-1601 Tight Space Roll Fixture/Tram Bar, which uses two A-1519-2.4ZB Targets to measure alignment in tight spaces. The following procedure describes the setup and procedure for using the T-1600.



T-1600 Non-Magnetic Roll Fixture

TDC Procedure

Note that the level vials on the target mag base or the T-1600 Non-Magnetic Roll Fixture will find TDC for most applications where the roll diameter is less than 2 ft. (0.6 m) and when the target post is also less than 2 ft. (0.6 m). However, when performing roll alignments on large-diameter rolls or when using long target posts, use the Sweeping Through the Arc Method.

1. Set up the T-1600 and T-1601 as shown in the photograph (or set up the target magnetic base). Make sure that the level on the fixture is centered, indicating you are close to TDC.
2. If using the T-1600, slowly slide it around the roll while watching the R-1356 display. You will see the readings start to increase you get closer to true TDC. When you get to TDC, the readings will stay the same for a short time as you rotate the roll and then start to decrease as you pass TCD – see *Arc Measurement Method - Sweeping Through the Arc* on Page 62.
3. If using the mag base, slowly rotate the roll in the same manner. For large diameter rolls that do not rotate, you will need to slide the mag base in the same way as the T-1600 fixture.
4. The highest reading (most positive) will be at the TDC and this is the value to record.

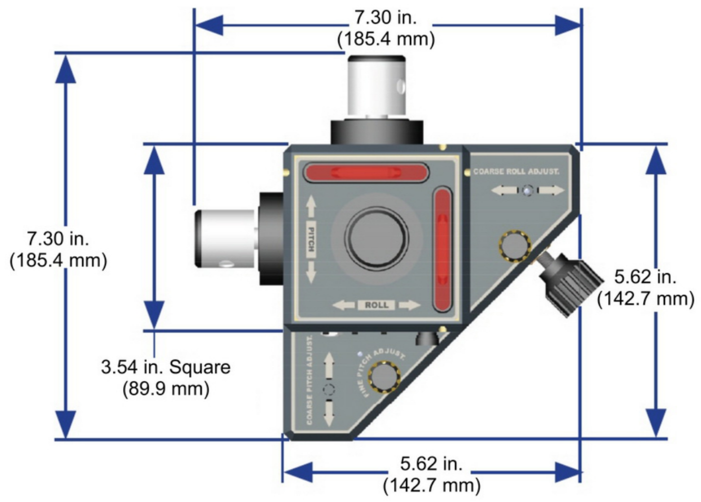
Checking Drive Shaft Alignment

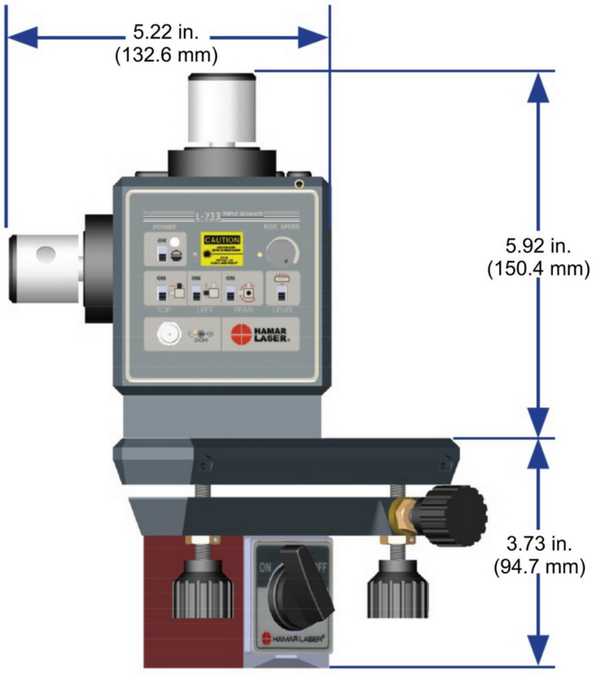
To check the drive shaft alignment, the L-742W or L-732W is placed either at the end of the drive shaft or in the middle, depending on the how long it is. The horizontal plane is made parallel to the top of the closest drive shaft using vertically mounted targets and the vertical scan plane is made parallel to the side of the same shaft.

Each shaft is checked for parallelism to the reference shaft and aligned accordingly. To check a shaft for parallelism/colinearity, a target is moved from the reference shaft without re-zeroing, and two measurements are made, one at either end of the shaft. The difference between the two readings is the angle of the shaft relative to the reference shaft and the average is how far off center it is from the reference shaft. Up to 200 ft. of drive shafts can be checked with one setup.

Appendix A – Equipment Drawings

L-733 Precision Geometry Laser





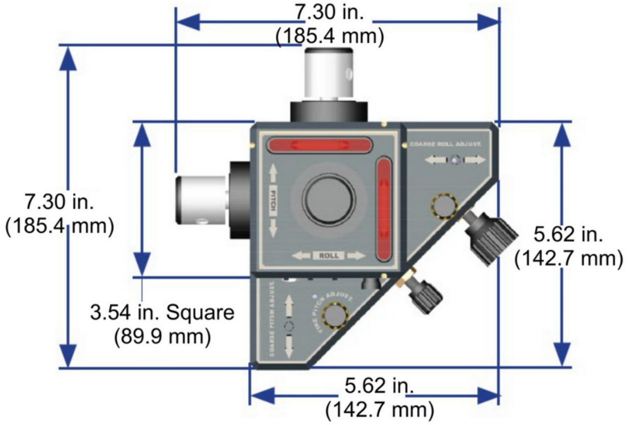
SPECIFICATIONS
L-733 TRIPLE SCAN LASER WITH L-126 COARSE ADJUST BASE

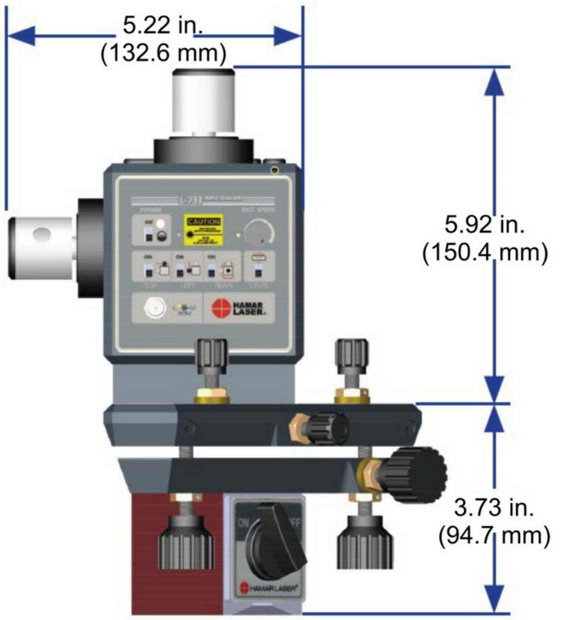
Weight	Laser: 3 lbs [1.3 kg] Base: 4.8 lbs [2.2 kg] Battery Pack: 1 lb [0.45 kg]
Material	Laser: Aluminum and Stainless Steel Base: Aluminum
Laser Type	Class II Visible Diode, 670 nM Wavelength (Class I in Scanning Mode); .160" [4.06 mm] Beam Diameter
Beam Power	.09 mW per Straight Beam
Beam Stability	.0001"/hr/°F [.005 mm/hr/°C] Translational 0.2 arc sec/hr/°F [0.36 arc sec/hr/°C] Angular
Beam Straightness	10 microinch/ft, ±.0001 Air Noise
Beam/Plane Flatness	30 uin/ft [2.5 u/M] Plus Maximum Translational Error of ±.0002" [5.0 u] 360° Sweep, 10 uin/ft [0.8 u/M] Plus Maximum Translational Error of ±.0002" [5.0 u] 90° Sweep
Beam/Plane Squareness	3 Beams Mutually Square to within 1.0 arc sec 3 Planes Mutually Square to within 1.0 asc sec
Mechanical Parallelism/Squareness	Top Scan Plane (Top Turret) Parallel to Base within .0003"/ft [0.025 mm/M], Top and Bottom Mounting Feet Parallel within .0002"/ft [0.017 mm/M], Side and Bottom Mounting Feet Square within .0004"/ft [0.033 mm/M]
Operating Modes	1,2, or 3 Beams and/or 1,2, or 3 Scanned Planes in Any Combination, Individually Switched
Power Supply	9 VDC External Battery Pack (4 Cells) 115 VAC Adapter
Power Draw	(See Chart)
Coarse Range	±1.5°
Fine Resolution	.0001" Fine Adjustment = 0.17 arc sec (.001"/100 ft)

POWER DRAW	LASER ONLY	LASER & SCANNER	BATTERY LIFE*
1 Beam	100 mA	130 mA	2.5 hrs
2 Beams	180 mA	230 mA	1.4 hrs
3 Beams	260 mA	330 mA	1.0 hrs

* Per 9V alkaline battery (500 mA hrs). Multiply battery Life figure by the number of batteries used (external battery pack uses 4 cells).

L-743 Ultra-Precision Geometry Laser





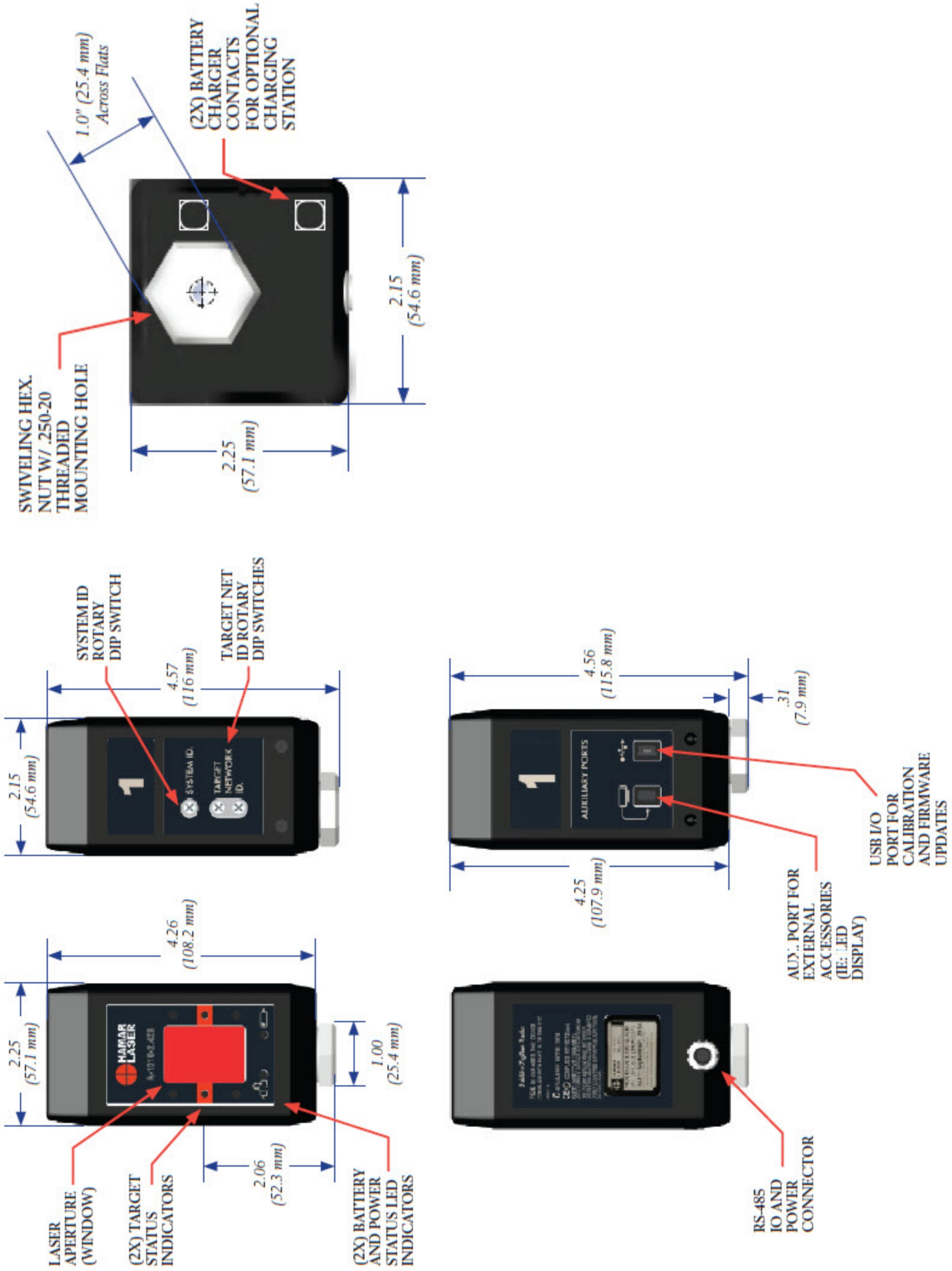
SPECIFICATIONS
L-743 TRIPLE SCAN LASER WITH L-127 COARSE/FINE ADJUST BASE

Weight	Laser: 3 lbs [1.3 kg] Base: 4.8 lbs [2.2 kg] Battery Pack: 1 lb [0.45 kg]
Material	Laser: Aluminum and Stainless Steel Base: Aluminum
Laser Type	Class II Visible Diode, 670 nM Wavelength (Class I in Scanning Mode); .160" [4.06 mm] Beam Diameter
Beam Power	.09 mW per Straight Beam
Beam Stability	.0001"/hr/°F [.005 mm/hr/°C] Translational 0.2 arc sec/hr/°F [0.36 arc sec/hr/°C] Angular
Beam Straightness	10 microinch/ft, ±.0001 Air Noise
Beam/Plane Flatness	30 uin/ft [2.5 u/M] Plus Maximum Translational Error of ±.0002" [5.0 u] 360° Sweep, 10 uin/ft [0.8 u/M] Plus Maximum Translational Error of ±.0002" [5.0 u] 90° Sweep
Beam/Plane Squareness	3 Beams Mutually Square to within 1.0 arc sec 3 Planes Mutually Square to within 1.0 asc sec
Mechanical Parallelism/Squareness	Top Scan Plane (Top Turret) Parallel to Base within .0003"/ft [0.025 mm/M], Top and Bottom Mounting Feet Parallel within .0002"/ft [0.017 mm/M], Side and Bottom Mounting Feet Square within .0004"/ft [0.033 mm/M]
Operating Modes	1,2, or 3 Beams and/or 1,2, or 3 Scanned Planes in Any Combination, Individually Switched
Power Supply	9 VDC External Battery Pack (4 Cells) 115 VAC Adapter
Power Draw	(See Chart)
Coarse Range	±1.5°
Fine Resolution	.0001" Fine Adjustment = 0.17 arc sec (.001"/100 ft)

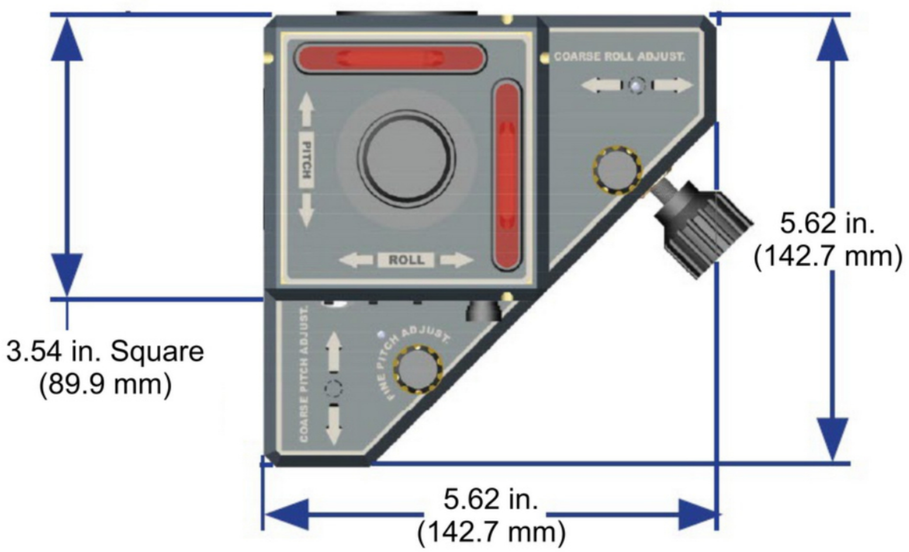
POWER DRAW	LASER ONLY	LASER & SCANNER	BATTERY LIFE*
1 Beam	100 mA	130 mA	2.5 hrs
2 Beams	180 mA	230 mA	1.4 hrs
3 Beams	260 mA	330 mA	1.0 hrs

* Per 9V alkaline battery (500 mA hrs). Multiply battery Life figure by the number of batteries used (external battery pack uses 4 cells).

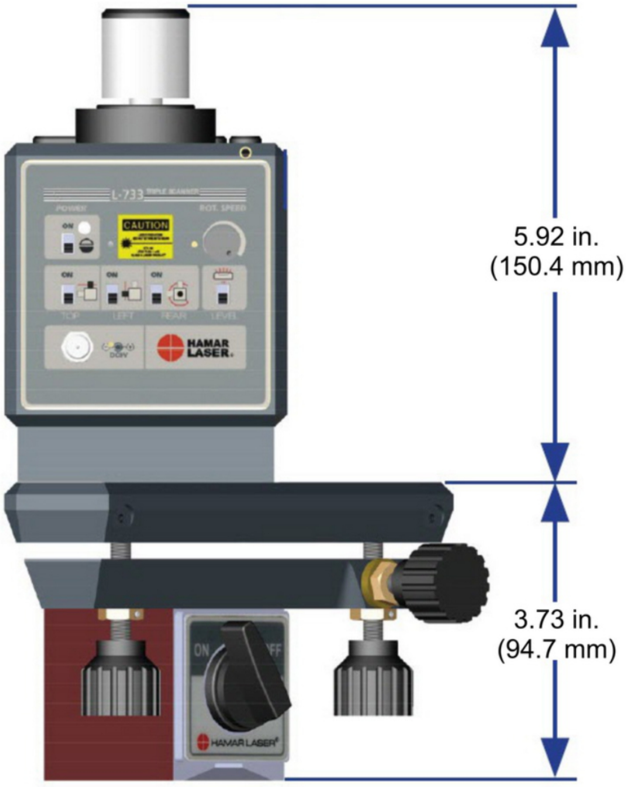
A-1519/A-1520 Universal Wireless Targets



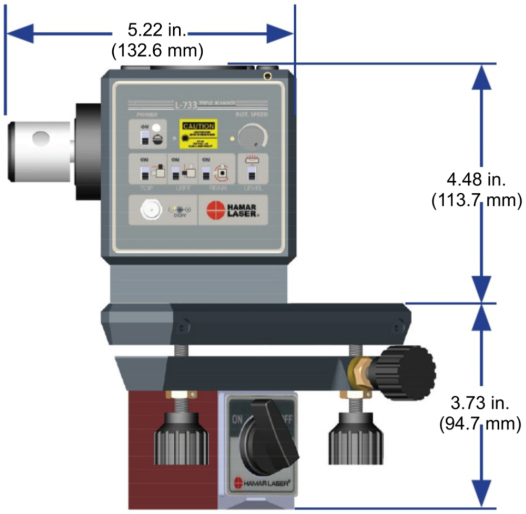
L-730 Top View



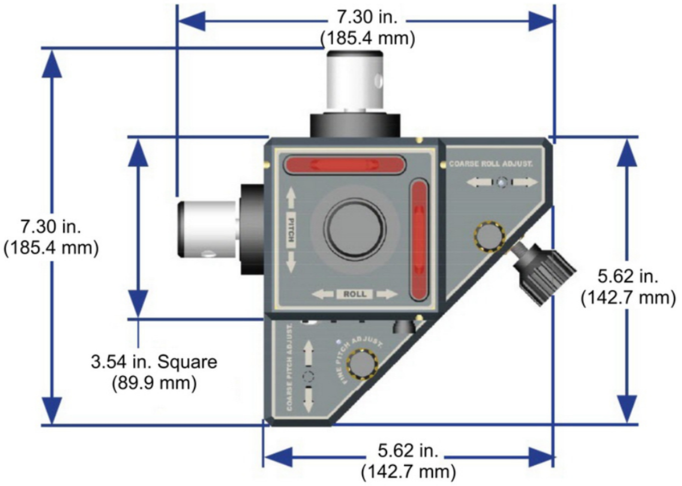
L-730 Side View



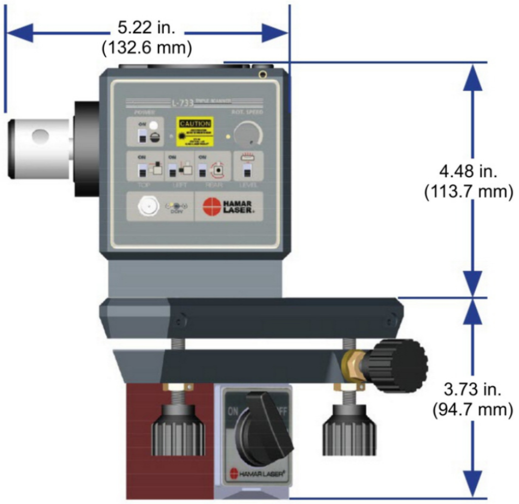
L-730W Side View



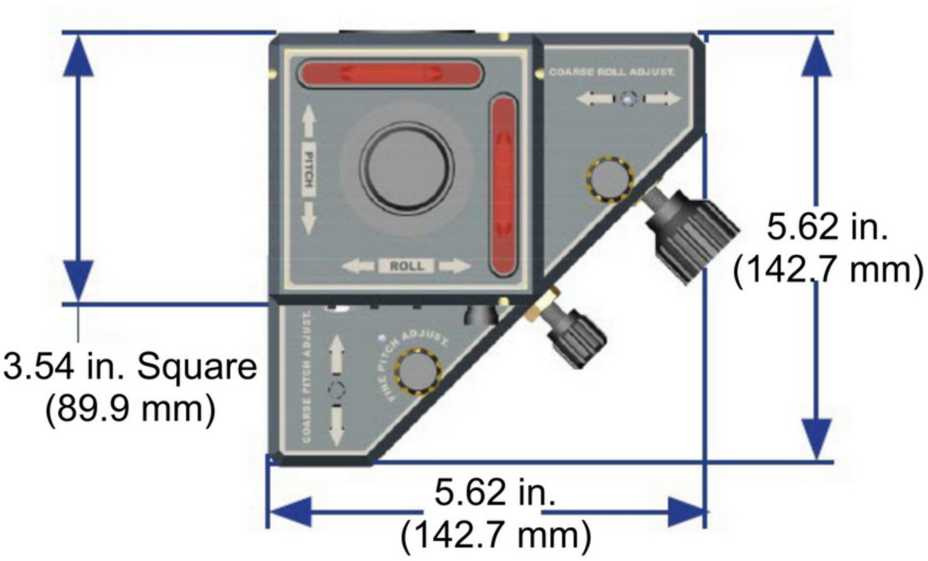
L-732WW Top View



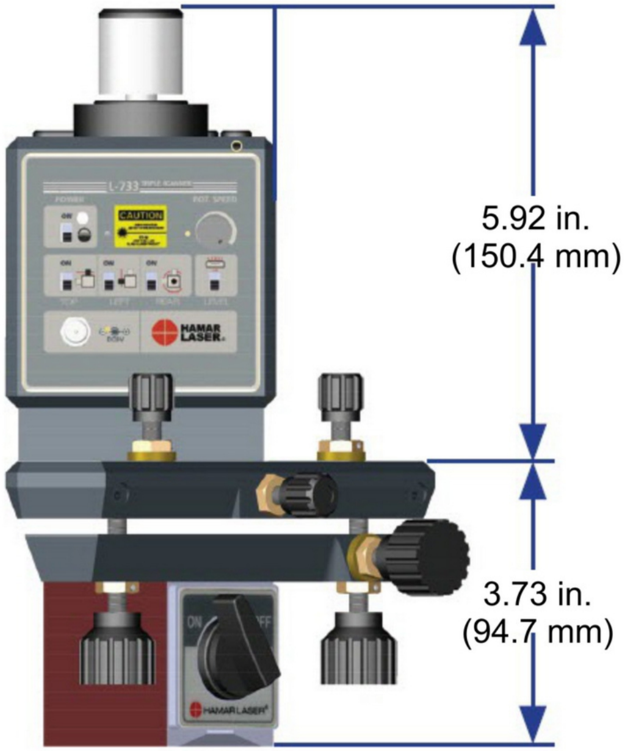
L-732WW Side View



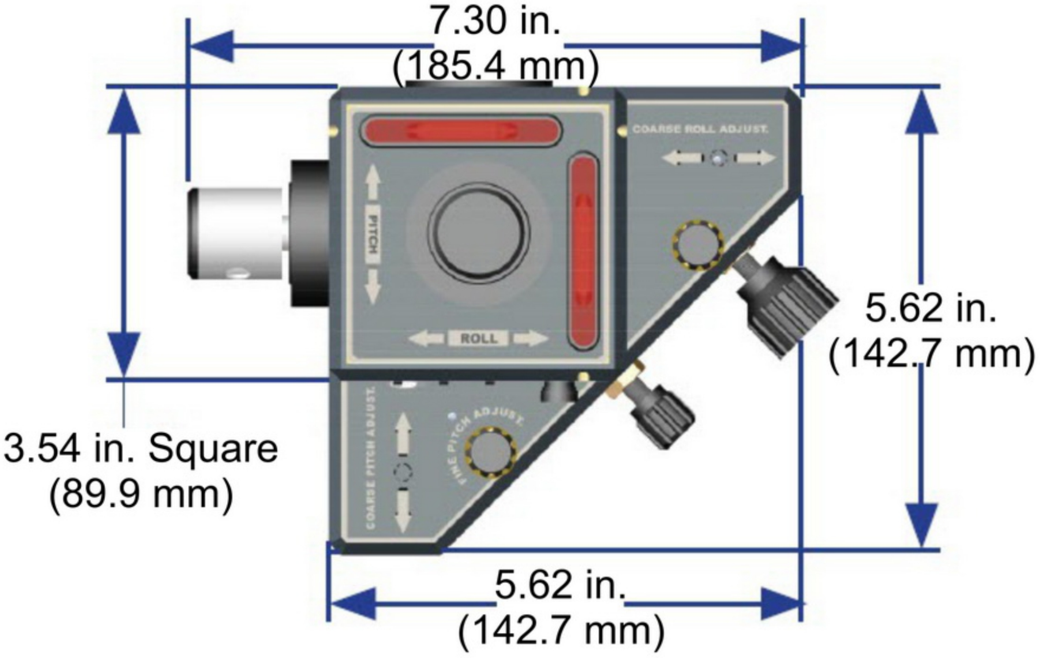
L-740 Top View



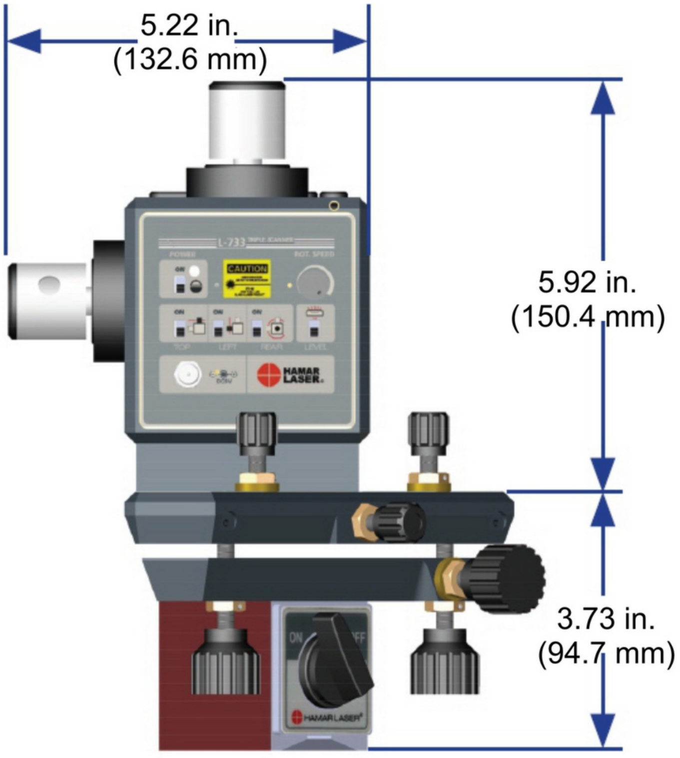
L-740 Side View



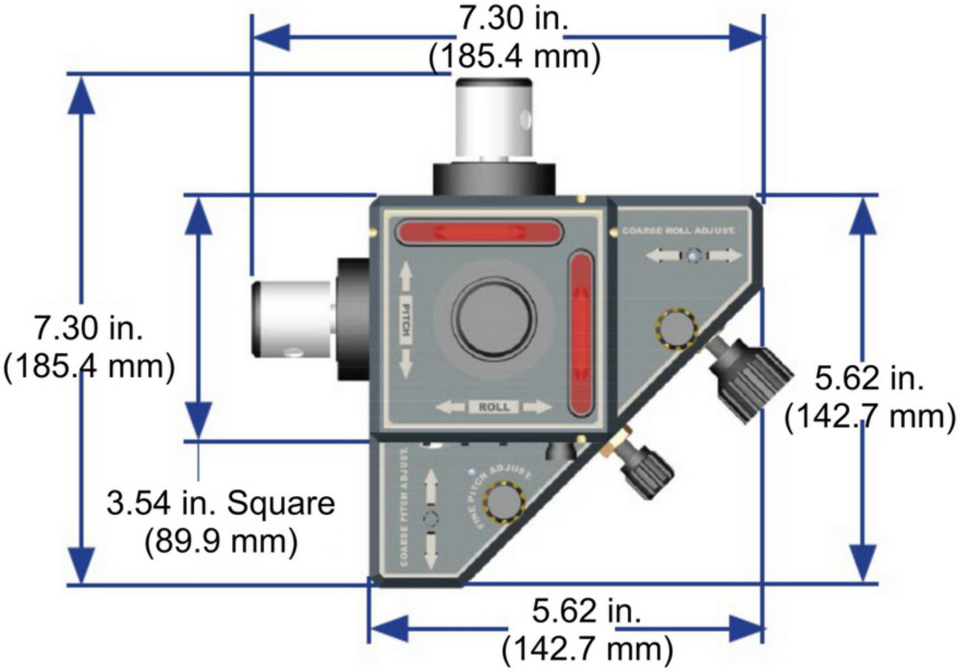
L-742 Top View



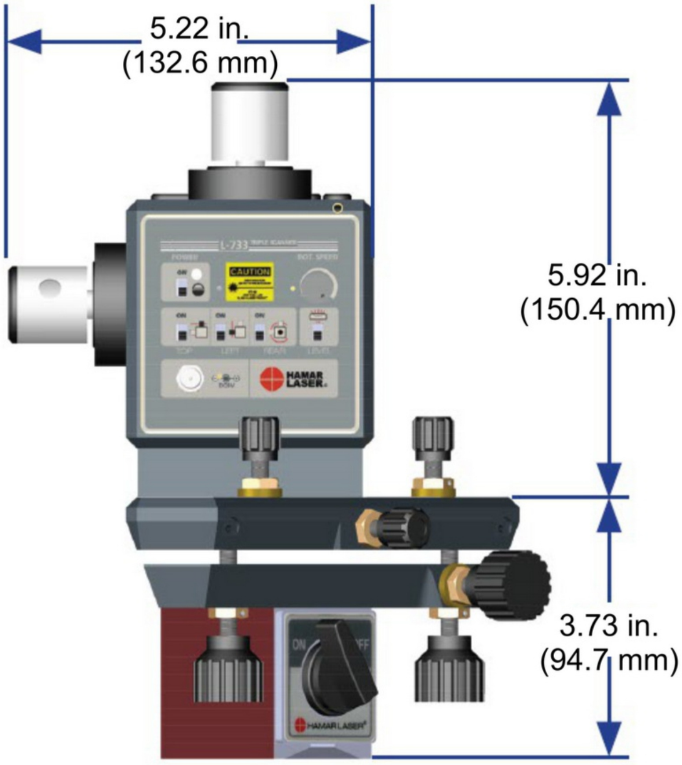
L-742 Side View



L-742WW Top View

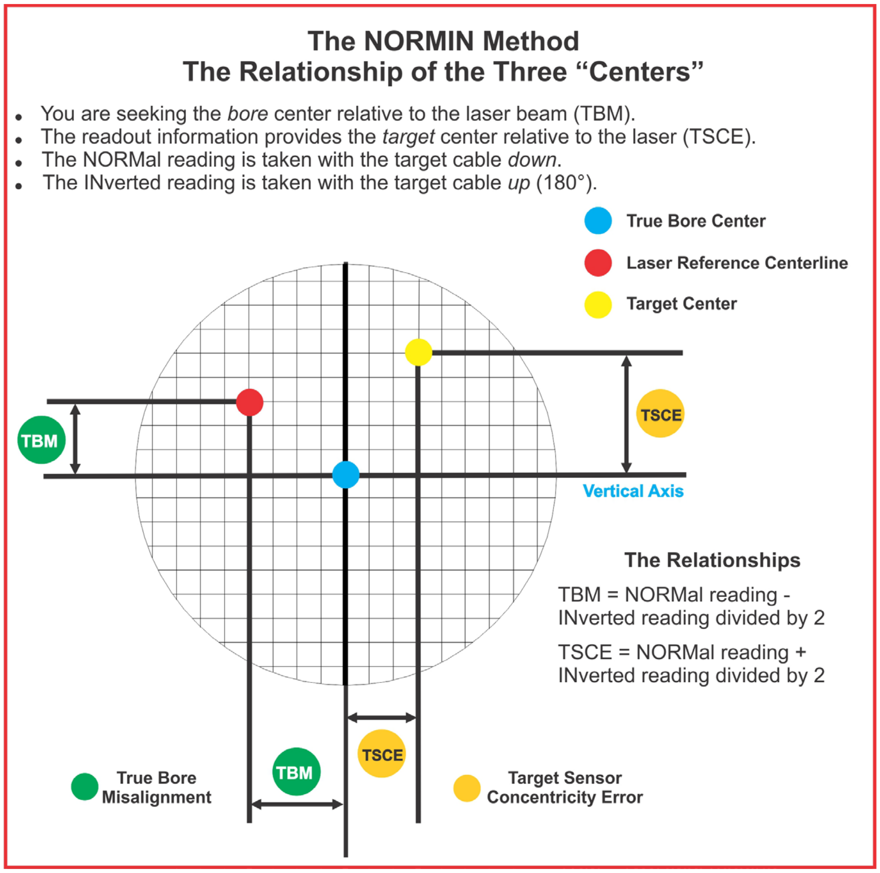


L-742WW Side View



Appendix B – 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 quite 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.



The NORMIN Method
The Relationship of the Three “Centers”

- You are seeking the *bore* center relative to the laser beam (TBM).
- The readout information provides the *target* center relative to the laser (TSCE).
- The NORMal reading is taken with the target cable *down*.
- The INverted reading is taken with the target cable *up* (180°).

The Relationships

TBM = NORMal reading - INverted reading divided by 2

TSCE = NORMal reading + INverted reading divided by 2

Figure 26 -- *Three centers of bore alignment*

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. In reality, however, they seldom line up. An example of the three centers with respect to one another is shown in Figure 26.

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

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

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 27 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.).

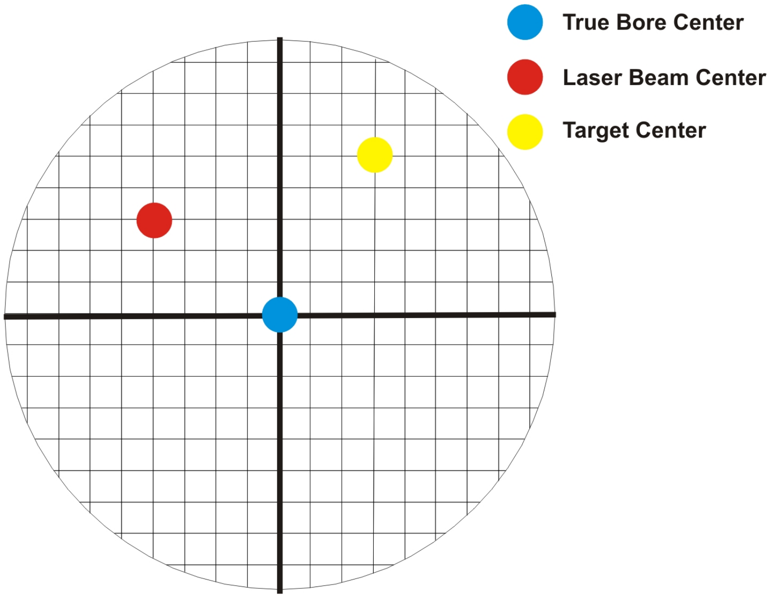


Figure 27 – *Target in the NORMal position*

Figure 28 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 28, the vertical readings are positive and the horizontal readings are negative. When the vertical TCE is calculated, (NORMal+INverted divided by 2) the Target Center is .004 in. higher and .003 in. to the right of the True Bore Center in the NORMal position.

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

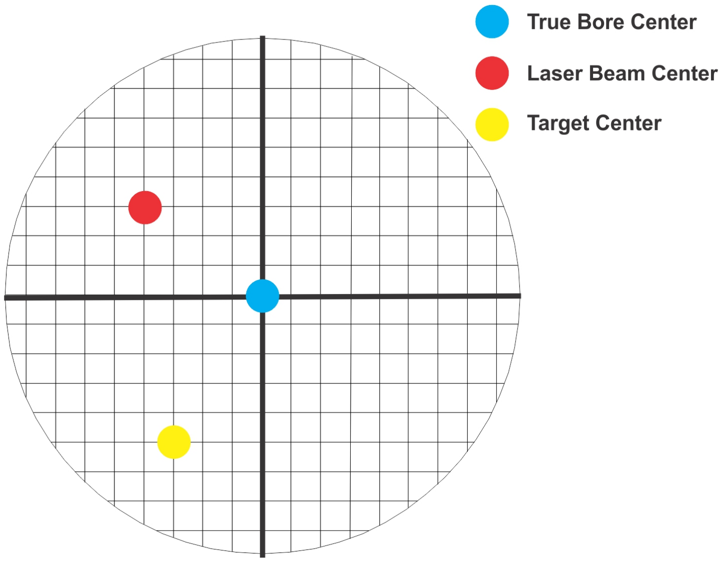


Figure 28 – *Target in the INverted position*

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 C – 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 D – Coping with Atmospheric Effects

The performance of a laser system is affected by turbulence in the atmosphere. The accuracy of the system is .0001 in/10 ft between the laser and the target in typical machine shop conditions. This accuracy can be lessened by a factor of 2 in the winter when the air is cold and dense and can improve by a factor of 2 in the summer when the air is hot and humid and not very dense.

Turbulence is caused by pockets of air at a slightly higher or lower temperature that act like weak lenses passing through the laser beam, causing it to fluctuate slightly. This causes an angular effect (the farther away the target, the greater the effect). This is similar to the "shimmer" that can be seen over a hot tar road in the summer.

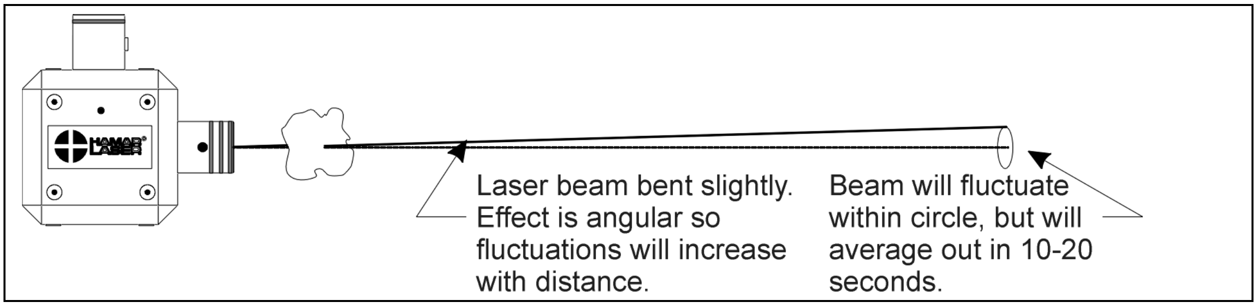


Figure 29 - *Turbulence*

Another effect is caused by a vertical temperature gradient, or refraction. In still air the temperature is warmer nearer the ceiling than at floor level. This condition can bend the line of sight downward as much as .008 in/40 ft at a 50 degree shop temperature. This same phenomenon occurs with optical tooling or theodolites. This effect only occurs when the air in a shop is very still and it can be recognized by a sudden shift in the apparent vertical reading of the target when a door opens or a faint breeze is created. Usually when vertical gradient errors are present, turbulence will be very light.

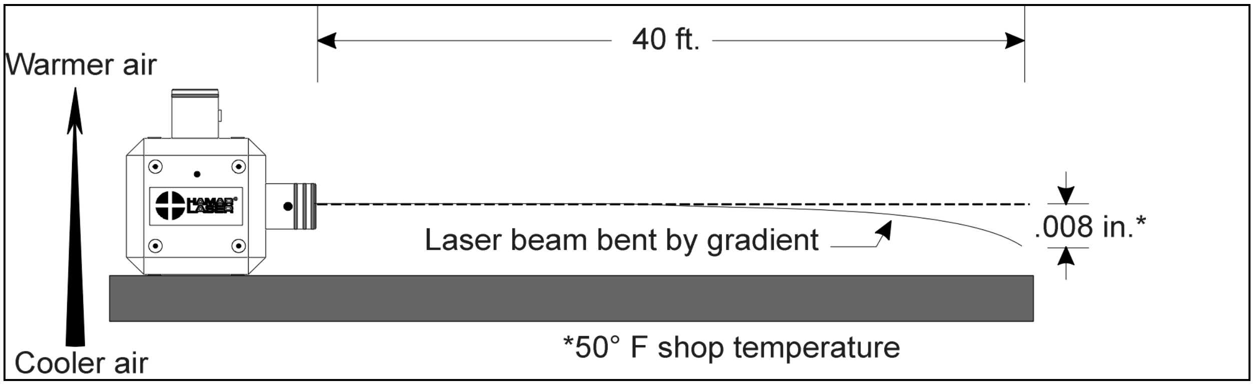


Figure 30 - *Vertical Temperature Gradient*

Note*: Turbulence will average out over a period of 10 to 20 seconds and accurate readings may be taken when it is present by noting the high limit and low limit of the fluctuations in the readout and splitting the difference.*

Reducing Atmospheric Effects with Fans

The most practical way of eliminating vertical temperature gradient and substantially reducing the fluctuations caused by turbulence is to place a fan *behind* the target with the air blowing toward the laser. When fans are used in conjunction with the "slow response" position on the readout switch, the effects of turbulence can be reduced up to a factor of 10 and vertical temperature gradient can be virtually eliminated.

Note: *It is extremely important to use both the fans and electronic damping when maximum system accuracy is required.*

When working to an accuracy of .001 in. in 20 ft. in the summer, the use of fans and damping is unnecessary. Their use *would* be necessary, however, if an accuracy level of .0001 in. is required. In the winter, fans are necessary at all times.

Recommended Fans

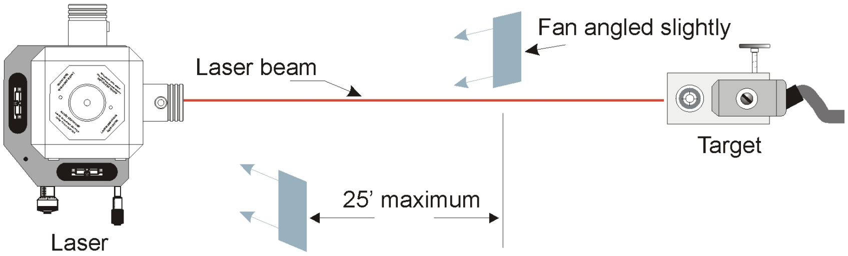


Figure 31 - *Using fans*

Two types of fans are recommended. The least expensive and most desirable is the ordinary box window fan available at department or hardware stores. These fans blow a *cylinder* of air, rather than a *cone* of air that is produced by more expensive fans and provide the maximum mixing of air. A single fan of this type can be used to a distance of about 25 ft. If greater distances are involved, several fans must be used and positioned as shown in Figure 31.

The use of fans will always improve the accuracy of readings except when the wrong type of fan is used or there is an insufficient number of fans. If turbulence proves to be *worse* with the use of a fan, the more fans are necessary.

The second type of fan that is particularly useful is the large, propeller-type shop fan. These fans are usually effective to 50 ft. or more, but they are not as portable as window fans. Oscillating fans with rounded blades and office fans do not work well.

Electronic Damping

Electronic damping involves adjustment of the selector switch on the front of the readout. Normally, all adjustments are performed with this switch set at "fast response." When switched to "slow response," additional damping, or electronic averaging, is switched in and substantially reduces the magnitude of fluctuations from air turbulence. When first switched to the "slow response" setting, the meter readings will likely change, but the original values will return in 10 to 20 seconds. This change occurs because of the residual charge existing in the capacitors, which are switched into the circuit. Fluctuations may still occur but will be greatly reduced. Take readings by observing the limits and splitting the difference. This procedure works well for turbulence but has no effect on vertical temperature gradient. ***Do not take readings until the numbers have returned to the original values.***

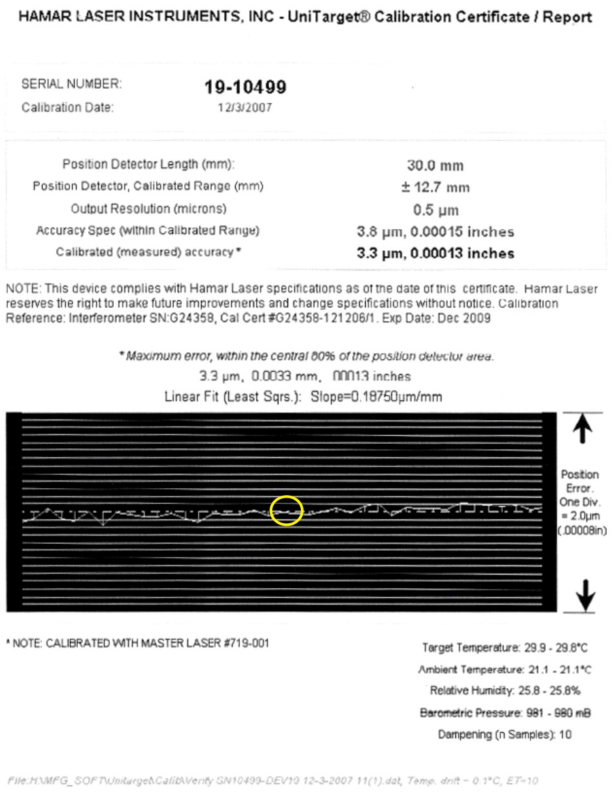
Air Turbulence and Outdoor Use - Fixed Centerline Alignment

When aligning the centerline of rotary equipment, such as large steam turbines or paper mills, the effects of air turbulence and gradient may be several times worse than those quoted for the machine shop. Since these alignments are often performed outside or in semi-protected work areas, the laser beam may be enclosed in 6 in. plastic sewer pipe. This will reduce atmospheric effects; however, a vertical gradient immediately sets itself up inside the pipe and blowers must be used to break up this gradient. These blowers are usually mounted in elbows or T's that can be obtained from Hamar Laser. We recommend that you contact Hamar Laser for detailed instructions when working in a situation like this.

Appendix E – Interpreting the A-1519/1520 Calibration Reports

The A-1519-2.4 Target has a 0.5 micron resolution and 3.5 micron accuracy, versus the A-1520-2.4 Target, which has a 0.25 micron resolution and 1.5 micron accuracy. When the elevation of either target is set near zero (within ± 1 mm from zero), the most accurate part of the sensor is in use. The calibration graph on Page 80 shows that the error in the central part of the sensor for the A-1519-2.4 is less than 1 micron, which is better than the total error of the A-1520-2.4 (± 1.5 microns). Furthermore, when a target is zeroed on a given spot on the sensor for high-accuracy measurements (for example, measurement deviations of less than 25 microns), the error in the measurement from one point to the next is extremely small.

When a target is calibrated, measurements are taken every 1 mm and the error in between is interpolated. This makes is very likely that the error in measurement at the point where the target is zeroed is nearly identical to the error in each subsequent measurement because the difference in sensor area between the two points is less than 1 mm. In effect the error really does not matter – it's like having the same error "offset" at each point. The errors start becoming important only when large deviations from zero are being measured, for example 1 mm or more.



HAMAR LASER INSTRUMENTS, INC - UniTarget® Calibration Certificate / Report

SERIAL NUMBER:	**19-10499**
Calibration Date:	12/3/2007

Position Detector Length (mm):	30.0 mm
Position Detector, Calibrated Range (mm)	± 12.7 mm
Output Resolution (microns)	0.5 µm
Accuracy Spec (within Calibrated Range)	3.8 µm, 0.00015 inches
Calibrated (measured) accuracy*	**3.3 µm, 0.00013 inches**

NOTE: This device complies with Hamar Laser specifications as of the date of this certificate. Hamar Laser reserves the right to make future improvements and change specifications without notice. Calibration Reference: Interferometer SN:G24358, Cal Cert #G24358-121206/1. Exp Date: Dec 2009

**Maximum error, within the central 80% of the position detector area.*

3.3 µm, 0.0033 mm, .00013 inches

Linear Fit (Least Sqrs.): Slope=0.18750µm/mm

* NOTE: CALIBRATED WITH MASTER LASER #719-001

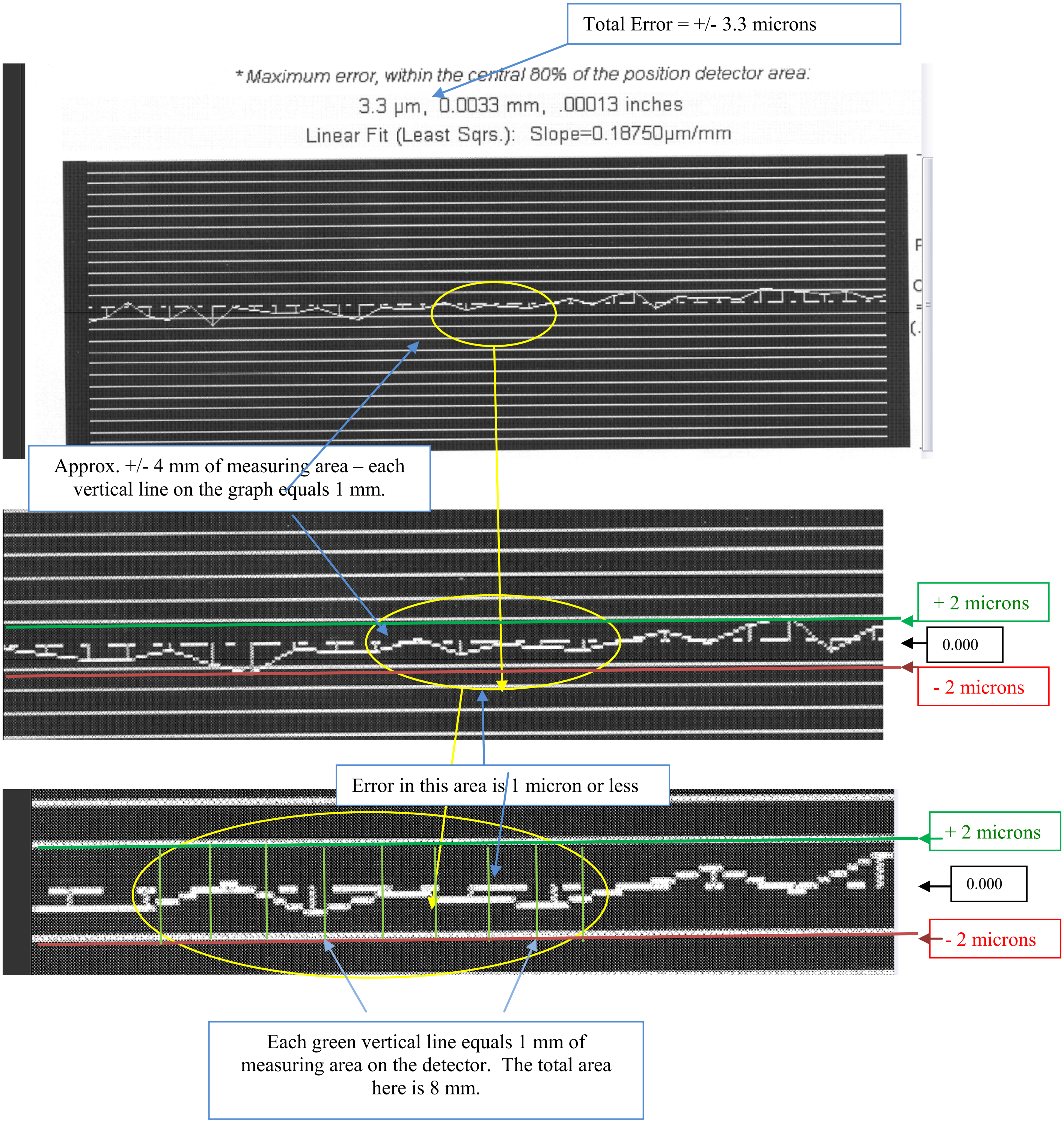
Target Temperature: 29.9 - 29.8°C
Ambient Temperature: 21.1 - 21.1°C
Relative Humidity: 25.8 - 25.8%
Barometric Pressure: 981 - 980 mB
Dampening (n Samples): 10

File:H:\MFG_SOFT\Unitarget\Calib\Verify SN10499-DEV19 12-3-2007 11(1).dat, Temp. drift ~ 0.1°C, ET=10

The accuracy of the A-1519/A-1520 Type II targets is specified in the report below as an error of 3.2 microns (µm). This means that the maximum error of a given measurement could be ± 3.2 µm over the central 80 percent of the measuring area of the target.

For example, if one measurement point was at -12.5 mm (-.492 in.) and the next measurement point was +12.5 mm (+.492), then the maximum error in the 25 mm deviation would be no more than 6.4 µm (.00024 in.).

When measuring small deviations in flatness/straightness (less than .1 mm), the maximum error is much lower (usually about 1 micron or better). See the explanation of the graph below for more details.



Total Error = +/- 3.3 microns

*Maximum error, within the central 80% of the position detector area:

3.3 µm, 0.0033 mm, .00013 inches

Linear Fit (Least Sqrs.): Slope=0.18750µm/mm

Approx. +/- 4 mm of measuring area – each vertical line on the graph equals 1 mm.

Error in this area is 1 micron or less

Each green vertical line equals 1 mm of measuring area on the detector. The total area here is 8 mm.

Appendix F – Troubleshooting Guide

Problem		Possible Solutions
1	***Laser turret spinning and A-1519/1520 target not detecting laser (target LED not illuminated)***	• Power off laser and turn back on (all L-740 and L-730 series lasers have a power protection circuit that needs to be reset if a power surge causes the laser to turn off). • Turn off rotation of laser if the beam is OK and check target battery. • Check where beam is hitting target. If it hits too low, target will not turn on.
2	***Turret spinning; laser beam not on***	• Power off laser and turn back on. If the laser does not power on, then it's possibly a blown laser diode. Return to HLI for repair.
3	***Laser beam on; turret not spinning***	• Ensure rotation switch is turned on. • Ensure rotation speed knob is turned up. • Check batteries – if the battery is low, there may not be enough voltage to spin the turret, but the laser may still be visible. • Environment is too cold. Laser cannot be used below 32 degrees F (0 degrees C). • Belt drive may be broken. Return to HLI repair.
4	***Laser not spinning and no laser beam***	• Ensure power supply is connected. • Replace batteries in the battery pack. • Check power supply connector. Widen split in pin inside the female connector on the laser with a small screwdriver. • Check A/C power source. Use second A/C power supply if available.
5	***Noisy target (A-1519/1520) readings on PDA***	**Note:** *On average the user can expect .00002in/ft to .00005 in/ft (0.0025 mm/m to 0.004 mm/m) of noise in good operating conditions.* • Check for vibration in laser instrument stand (tripod) or surface the laser is sitting on. If laser is mounted on a machine tool, try turning machine tool off. • For very noisy readings, check for rotary lights (like on forklift) or strobe lights (this will look like a "laser" to the target). • Check for air turbulence – air conditioning vents right over target? Check for open doors in summer or winter. See manual for Atmospheric Conditions. • Turn off the rotation of the laser and slowly rotate is by hand to check for reflections from metal surfaces. Dim overhead lights if possible. • Check for excess background light (use light shields). A warning may pop up on PDA display. • Ensure only one laser is hitting the target at a time. Turn off other laser plane rotation to see if this helps. • Ensure the target is facing/pointing directly at the laser (within ± 5 degrees). • Check light frequency (50 Hz vs. 60 Hz for background light). For correction feature of A-1519/1520 targets, see Target Utility Manual. North & South America is 60 Hz. Europe, Australia and parts of Asia are 50 Hz. • If PDA is plugged in, try unplugging PDA from A/C adapter. • Check for possible radio interference.

6	***No target readings in PDA. Target LEDs illuminated (means target is detecting laser)***	• Check radio receiver battery. Plug in A/C adapter to ensure it has power. • Ensure “check box” to the left of the display window in Read15 (see manual) is checked for each target. • Ensure channel setting (system ID) on A-1519/1520 matches the setting in PDA (see Read15 Manual). • Ensure target ID on A-1519/1520 is set to 1-4 for first screen or 5-8 in second screen in Read15. • Target is too close to laser (target LEDs will blink). • Check for reflections. • Check for strobe lights and rotary lights. • Check for excess background light (normally target LEDs will blink). • Plug target into computer via USB cable and open Target Utility software. If software shows reading, then there is probably a problem with the radio. • Ensure PDA has same radio frequency as target (900 MHz or 2.4 GHz). • Reset target (use paper clip in hole near Target ID/Channel Selector Panel). • Laser could be hitting too low or high on target window (it should be near the window). It’s possible for the laser to activate the auto wake up feature of target, but not enough of the beam is hitting the PSD (target sensor) to get a reading.
7	***No target readings in software. Target LED illuminated***	• Ensure A-910 radio base station is connected to USB port. • Ensure the correct COM port is selected for the USB bridge controller – see Windows Device Manager (has to be lower than COM10. • Check Device Manager in Windows Control Panel. Set COM port for USB bridge controller lower than COM10. • Ensure the correct target ID is chosen in Machine Tool Geometry or Read8 software. • Ensure channel setting (system ID) on A-1519/1520 matches the setting in A-910 (see the Target Utility Manual). • Ensure SND/RC LEDs on A-910 are blinking (see the Target Utility Manual). • Ensure ACTUAL TARGETS (RADIO in Plane5) is selected in Read8, Plane5 or Machine Tool Geometry software. • Ensure antenna is connected to A-910. • Target may be too close to laser (target LEDs will blink). • Check for excess background light (normally target LEDs will blink). • Ensure A-910 radio base station has same radio frequency as target (900 MHz or 2.4 GHz). • Laser could be hitting too low or high on target window (it should be near the window). It’s possible for the laser to activate the auto wake up feature of target, but not enough of the beam is hitting the PSD (target sensor) to get a reading.
8	***Target LEDs Blink – Laser Beam OK and Rotating***	• Check for reflections. • Check for strobe lights and rotary lights. • Check for excess background light (normally target LEDs will blink). • Ensure the beam is not being clipped by an obstruction or not on the edge (upper or lower) of the PSD sensor. • Laser rotation may be too slow. • Make sure two lasers are not sweeping across the target. • Make sure target is facing the laser within +/- 5 degrees. • Reset target (use paper clip in hole near Target ID/Channel Selector Panel).

9	***"OFF TGT" shown in target display – PDA***	• Radio communication is working, but the target does not "see" the laser. ▪ Ensure laser beam is not blocked. ▪ Ensure laser beam is bright. ▪ Check laser power supply, especially if using a battery pack.
10	***Cannot see level vials***	• Turn on level light switch. • Turn on master power switch. • Check power supply connection.
11	***"Runtime Error" in software***	• Do not unplug the A-910 from the USB port while still using the program. • Report to HLI the exact keystrokes that created the Runtime Error.
12	***Software crashes upon loading***	• Ensure USB/Serial Converter cable is connected to the laptop's USB port. If problem persists, contact HLI.
13	***PDA locks up***	• Hit RESET switch ▪ Dell PDA – RESET is on right hand side of the back of PDA, near the lower right corner of the radio module. ▪ HP IPAQ – RESET is on bottom end of PDA.
14	***PDA turns off automatically***	• Check the Power Saving Options in the PDA (see PDA manual for details).
15	***PDA is frozen***	• Check the lock switch on the side of the PDA. If that does not work, press RESET.

Appendix G – The A-910 Radio Transceiver/Hub and the A-910-2.4ZB Radio

Front Panel Features

1. **Power ON indicator and Low Battery indicator**
2. **Internal backup battery charging indicator and USB LINK ESTABLISHED indicator**
3. **TX indicator:** blinks when device is transmitting data to the target(s)
4. **RX indicator:** blinks when the device is receiving data from targets or other transceivers.
5. **System ID setting switch:** set to the same number as the R-1307 CH (Channel) number.

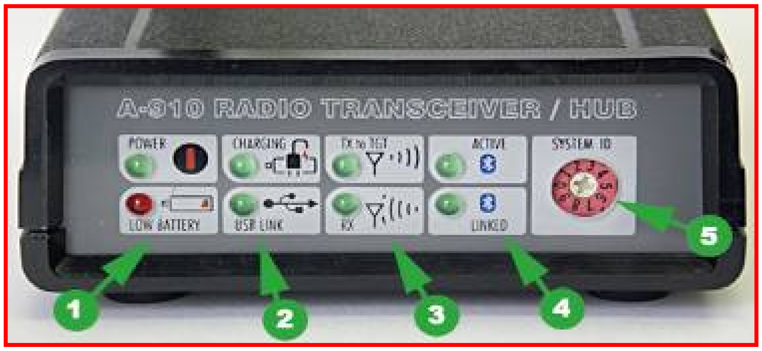


Figure 32 – *The A-910 Radio Transceiver/Hub FRONT PANEL*

Rear Panel Features

1. **Not used**
2. **USB/Data I/O Port**
3. **Power Switch**
4. **External power supply:** required only for computers that cannot provide adequate power (5V, 400 mA) through the USB port.
   Note: *When using the USB Extender™ cable extension kit, plug the A-910-2.4 into an A/C power supply.*
5. **Antenna**

Figure 33 – *The A-910 Radio Transceiver/Hub REAR PANEL*

MODEL NUMBER	PRIMARY FREQUENCY
A-910-900	900 MHz
A-910-2.4	2.4 GHz

The Zigbee® Radio Utility for the A-910-24.ZB

Pre-installing the Common USB Port Driver (A-910-2.4ZB)

This driver is required for the A-910-2.4ZB Transceiver and to communicate with targets via the computer's 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 A-910-2.4ZB Radio Programmer CD in the CD ROM drive.
2. Select **My Computer**, locate the CD ROM icon and click to open it.
3. Select the USB Drivers folder.
4. Select the correct Operating System installed on your computer (Windows 2000, Windows XP, etc.) and open the folder.
5. Locate the **CP210x_VCP** icon and click to initiate the installation process. The **Install Driver** dialog box displays.
6. Click **Browse** to select an installation folder different from the default folder (optional).
7. Click **Install** to continue. Once the installation is complete, the **Installation Successful** message displays.

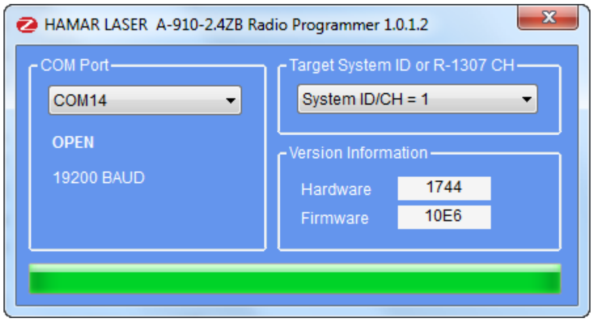
Installing the A-910 Utility Software

1. Insert the A-910-2.4ZB Radio Programmer CD in the CD ROM drive.
2. Select **My Computer**, locate the CD ROM icon and click to open it.
3. Locate the **Setup** icon and click to initiate the installation process. Click **NEXT** to continue.
4. Click **Browse** to select an installation folder different from the default folder (optional).
5. Click **Next** to continue. Once the installation is complete, the **Installation Complete** message displays. Select **Close.**

Configuring the Hardware and Utility Settings

1. Insert the A-910 AB dongle into any unused USB port. The computer should automatically assign a COM port number to the dongle.
2. Start the A-910 Utility Software. The software should display the COM port assigned to the Zigbee Dongle (see Figure 34).
3. If the utility does not automatically detect the COM port, it must be manually selected (see *Manually Selecting a COM Port* on Page 87).
4. The Target System ID or R-1307 CH (channel) is the number associated with the A-1519/1520 targets or R-1307 Readout. If using both the A-1519/1520 targets and an R-1307 Readout, both need to be set to the same system ID and channel (see Figure 35). Also see the R-1307 user manual for more information.

Figure 34 – *A-910-2.4ZB Dongle*



HAMAR LASER A-910-2.4ZB Radio Programmer 1.0.1.2

COM Port: COM14

OPEN

19200 BAUD

Target System ID or R-1307 CH: System ID/CH = 1

Version Information

Hardware: 1744

Firmware: 10E6

Figure 35 – *A-910 Utility showing the COM Port, System ID and Channel settings*

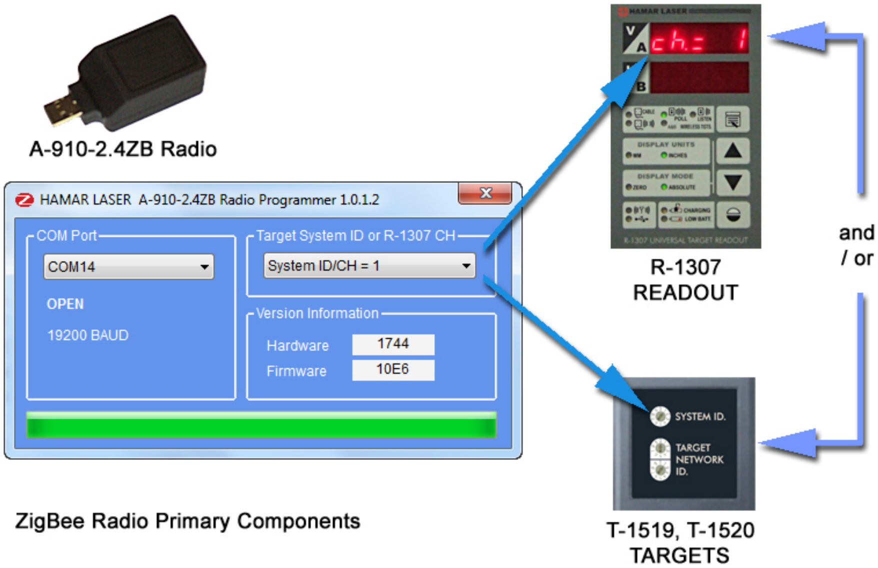


Figure 36 – *System ID Setup*

Manually Selecting the COM Port

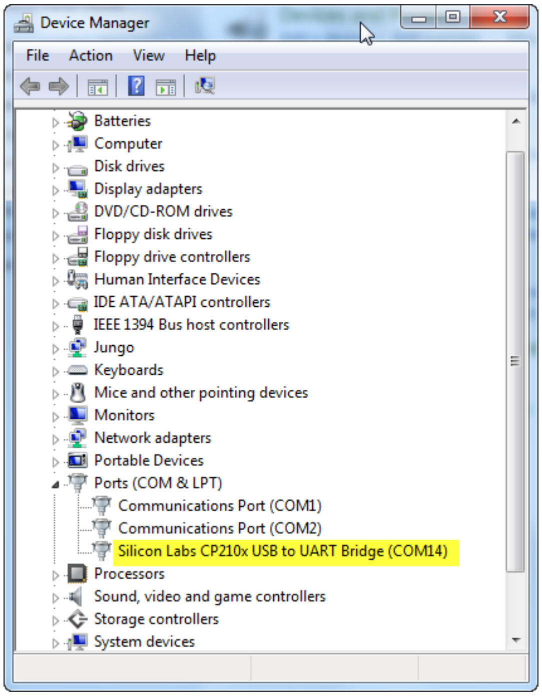
The A-910 Utility should automatically detect the COM Port upon startup. If not, use the following steps to locate the correct COM Port.

Windows XP

1. Right-click My Computer.
2. Click **Properties** and then select the **Hardware** tab.
3. Click **Device Manager**.

Windows 7

1. Click the **Start** button and select **Control Panel**.
2. Click the **System** icon.
3. In the **System** window, click on the Device Manager link located under the **System** heading.
4. In Device Manager, scroll down to **Ports.** Expand the listings under **Ports** to reveal all the ports installed.
5. Locate **SILICONLABS CP210x to UART Bridge (COM x)** as shown in Figure 37.
6. Note the COM Port listed and select that COM Port in the A-910 Zigbee Utility software using the drop-down arrow.



- Batteries
- Computer
- Disk drives
- Display adapters
- DVD/CD-ROM drives
- Floppy disk drives
- Floppy drive controllers
- Human Interface Devices
- IDE ATA/ATAPI controllers
- IEEE 1394 Bus host controllers
- Jungo
- Keyboards
- Mice and other pointing devices
- Monitors
- Network adapters
- Portable Devices
- Ports (COM & LPT)
  - Communications Port (COM1)
  - Communications Port (COM2)
  - Silicon Labs CP210x USB to UART Bridge (COM14)
- Processors
- Sound, video and game controllers
- Storage controllers
- System devices

Figure 37 -- *Device Manager showing COM Port for A-910 Dongle*

Setting the Target System ID and Target Network ID
(A-1519-2.4ZB/A-1520-2.4ZB Targets, A-910-900/2.4, A-910-2.4ZB)

The System ID is a radio network address that is used by the Radio Communications Protocol to filter unwanted data from other radio transceivers and targets using a different address. Only targets and radio transceivers that are set to a matching System ID can communicate with each other.

Because no two targets with the same System ID can transmit simultaneously, it is necessary for each target to be programmed to respond only when it is being addressed. The Target Network ID is the target address on the communications network. Under Host (computer) control, the radio transceiver transmits a message called a *polling request* that contains the Target Network ID of one specific target. All targets receive all polling requests, but only the target with a Network ID matching the ID contained in the polling message will reply (Transmit Data to the Host).

There are three rotary DIP switches located on the right side of the target, shown in Figure 38.

- The uppermost switch sets the System ID.
- The two lower switches are used to set the target network ID.

Setting the System ID

Note: *Before selecting a System ID, ensure that it is not already in use by another system within the radio coverage area.*

Using a small screwdriver, rotate Switch 1 to align the arrowhead with the System ID number (0-9). Figure 38 shows the System ID switch set to 1.

Figure 38 – *Unitarget ID Switch set to 1*

Appendix H – Centering the Targets on the Floor Monuments

When performing roll alignments, it is often necessary to use floor benchmarks at the side of the machine as a reference. Hamar Laser offers floor plates on which to mount targets so that these floor benchmarks may be used as a reference. When using these floor plates, the target center must be mounted over the pointed set screw on the bottom side of the floor plate. This is accomplished via the NORMIN method, described in Appendix B, beginning on Page 73. There are three centers involved: the target center, the laser beam center and the true bore center (or the rotational center). You must determine the amount that the target center is off from the rotational center, and then move the laser center to be coincident with the rotational center.

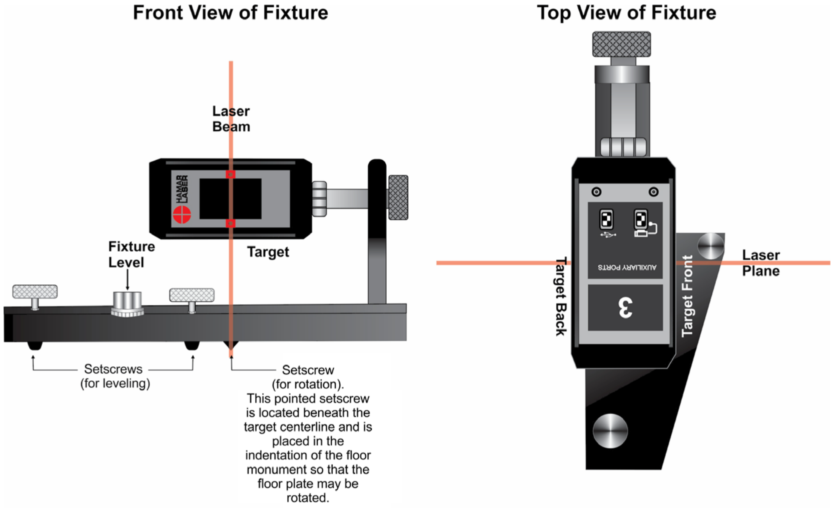


Figure 39 – *Target Centered*

The target can then be electronically centered, so all three centers are coincident as shown in Figure 39. This is accomplished by recording a target reading with the target facing in one direction and then rotating the floor plate holding the target 180 degrees and recording the target reading again, as shown in Figure 40 . The two recorded readings are averaged by adding them together and dividing by 2. This average becomes the *Set Point*. The laser is then adjusted until the readout displays the Set Point number, which makes the laser beam coincident with the rotational center as shown in Figure 41.

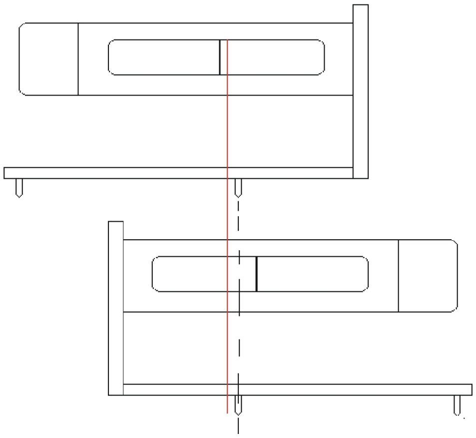


Figure 40 – *Target Rotated*

When the laser center is coincident with the rotational center, the readings and the signs (+ or -) will be the same when the target is rotated from one position to the other, as shown in . You can then zero the target and all three centers will be coincident, as shown in Figure 42.

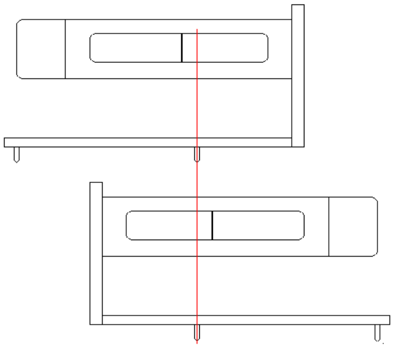


Figure 41 – *Laser Beam Coincident with Rotational Center*

1. **Place a floor monument on a specific point by ensuring that the pointed set screw that is directly underneath the target centerline is firmly positioned into an indentation in the surface.**
   Be sure that the target face is square to the laser beam. This is a user call. There is no specific method of accomplishing this.

2. **Level the floor plate by adjusting the two thumbscrews.**
   Be particularly careful as any out-of-level condition can influence the target centerline.
3. **Record the target reading, paying close attention to the plus (+) or minus (-) signs.**
4. **Rotate the entire floor plate 180°.**
   Be sure that the target face is rotated to receive the laser beam and is square to the incoming beam.
5. **Carefully re-level the floor plate and record the reading.**
   If you add the two numbers together and then divide by two you will get the target error (the amount that the target center is off from the axis of rotation.).

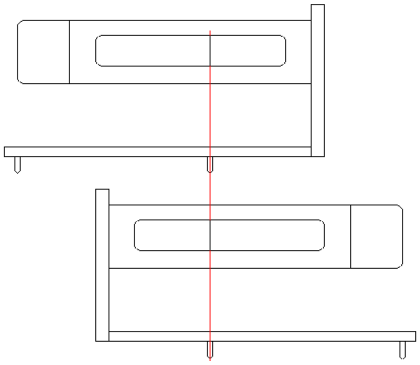


Figure 42 – *Three Centers Coincident*

Example

First reading	-.063
Second reading	+.075
Added together	+.012
Divided by two	+.006

The target center is +.006 in. off center of the axis of rotation. It is not possible to manually adjust the target center, so you must adjust the laser to this offset and then zero the target.

In this case, adjust the laser (using the azimuth adjustments) until the readout reads +.006 in.

Note: *In the above example, if the current reading is +.075, adjust the laser until the reading is +.006 in.*

If you rotate the floor monument back to its first reading position, the reading should still be +.006 in. If the laser center is exactly over the center of the axis of rotation, you will see the same number and same sign when rotating the floor monument.

6. **Zero the target and repeat this procedure with the second target.**
   Place the two targets in the desired locations and be sure that they are both facing the same direction. If they are placed facing opposite directions, you can have some serious errors when repositioning the laser for centerline offsets.

Appendix I – Using Older Alignment Systems

The following section covers some of Hamar Laser's older alignment systems and how to use them when performing the procedures covered in the previous sections.

Lasers

Hamar alignment systems are used for straight line measurement and alignment, scanning or sweeping of 360^0 planes for flatness checking, or a combination of both straight and scanning operations for alignment, parallelism and offset calculations.

Some of the models with which you might be familiar are the L-700 Spindle Laser® or the L-705 Bore Alignment Laser (of the straight line laser family), the L-719 and L-720, which are compact and accurate Crown Roll Lasers of the scanning family, or the combination lasers that can be set to either scanning or straight line mode, such as the L-723 Triple Scan® Laser.

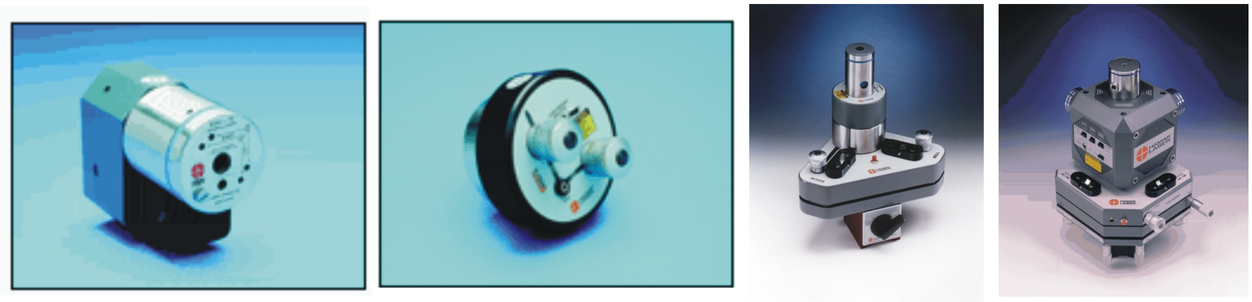


Figure 43 – *Left to right: L-700, L-705, L-720 and L-723*

Targets

Any of the following targets may be used with any older laser manufactured by Hamar Laser. Each target, however, was developed with a specific purpose. The list below provides descriptions of the most commonly used targets and their capabilities.

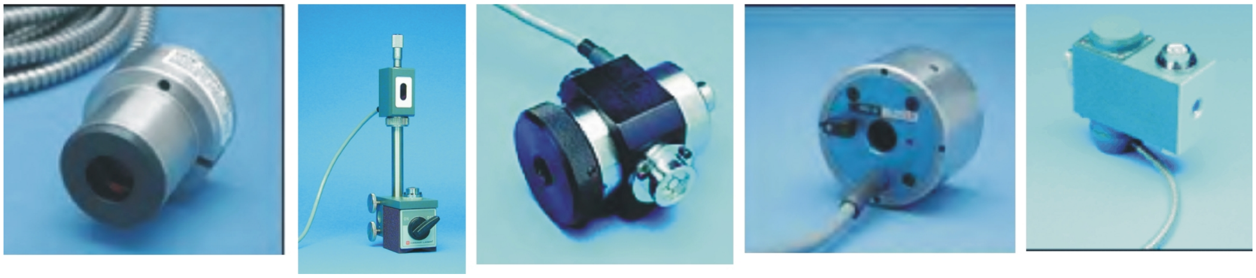


Figure 44 – *Left to right: A-510, A-517, T-212, T-218, T-261*

A-510

A two-axis target used mainly with straight line lasers, this target displays vertical and horizontal center readings. It is ordinarily used with a self-centering adapter that can be placed in various locations inside of a continuous bore. The A-510 target was developed specifically for extruder barrel to extruder gearbox alignment, but it has also proved very useful in a number of other bore applications.

Accuracy	.0001 in.
Range	±.075 in.

A-517

A two-axis target that is normally used with scanning lasers as a scan target. It can be used as a single-axis target in that it displays vertical axis center readings only. The A-517 is the ideal target to use for flatness, straightness, and/or level-to-earth measurements.

Accuracy	.0001 in.
Range	±.075 in.

T-212

A four-axis target designed for use with straight line lasers. This target can display vertical and horizontal center readings as well as vertical and horizontal *angle* readings (pitch and yaw). The T-212 target is a general purpose target that serves a wide range of applications.

Accuracy	.0001 in.
Range	±.075 in. Single Axis
	±.050 in. Combination Both Axes

T-218

A two-axis target that is used primarily with straight line lasers and displays both vertical and horizontal center readings. The target cell can be rotated (flipped) out of the line of sight to make it “see-through.” This would be the target to use for measuring a *series* of bores. It is easily adaptable to either a Hamar Laser three-legged bore flange fixture or fixtures that are custom designed to fit specific bores.

Accuracy	.0001 in.
Range	±.075 in. Single Axis
	±.050 in. Combination Both Axes

T-261

A four-axis target that displays vertical and horizontal center readings as well as vertical and horizontal *angle* readings (pitch and yaw) simultaneously. This target was developed specifically for spindle alignments but is very useful in a number of other applications.

Accuracy	.0001 in.
Range	±.075 in. Single Axis
	±.050 in. Combination Both Axes

Target Cell Function and Accuracy

Hamar Laser targets use a position-sensitive cell with varying ranges of detection. This type of cell will integrate to and find the center of energy of any light shining on the surface, regardless of the light spot's shape or size. There are four connections on the front face of the cell--two vertical connections and two horizontal connections--and a fifth (or substrate) connection on the rear of the cell.

The two vertical leads, one on the top and one on the bottom of the cell, each yield a positive voltage in proportion to the position of the center of energy of the light spot. When these two vertical signals are combined by the electronics, a bipolar (±) DC voltage is produced. This voltage is proportional to the vertical position of the spot's center of energy in relation to the electrical center of the cell. If both voltages are equal, the center of the spot is located at the electrical center of the cell. (Generally speaking, the electrical center is located at the mechanical center of the active area of the cell.) The same is also true for the two horizontal leads.

Target resolution (for centering) is typically .0001 in. (2.5 microns). The linear ranges for single and dual axes vary with cell size. Angular range for a four-axis target varies with the focal length and application, from as much as 10 degrees to .5 degrees for the most sensitive target.

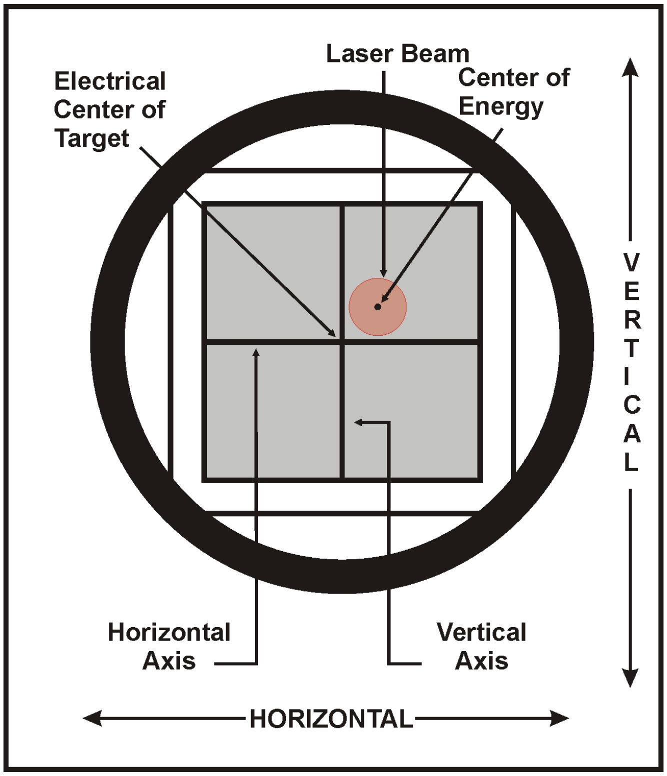
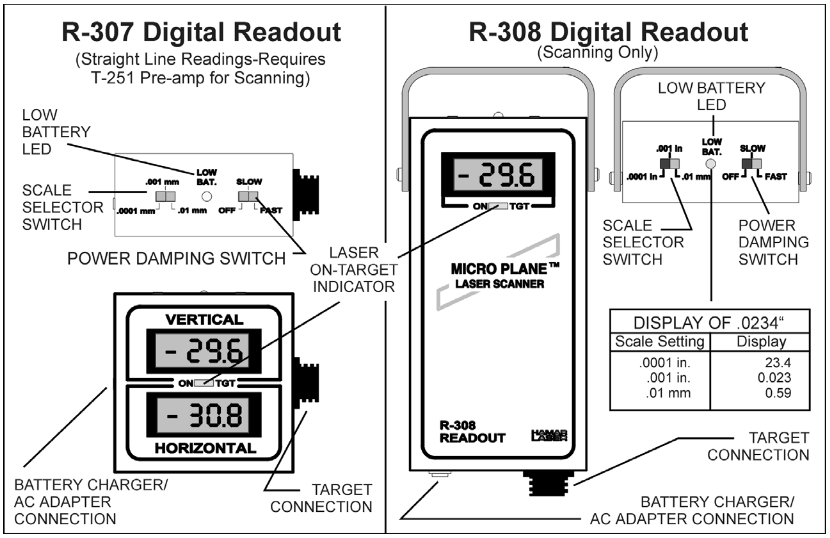


Figure 45 - *The Target Cell*

Readouts

The R-307 Digital Readout

The Model R-307 is a portable two-axis readout used for measuring a stationary laser beam. Used with the T-251 Scanner Preamp, the R-307 can also measure data from single axis scanning targets (see Figure 46). The R-307 Readout can display data supplied by the A-510, A-517 (T-214 with stand), T-212, T-218 and the T-261 targets.



DISPLAY OF .0234"

Scale Setting	Display
.0001 in.	23.4
.001 in.	0.023
.01 mm	0.59

Figure 46 – *R-307 and R-308 Digital Readouts*

The R-308 Digital Readout

The Model R-308 is a portable one-axis readout used specifically for measuring the height of a target above or below the scan plane of a laser beam. It has a single display window; otherwise, the connections and controls are the same as those of the R-307. The R-308 Readout can display data from various targets; however, it is most frequently used with the A-517.

In addition to a Low Battery LED on top of the unit, there are also two manual switches: The *Power Switch* and the *Scale Selector Switch*. The Power Switch has three positions: OFF, SLOW and FAST. When there is a great deal of air turbulence, set the readout to the SLOW setting and watch the numbers on the display adjust slowly. This averages out some of the readout variations often caused by heat, fog or particulate matter in the atmosphere. In normal conditions, the Power Switch should be set to FAST.

The Scale Selector Switch sets the unit to display readings in either inches or millimeters. On some readouts, both English and metric scales are accommodated. Other units provide only metric data settings. Switching between scales will show that the number .0234 in. will read as 23.4 on the .0001 in. scale, .023 on the .001 in. scale and 0.59 on a .01 mm scale.

The Low Battery LED between the two switches flashes to indicate when the charge on the battery is too low for proper operation of the unit. When the power is too low, the LED may stop flashing even though the unit may continue to operate for a short while.

Target Connections for Scanning Lasers

Whenever a *scanning* laser is used, there must be a T-251 Pre-Amp in the line. If you are using an R-307 Readout, the preamp must be installed between the target and the R-307 Readout. If you are using more than one target, there must be a T-251 Pre-Amp in each target connection. R-308 Readouts have a built-in T-251 Pre-Amp and do not require an external T-251.

Target Connections for Straight Line Lasers

When using straight line lasers, the targets are connected directly to the R-307 Readout.

Calibration of Readouts to Targets

The purpose of calibration is to certify that the readout displays accurate information about the target location whenever the target is displaced from the exact center position of an oncoming straight line or scanning laser beam.

All Hamar Laser equipment is aligned and calibrated when it leaves the factory. The alignment or calibration of most units can be checked or verified in the field. No adjustments in the calibration should be necessary unless a new target has been added to the setup. Because the readout units are rugged and built to withstand the shop floor environment, we recommend that any unit showing severe miscalibration (position changes shown on the readout display are ±15 percent of the actual physical position change) be checked and serviced by Hamar Laser factory technicians.

When a new target is purchased, any necessary adjustments can be made immediately before using the equipment. If there is a question on the result of an alignment, the readout can be calibrated by the operator. If you must calibrate the readout to the target, the process involves:

- Using micrometers (or another traceable reference) to move the target an exact amount off of absolute center or "zero".
- Checking the numbers on the readout display.
- Adjusting those displayed numbers by changing the set of the calibration trimpot.

Hamar targets and readouts leave the factory calibrated to within 5 percent. This means that any numerical information displayed on the readout can have a maximum error of 5 percent. For example, the total of a 5 percent calibration error on a reading of **.001 in.** would actually be **.00005 in.** (a very small deviation). The table below shows the allowable 5 percent error for readings when the scale is set to **.0001 in.**

READOUT DISPLAY	**ALLOWABLE 5 PERCENT ERROR**	
25.0 in.	.0013 in.	(1.3 in display units)
.010 in.	.0005 in.	(0.5 in display units)
.001 in.	.00005 in.	(.000 in display units)
.0001 in.	.000005 in.	(00.0 in display units)

As the table shows, a 5 percent deviation of the numbers displayed on the readout is quite small. In most procedures the operator will center the target in the path of the laser beam so that all readings are deviations from the null center point and are displayed as close to 0.000 as possible on the readout. As with most electronic devices, accuracy is a matter of tuning the receiver to the signal. For further information, see the sections of this manual titled *Calibration Checking Procedure* on Page 96 and *The Calibration Trimpot* on Page 98 for more detailed information.

Calibration Checking Procedure

To ensure that a readout display accurately reflects changes in target position, perform the following procedure.

1. **Set the Readout Scale Switch**
   Set the Readout Scale Switch to the scale with the highest resolution (the .0001 in. setting).
2. **Manually center and square the target to the oncoming laser beam**
   Make sure that the target is mounted in the target stand with the cable hanging down from the lowest (6 o'clock) position on the target.
3. **Mechanically center target with the micrometers on the target stand**
   Adjust the vertical axis first by turning the micrometer on the target stand until the vertical readout display window reads 0.000. Be sure to center in such a way as to remove the micrometer backlash (if you happen to turn the micrometer dial beyond the desired position, you will have to back the micrometer off and, once again, approach the desired measurement). Complete the mechanical centering by adjusting the horizontal axis micrometer control until the remaining readout display (R-307) reads 0.000.
4. **Read and record the micrometer settings (not the readout display)**
   Once the readout displays 0.000 (both windows on the R-307) the corresponding micrometer settings should be noted on a worksheet (see Page 97 for a sample worksheet).
5. **Turn the vertical axis micrometer +.025 in. (one full turn)**
   Turn the vertical axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.
6. **Read and record the number on the vertical readout display window**
   Record the readout number on the worksheet.
   Note: *While adjusting only the vertical micrometer, watch both readout windows (on the R-307) for changes. If the numbers in both windows change, the target will need to be rotated until it is square to the laser beam.*
7. **Re-zero the Display using both micrometers**
   Turn both micrometers until the readout display reads 0.000 in both axes.
8. **Change the vertical axis micrometer -.025 in. (one full turn)**
   Turn the vertical axis micrometer control one full revolution (-.025 in.). Be sure to eliminate micrometer backlash.
9. **Read and record the number on the readout display**
   Record the readout number on the worksheet.
10. **Re-zero the Display using the vertical micrometer**
    Turn the vertical micrometer until the readout display reads 0.000.

If your readout is a Model R-307, check the horizontal calibration.

11. **Turn the horizontal axis micrometer +.025 in. (one full turn)**
    Turn the horizontal axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.
12. **Read and record the number on the readout display**
    Record the readout number on the worksheet.
13. **Re-zero the display using both micrometers**
    Turn both micrometers until the readout display reads 0.000 in both axes.
14. **Change the horizontal axis micrometer -.025 in. (one full turn)**
    Turn the horizontal axis micrometer control one full revolution (-.025 in.). Be sure to eliminate micrometer backlash.
15. **Read and record the number on the readout display**
    Record the readout number on the worksheet. To calculate the percentage of error in the readout display for a move of .025 in., see *Calculating Error in Calibration* on Page 96

Calculating Error in Calibration

1. **Calculate the difference between actual micrometer travel and change in the readout display**
   Determine the difference between the actual .025 in. micrometer move and the number displayed on the readout window.

   - If the .025 in. physical micrometer move is displayed as a number between **23.7 and 26.3**, (within 5 percent or 1.3 units on the .0001 in. scale) the readout is correct and ready for use.
   - If the difference (error) of the .025 in. physical micrometer move is greater than 5 percent, the readout will need to be calibrated to the target (see *Calibration Checking Procedure* on Page 96).
   - If the error is greater than 15 percent, return the target and readout to the factory for repair.

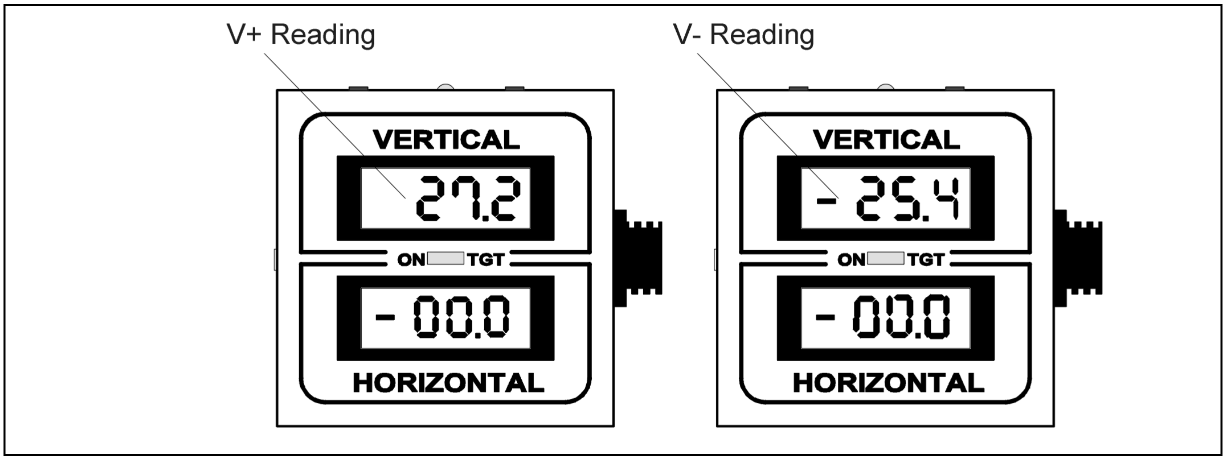


Figure 47

Error Calibration Worksheet (Scale .0001 in.)

Micrometer move/Axis	Readout Display	Absolute Value	Percent Error
+.025 in./Vertical V+	(+) 27.2	.0272	8.8%
-.025 in./Vertical V-	(-) 25.4	.0254	1.6%

$$\left[\frac{\text{(Absolute Reading Value - .025)}}{.025}\right] \text{X } 100 = \text{\% Error}$$

$$\frac{.0272 - .025}{.025} = .088 \times 100 = 8.8\%$$

2. **For vertical calibration errors greater than 5 percent and less than 15 percent:**
   If the V+ calibration is greater than 5 percent (**1.3 units on the .0001 in. scale for a .025 in. move**) and less than 15 percent (**3.8 units on the .0001 in. scale for a .025 in. move**), an operator can recalibrate the readout by following the directions for adjusting the calibration trimpots beginning on Page 98.
3. **For vertical calibration errors less than 5 percent:**
   If the total vertical calibration error is less than 5 percent, proceed with a check of the horizontal calibration error.

The Calibration Trimpot

If the error in the calibration checking procedure is between 5 and 15 percent, calibrate the readout to the target as follows:

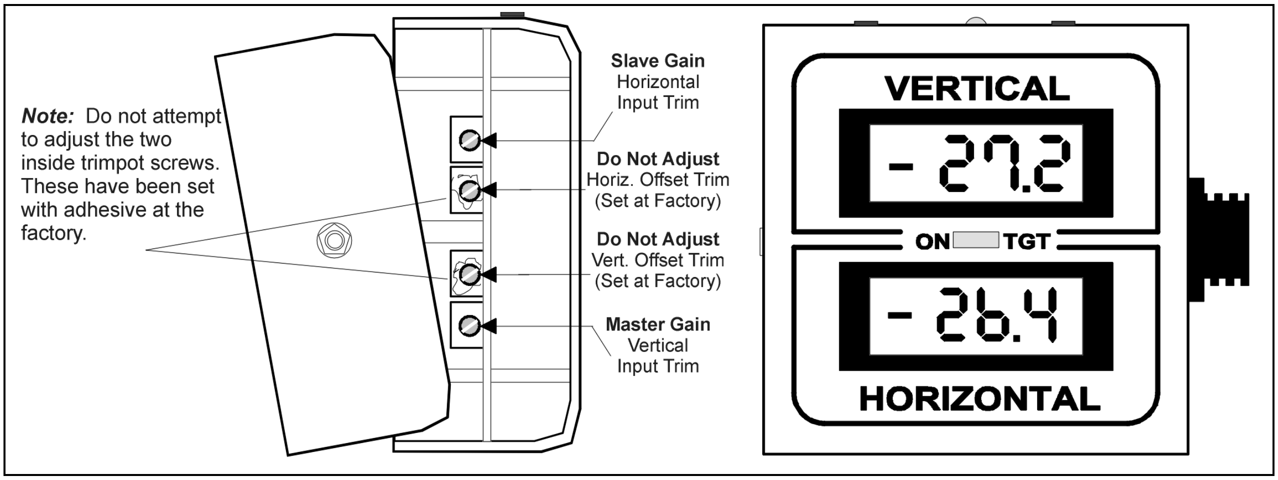


Figure 48 - *Open R-307 Readout with trimpots exposed*

1. **Unscrew the screws on the back of the readout housing**
   Separate the top and bottom half of the readout to gain access to the **Master (vertical) and Slave (Horizontal) Input Trim Screws**.
2. **Set the Readout Scale Switch**
   Set the Readout Scale Switch to the .0001 in. scale (highest resolution).

The Calibration Trimpot is located on the side of the circuit board on the inside of the readout. The Trimpots are actually small screws that can be manually turned with a small, flat-head screwdriver (see Figure 48.

- On the Model R-307 Readout, two of the four trimpot screws (the inside pair) have been glued into position and should be left alone. If these screws have been tampered with or turned, return the readout to the factory for service.
- On the Model R-308 Readout, one of the two screws (lowest on the readout) has been glued into position and should be left alone. If this screw has been tampered with or turned, return the readout to the factory for service.

The readouts are very sensitive. A turn of the screw will be instantly displayed as a change in the numeric information on the readout window. As you go through the procedural steps on the next pages, watch the readout while adjusting the trimpot screw to the left or right. The numbers on the readout display will change.

As with most analog electronic devices, the receiver must be tuned to the signal. Micrometer turns of +.025 in. and -.025 in. may "read out" as 24.0 and -23.0 or 28.0 and -22.0. The readout is accurate when the total of the readout numbers is within 5 percent of the .025 in. micrometer move.

To calculate:

$$\left[\frac{(\text{Absolute Reading Value} - .025)}{.025}\right] \text{X } 100 = \%\ \text{Error} \qquad \left[\frac{(.0272 - .025)}{.025}\right] \text{X } 100 = 8.8\%$$

Adjusting the Vertical Trimpot

1. **Manually center and square the target to the oncoming laser beam**
   Make sure that the target is mounted in the target stand with the cable hanging down from the lowest (6 o'clock position) on the target.
2. **Mechanically center target with the micrometers on the target stand**
   Adjust the vertical axis first by turning the micrometer on the target stand until the vertical readout display window reads 0.000. Be sure to center in such a way as to remove the micrometer backlash (turn the micrometer dial beyond and then back to the desired measurement). Complete the mechanical centering by adjusting the horizontal axis micrometer control until the remaining readout display (R-307) reads 0.000.
3. **Read and record the micrometer settings (not the readout display)**
   Once the readout displays 0.000 (both windows on the R-307) the corresponding micrometer settings should be noted on a worksheet.
4. **Turn the vertical axis micrometer +.025 in. (one full turn)**
   Turn the Vertical axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.
5. **Adjust the Master Gain (Vertical Input Trim Screw)**
   While watching the numbers in the vertical window of a readout, use a small, flat-head screwdriver to adjust the set of the Master Gain (vertical input trim screw). Turn the screw until the vertical window on the readout reads **25.0**.
6. **Re-zero the Vertical axis control Micrometer**
   Reset the Vertical Axis Control Micrometer until the display reads 00.0.
7. **Adjust the Master Gain (Vertical Input Trim Screw)**
   If the readout display shows -25.4 for a micrometer move of -.025 in., adjust the Master Input Trimpot until the readout reads (-25.4 + -.2) = -25.2. While watching the numbers in the vertical window of a readout, change the set of the Master Gain (vertical input trim screw) with the screwdriver. To trim out half of the difference between the displayed move and the micrometer move, adjust the trimpot so that the numbers in the vertical display read out with half of the error removed. Adjusting the -25.4 display reading to -25.2 trims out half the error on the readout display for an -.025 micrometer move.
8. **Re-zero the Vertical Micrometer**
   Reset the Vertical Axis Control Micrometer until the display reads 00.0. Calibration of an R-308 Readout is complete when numbers on the readout windows fall within 5 percent of corresponding micrometer moves.
9. **Close the R-308 Readout housing and tighten all screws. Review results.**
   If you would like to see the effect of the calibration trimpot adjustments, recheck the V+ reading with a +.025 in. micrometer turn. You will notice that the display will not register as exactly +.025 in. When you recheck the vertical readout window with a +.025 in. micrometer move, the number 24.8 will be displayed in the vertical window of the readout. In this example, you have read -25.4 for a -.025 in. vertical micrometer move, adjusted the trimpot Master Input gain and "split" the difference.

   Trimming out the entire V+ reading error eliminates the major difference between the micrometer move and the readout display. During the V- adjustment of the calibration trimpot, the remainder of the vertical axis calibration error is removed by changing the span to balance the V+ and V- readout error. After adjustment, the readout display will show a smaller amount of error for both V+ and V- readings.

Any target readings will now have an integral 0.8 percent error. If you are aligned within .001 in., the integral readout calibration error will mean that the alignment is within .001 in. ± 8 micro in. (8 millionths of an in,).

Note: *Follow this procedure to calibrate a readout as perfectly as is possible with an analog electronic device.*

Adjusting the Horizontal Trimpot

If you are using Model R-307 Readout, the horizontal axis display may also require calibration.

1. **Turn the horizontal axis micrometer +.025 in. (one full turn)**
   Turn the horizontal axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.
2. **Adjust the Slave Gain (Horizontal Input Trim Screw)**
   While watching the numbers in the Horizontal window of a readout, use a flat-head screwdriver to adjust the set of the Slave Gain (Horizontal input trim screw). Turn the screw until numbers in the vertical display read **25.0** on the .0001 scale.
3. **Re-zero the micrometers**
4. **Turn the horizontal axis micrometer -.025 in. (one full turn)**
   Turn the horizontal axis micrometer control one full revolution (-.025 in.). Be sure to eliminate micrometer backlash.
5. **Read and record the number on the readout display**
6. **Adjust the Slave Gain (Horizontal Input Trim Screw)**
   If the readout display shows -25.4 for a micrometer move of -.025 in., adjust the Slave Input Trimpot until the readout shows (-25.0 + -.07) = -25.7.

   While watching the numbers in the Horizontal window of a readout, use a flat-head screwdriver to adjust the set of the Slave Gain (Horizontal input trim screw). To trim out *half* of the difference between the displayed move and the micrometer move, adjust the trimpot so that the numbers in the vertical display read with half of the error removed. By adjusting the -26.4 display reading to -25.7, you can trim out half the error on the readout display for an -.025 micrometer move. Turn the trimpot screw until numbers in the horizontal display reads out with half of the error removed (**-25.7** on the .0001 scale). This number represents the closest possible calibration to a true reading of -.0257 in.

   Trimming out the entire H+ reading error eliminates the major difference between the micrometer move and the readout display. During the H- adjustment of the calibration trimpot, the remainder of the vertical axis calibration error has been removed by changing the span to balance the H+ and H- readout error. After adjustment, the readout display will show a smaller amount of error for both H+ and H- readings.

   Note: *Following this procedure will allow readout calibration as perfectly as possible with an analog electronic device.*
7. **Re-zero the micrometers**
   Calibration of the readout is complete when numbers on the vertical/horizontal axis readout windows fall within 5 percent of corresponding micrometer moves.
8. **Close the R-307 Readout housing and tighten all screws.**

Appendix J – Machine Tool Alignment Methods for Older Equipment

Level to Earth Measurements

Scanning lasers provide the ideal tool for leveling machine tools, surface plates and bases.

Setting Up and Leveling the Laser

1. Place the laser on any stable steel surface such as a machine bed or an L-104 floor stand.
2. Twist both magnetic levers (the base of the unit) to **ON**. This locks the instrument down securely on the surface.
3. Plug in and turn on the laser using the switch on the top cover or the control panel.
4. Turn each of the coarse leveling thumbwheels or screws (on either the top of the instrument or, in the case of the L-723, the L-123 leveling base) and adjust the tilt of the instrument to roughly center the level bubble in each of the level vials.

   Note: *Some Hamar Laser alignment systems use level bubbles, some use split prism levels with level bubbles and some use digital levels.*

5. Using the fine leveling micrometers, adjust the instrument while viewing the split image of the level bubble through the viewing prism.
6. Depending on the light conditions, a small flashlight (held at least a foot away from the laser) may be used for short periods of time to view the split-prism while leveling adjustments are being made.
7. Place an A-517 Target on the unit that needs to be leveled or adjusted. Adjust the target so that the beam scans near the middle of the red glass on the front of it by adjusting the height of the rods. Zero the readout by adjusting the micrometer on the top of the target.
8. Set the target on various places on the surface to be leveled and adjust the unit until the readout reads zero. Once the laser has been leveled and the target has been set to zero, these two units will not be adjusted any further. Any further adjustments will be made in the unit to be leveled.

   Note: Some users prefer to take readings at the various leveling points to find the highest point first. They will then use the highest point to set their target to zero and bring all of the other points up to this height.

Three-Point Buck-In (Flatness)

The Three Point Buck-In procedure requires adjusting the laser plane to be parallel to the surface being measured; for example, a tabletop, a surface plate, or a way surface. Three points are required in order to relate one plane to another. *Any* three points on a surface may be used, however Hamar Laser recommends the setup illustrated in Figure 51.

When performing this procedure, it is best to place the laser source in a position that is as close to the near target position as possible. The third target position should be approximately 90 degrees to these two points. This is not always possible, but this is the easiest configuration for this procedure.

This procedure will almost always be performed using a scanning laser beam and one or more A-517 Single Axis Targets. The example provided uses an L-720 laser.

With a scanning laser you can use either:

- An R-307 Readout with a T-251 Pre-Amp in the line
- An R-308 Readout
- The computer and interface with a T-251 Pre-Amp in the line.

Three-Point Buck-In Procedure Using One Target

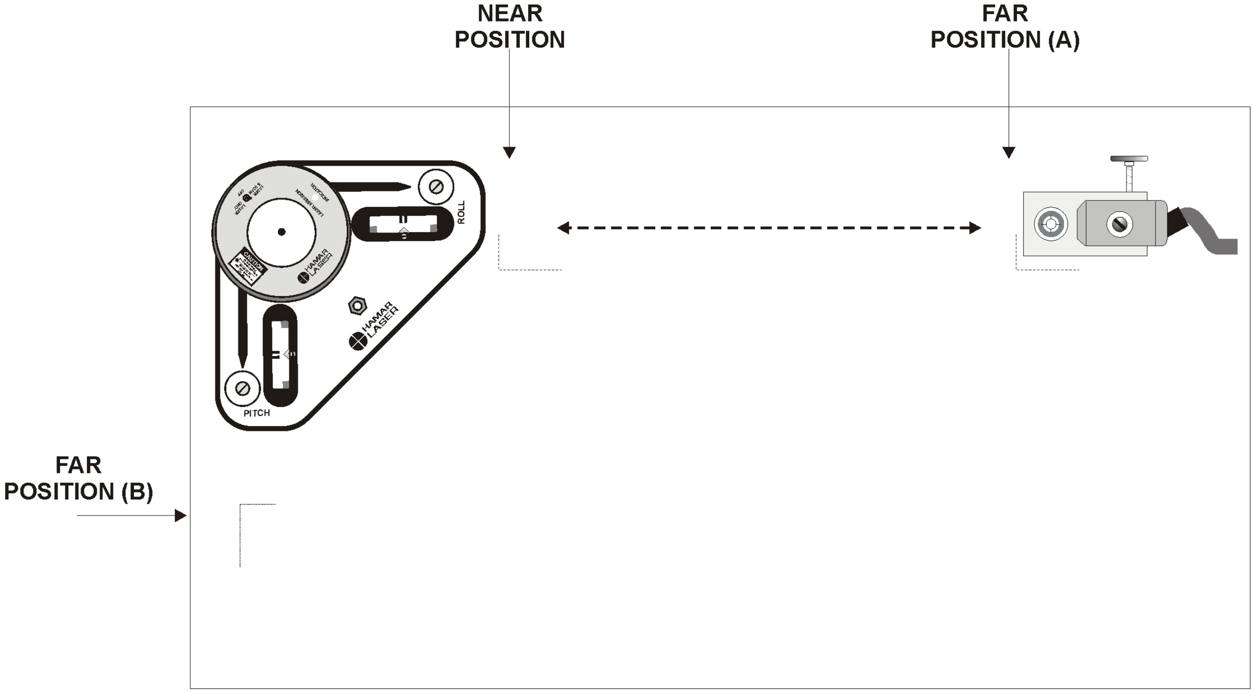


Figure 49 - *Three-Point Buck-in Using One Target (Recommended Setup)*

1. **Position and secure the laser.**
   Position the laser as shown and turn the lever on the magnetic base to ON to lock it securely to the metal surface.
2. **Coarse level the laser.**
   Turn the selector switch on the laser to LASER & SCAN and turn the light switch for the bubble level vials ON. Using the coarse micrometers and observing the position of the bubble levels, coarse level the laser so that the laser plane is approximately parallel to the surface.
   Note: *At this point in the setup procedure, it is beneficial to perform the following coarse buck-in, particularly if the levelness of the machine is in question.*
   a) With the laser in non-scanning mode, hold a tape ruler at the Near Position (see Figure 49). Point the laser until it strikes the ruler and note the exact location where the laser beam hits.

   b) Move the tape ruler to Far Position A (see Figure 49). Point the laser beam at the tape ruler and adjust the center of the beam to hit the same location obtained in Step 2a.

   c) Repeat this process until the laser hits the same location on the tape ruler in both the Near Position and Far Position A.

   d) Place the tape ruler at Far Position B (see Figure 49) and rotate the laser beam to hit the tape ruler. Adjust the laser so that the center of the beam hits the same location recorded at the Near Position.

   e) The procedure is complete when the laser beam hits the same location on the tape ruler *for all three of the target positions.*

3. **Position and secure the target.**
   Place the target in the *Near Position*. Move the target in its magnetic base until the laser beam roughly hits the mid-position of the target and turn the lever on the magnetic base to ON to lock it securely to the metal surface.
   Note: *As you move the target to the Near Position, Far Position A and Far Position B, mark where the base of the target sits on the surface so that it may be repositioned in the same place each time.*
4. **Set the readout.**
   Set the readout to the .001 in. scale setting and FAST mode.

Performing the Three-Point Buck-In

1. **Center the target in the Near Position.**
   With the target in the Near Position, adjust the *target* micrometer until the readout reads zero.
2. **Move the target to Far Position A and tilt the laser beam until the readout reads zero.**
   With the target in Far Position A, tilt the laser beam with the *laser* micrometers until the readout reads zero. Be sure to use *only* the micrometers that face the target (in the setup displayed in Figure 49, this would be the micrometers marked ROLL).
   Note: *When the target is in the Near Position, always use the target micrometer to center the target photocell. When the target is in a Far Position, always use the laser micrometers to tilt the laser beam. This is easily remembered by the phrase, "Center Near, Tilt Far."*
3. **Repeat Steps 1 and 2 until the readout reads zero with no adjustments.**
   Continue to move the target between the Near Position and Far Position A and adjust the target and laser micrometers (depending on the target position) until the readout reads zero without adjustments.
4. **Move the target to Far Position B and tilt the laser until the readout reads zero.**
   Be sure to use only the laser micrometers that face the target when tilting the laser beam (in the setup displayed in Figure 49, this would be the micrometer marked PITCH).
5. **Recheck the readings at the Near Position and at Far Positions A and B and adjust to zero if necessary.**
   When all readings are zero *without adjustment*, the laser plane is parallel to the surface.

Three-Point Buck-In Procedure Using Multiple Targets

This method requires three A-517 Targets and three readouts. The procedure is basically the same as with one target but saves the time required to move a single target to the three different footprints.

1. Zero all three targets on the near footprint.
2. Place two of the targets on the other two footprints.
3. Tilt or aim the laser until all three readouts read the same numbers and the same sign.
4. When all three readouts read the same, the laser plane is then parallel to all three points.
5. It is best to have the numbers on the three readouts less than .025. If they are greater than .025, re-zero all three targets on the near footprint and repeat this procedure.

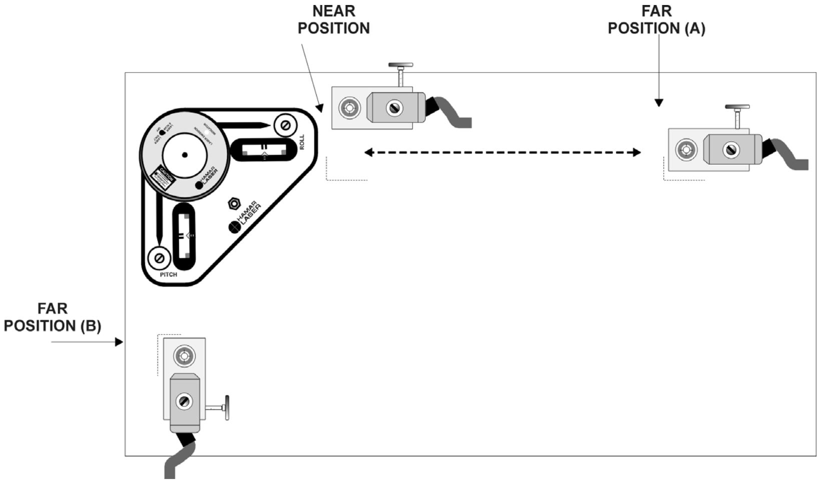


Figure 50 – *Three-Point Buck-in Using Three Targets (Recommended Setup)*

Two-Point Buck-In (Straightness)

A laser beam is often used as a "straight edge" to measure straightness. Examples are machine tool ways or bore straightness measurement. The laser beam must be adjusted to be parallel to or coincident with an edge or centerline. The process of making that adjustment is called "bucking in."

Two points in space define a unique straight line; therefore, two reference points are needed in order to relate the position of a laser beam to a surface or centerline. Any two points may be chosen (the suitability of the points cannot be judged until after the measurement has been done). The points are usually selected near the extreme ends of the job for the sake of convenience. A Two Point Buck-In makes the laser beam parallel with these two points.

The Two-Point Buck-In procedure is most commonly performed using an A-517 Single Axis Target and a scanning laser. If you are using a straight line laser you will need a two-axis target on a T-230 x and y adjustable stand. The procedure will be the same, but you must also adjust the horizontal readings to zero. On the near point, adjust the target micrometer, and on the far point, aim the laser with the azimuth adjustments.

Two Point Buck-In Procedure

1. **Place the laser in a position that is as close to the *near* target position as possible.**
   Orient the laser so that either the long axis of the base or the short axis of the base is parallel to the near and the far target positions.
2. **Adjust the target micrometer until the readout reads zero.**
3. **Move the target to a far position and aim the laser using the adjustment micrometers until the readout reads zero.**
4. **Move the target back to the near position and adjust target again until the readout reads zero.**

Repeat this until both positions read zero and no further adjustments are necessary.
Note: *Place the target in exactly the same place each time you move from near to far or from far to near. Marking the footprint is usually the best way to ensure that you are back in the same spot each time you move the target. Also, make it a habit to clean the bottom of the base and the surface with your hand before placing the target on the footprint.*

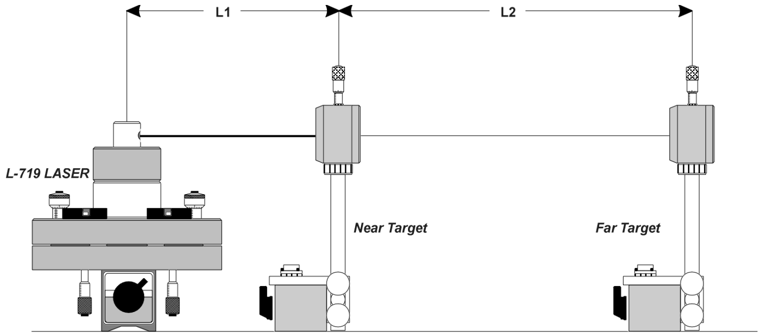
Always ADJUST the TARGET to zero on the near point. Always AIM the LASER to zero on the far point.

When both near and far points produce zero readings, the laser beam is parallel to these two points. Any number of points in between these two points may now be checked to see if they are in that same line. If the readings are + (plus) numbers, the points are higher than the line drawn from the near point to the far point. If the numbers are - (minus) numbers, the points are lower than the line drawn from the near point to the far point.

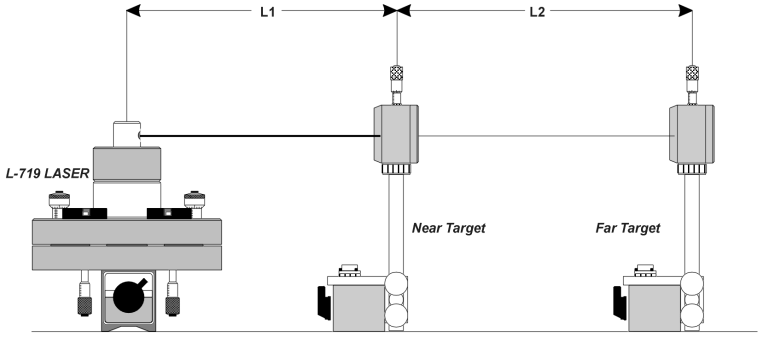
Close versus Remote Buck-In

There are two procedures for bucking in the laser, the close and the remote buck-in. The procedure used depends on the relationship of two distances: the distance between the laser unit and the first target, and the distance between the first and second targets. The close buck-in is easier; the remote buck-in is useful in situations where the close method would be nearly impossible.

Figure 51 illustrates the general rule for determining the buck-in method to use. L1 represents the distance from the laser to the first target. L2 represents the distance between the two targets. If L1 is less than one tenth of L2, the close buck-in procedure is used. If L1 is greater than one tenth of L2, the remote buck-in procedure should be used. When in doubt, or if the close procedure is not producing good results, use the remote procedure.



If L1<10% of L2, use the Close Buck-in Method



If L1>10% of L2, use the Remote Buck-in Method

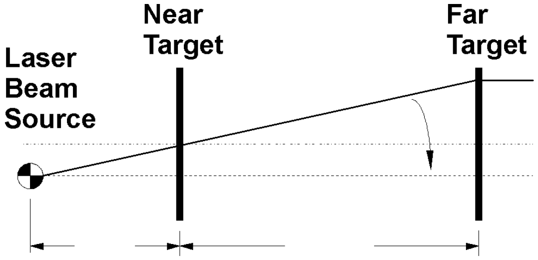
Figure 51 - *Determining the Buck-in Method*

Close Buck-In

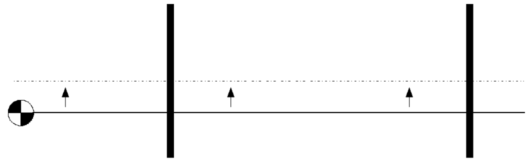
The close buck-in procedure can be remembered by the rule, “Zero Near, Point Far.” Buck in the laser beam by zeroing it on the *near* target, and then tilt the entire laser unit to "point" the laser beam, *centering* on the far target. The two steps are repeated until both targets show zero readings.

Remote Buck-In

As the distance between the laser and the near target increases with respect to the distance between the two targets, bucking in by the close method becomes nearly impossible. A special remote procedure has been developed for these situations. The remote buck-in uses simple geometry to make the laser beam parallel to the centerline of the two targets and then centers the beam on that line. Figure 52 illustrates how the remote method works.



Make the beam parallel to the target centerline.



Center the beam on the target centerline.

Figure 52 - *Remote Buck-in*

Unlike close buck-in, where the laser is pointed ***to*** zero on the far target, the remote procedure has the laser point ***through*** zero to a point called the "Set Point." The Set Point distance is the offset between the parallel laser beam and the target centerline.

The uncorrected laser beam, the offset parallel beam, and the set distance form a triangle. The uncorrected beam, the target centerline, and the distance between the far target center and the far reading form a second triangle. The two triangles are geometrically identical because they have the same three angles.

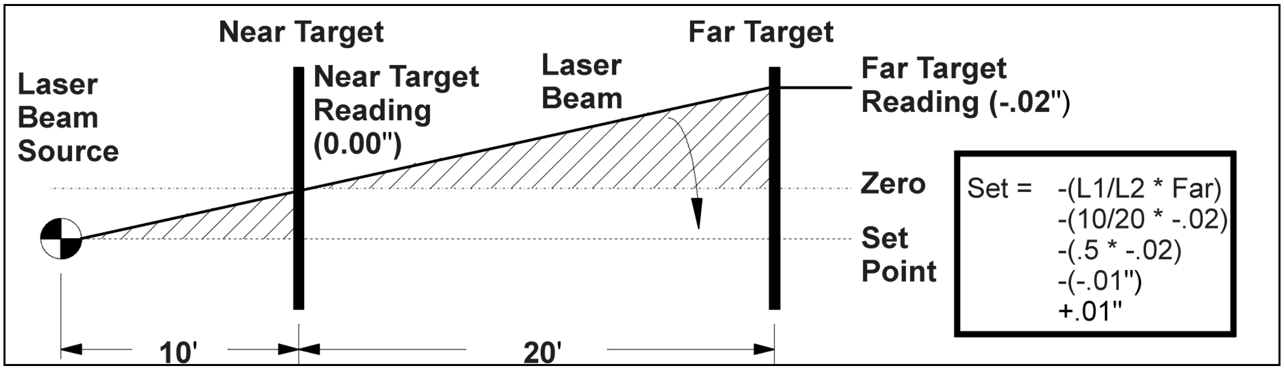


Figure 53 - *Calculating the Set Point*

A relationship between these two triangles can be stated in the formula, “The set is to L1 as the far reading is to L2.” Stated mathematically, the ratio is Set/L1 = Far/L2. If L1, L2, and the far reading are known, the set can then be determined by the following formula: Set = (Far reading * L1/L2).

Note: *This is a simplified formula for cases where the laser beam is centered on the near target.*

In remote buck-in, point ***through*** zero to the Set Point. This means moving the laser until it reads the set amount on the ***other side*** of zero from the starting point. In doing so, the sign of the number (negative or positive) will be reversed. Figure 53 illustrates this by taking sample readings and showing how the Set Point is derived. (Notice the far reading is a negative number and the Set Point is positive as you go "through zero.") This results in a laser beam parallel to the target centerline but offset by the set distance.

If the calculated Set Point exceeds the linear range of the target, (.1 in. or 2.5mm) ***the laser unit itself must be moved*** by the Set Point amount. New measurements must then be taken for both targets and a new set point calculated. Figure 54 shows how to move the laser depending upon the sign of the calculated Set Point.

Note: *If the laser is mounted on an L-104A screw lift stand, each full turn of the knob lifts or lowers the stand .125 in. or 3 mm).*

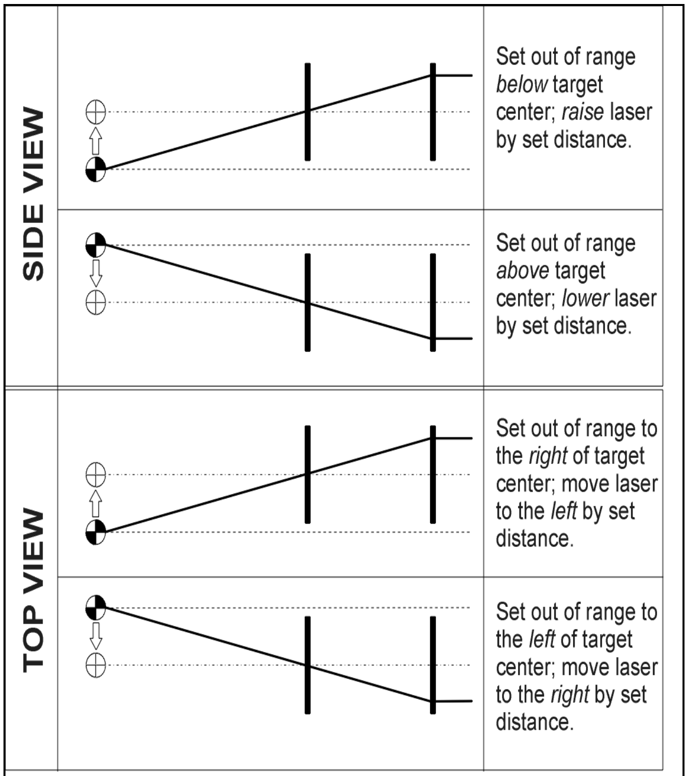


Figure 54 - *Moving the laser when the Set Point is out of range of the target cell*

Once the laser beam is parallel to but offset from the target centerline, center the beam on the near target. The targets should give the same reading, both number and sign, for both axes (horizontal and vertical). If not, refigure the set and buck in again. In most cases, remote buck-in can be accomplished in two or three passes. This method will work even when L1 is much greater than L2, or when the beam does not even hit the target (in such cases the far reading can be taken by using a ruler to measure the beam's distance from the target center).

The determining factor for which method to use can be summed up as follows:

- Use Close Buck-in if the distance from the laser to the first target is less than one-tenth of the distance between the two targets.
- Use Remote Buck-in if the distance from the laser to the first target is more than one-tenth of the distance between the two targets, or if close buck-in method is not effective.

When using close buck-in, the rule is: *Zero Near, Point Far*. Zero on the near target, and then point to the far target by adjusting the laser unit. Repeat until both targets provide the same readings.

When using remote buck-in, the rule is: *Point Through Zero to Set Point*. Center to zero on the near target, determine the Set Point (making sure the sign is correct), adjust the laser unit to point to the Set Point (rather than zero) on the far target, and then center the beam again on the near target. Repeat if necessary, until both targets give the same readings. The laser beam is now bucked-in to the centerline as defined by the two targets.

Appendix K– Agency Certifications

Agency Certifications for the 2.4 GHz Radio Transceiver

FCC (United States of America) Certification

Contains FCC ID: OUR-24XSTREAM
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

⚠ RF EXPOSURE WARNING: This equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 m or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended

IC (Industry Canada) Certification

Contains Model 24XStream Radio (2.4 GHz), IC: 4214A 12008
Complies with IC ICES-003

Complies with ETSI. *France – France imposes restrictions on the 2.4 GHz band. Go to www.art-telecom.Fr or contact MaxStream*♦ *for more information. Norway – Norway prohibits operation near Ny-Alesund in Svalbard. More information can be found at the Norway Posts and Telecommunications site (www.npt.no).*

Since the 2.4 GHz band is not harmonized throughout Europe, other restrictions may apply to your country.

Technical Data:
- OEM radio transceiver, model number: 24XStream
- Frequency Band: 2400.0 – 2483.5 MHz
- Modulation: Frequency Shift Keying
- Channel Spacing: 400 kHz
- ITU Classification: 400KF1D
- Output Power: 100 mW EIRP max.
- Notified Body Number: 0891

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(1) The radio Transceiver contained in the A-1519/A-1520 Type II Universal Wireless Targets is manufactured by MaxStream®. For more information pertaining exclusively to the Radio Transceiver please contact MaxStream at 1.801.765.9885 or visit their web site: http://www.maxstream.net

Agency Certifications for the 900 MHz Radio Transceiver

FCC (United States of America) Certification

Contains FCC ID: OUR-9XCITE
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

⚠ RF EXPOSURE WARNING: This equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 meters or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended

IC (Industry Canada) Certification

Contains Model 9XCite Radio (900 MHz), IC:4214A-9XCITE

Agency Certifications for the XBee® 802.15.4 Series 1

FCC (United States of America) Certification

Contains FCC ID: OUR-XBEE
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

⚠ RF EXPOSURE WARNING: This equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 meters or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended

IC (Industry Canada) Certification

Contains Model XBee 902.14.4 IC:4214A-XBEE

Complies with ETSI (Europe), C-TICK (Australia) and Telec (Japan)