L-703B Self-Centering Laser Bore Alignment System

February 2025

HAMAR LASER INSTRUMENTS, INC.
www.hamarlaser.com

5 Ye Olde Road, Danbury, CT 06810
Ph: +1-203-730-4600
Fax +1-203-730-4611

WARRANTY

Hamar Laser Instruments, Inc., warrants each instrument and other articles of equipment manufactured by it to be free from defects in materials and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument and other article of equipment which shall within one year after shipment of each instrument and other article of equipment to the original purchaser be returned intact to Hamar with transportation prepaid, and which Hamar's examination shall disclose to Hamar's satisfaction to have been thus defective; other than this express warranty, Hamar neither assumes nor authorizes any other persons to assume for it any other liability or obligation in connection with the sale of its products.

This warranty is not applicable to instruments or other articles of equipment manufactured by other companies and limited by a warranty extending for less than one year. In such an event, the more limited warranty applies to said instrument or article of equipment.

This warranty shall not apply to any instrument or other article of equipment which shall have been repaired or altered outside the Hamar factory, nor which has been subject to misuse, negligence, or use not in accord with instructions furnished by the manufacturer.

5 Ye Olde Road, Danbury, Connecticut 06810

Contents

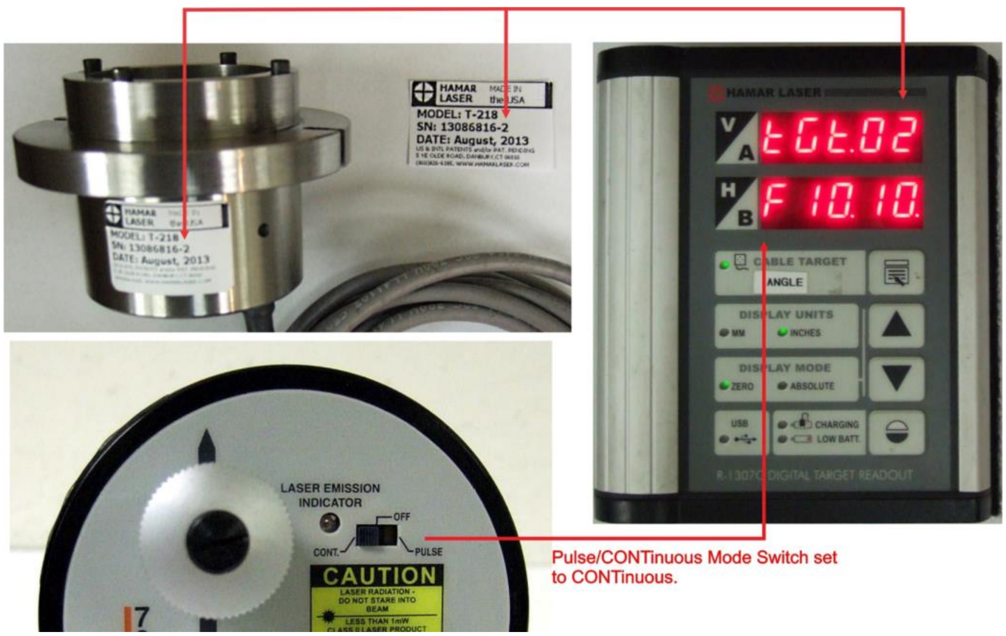
Important Note on Calibration

When configuring the R-1307 Readout, it is important to match the target ID setting in the Menu with the target ID identified on the serial number of the target. For example, if the target ID on the target serial number label is 2, then the R-1307 must also be set to TGT.02. If the target and readout and not matched, a centering error of up to .002 in. (0.05 mm) can occur.

In addition, the L-703B, L-705 or L-706 laser switch setting (CONT. *or Fixed* **vs. PULSE) must also agree with the R-1307 Readout setting. To set the readout for:**

For the L-705, L-706 andL-708, there is a slide switch to change the laser mode:

- **CONTinuous (Fixed) Mode - set the readout to F10.10; and**
- **Pulsed Mode - set the R-1307 to P10.10.**



For the L-703B, there is a Mode Button to change the laser mode – see page 5.

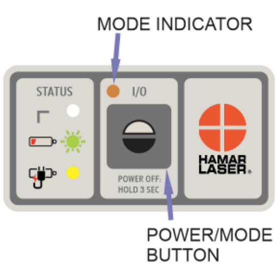
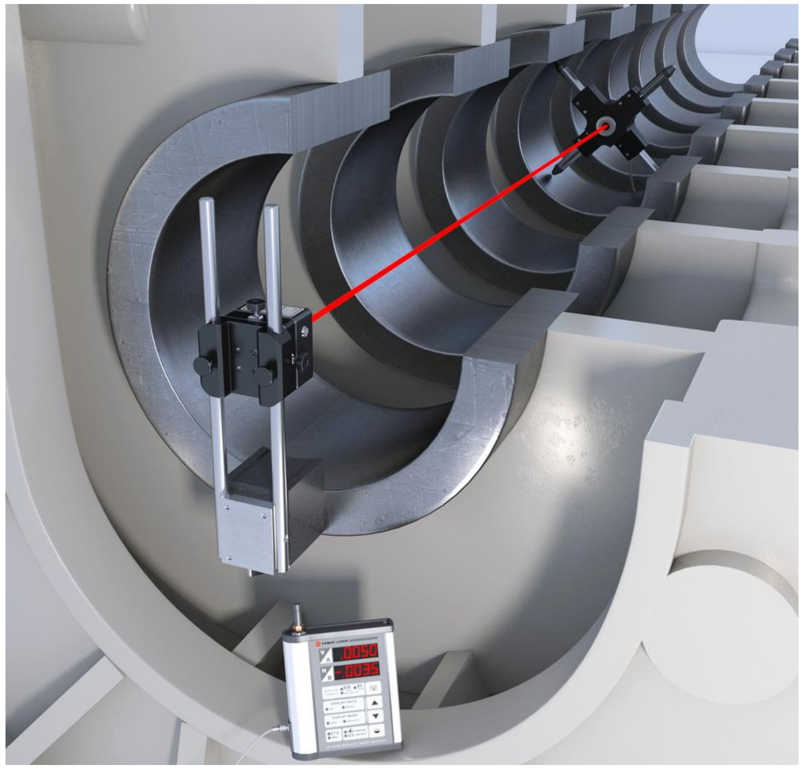


Figure 1 - L-703B Laser Power/Mode Button

For more information on the Pulse/CONTinuous modes on the laser, see *Pulse/Continuous Modes (L-703B, L-705, L-706 and L-708 Lasers)* on **Page 5**. For complete information on matching the target to the readout, see *Configuring the R-1307 or R-1307C for a Local Target* on **Page 16**.

Introducing the L-703B Self-Centering Laser Bore Alignment System

Bore alignment can be defined as aligning or checking a bore for straightness or making a series of bores concentric with two reference bores. Reference bores are usually the end bores, but they can be *any* two of the series.



To check bore alignment, the L-703B Laser is placed in the L-112 Laser Stand outside of the series of bores and the laser beam is adjusted so it passes through the center of the 2 reference bores – we call this a *2-point buck-in*. Once the laser is centered to the 2 reference bore centers, the remaining bores can be measured using the same target for their concentricity to the reference bores.

Designed for high accuracy bore alignments, the 703B Self-Centering Laser Bore Alignment System offers the most accurate, yet easy to use, laser alignment systems. With high resolution, capability to measure a wide range of bore diameters, and our patented self-centering bore adapters, the L-703B is the best bore alignment system on the market.

The alignment system also offers a variety of target options, including self-centering, see-through, 2-axis and 4-axis targets, hand-held readouts, and Windows®-based software to display and analyze alignment data. The system handles a wide range of bore alignment applications, such as:

- Aluminum can-making machinery,
- Bar-turning machines,
- Bore straightness checks for cylinders,
- Engine-block crankshaft bore alignment,
- Stern tube alignment,
- Tail rotor bearing alignment for helicopters, and
- Tube support plate bores for heat exchangers.

Simplified fixturing and self-centering targets make it possible to set the system up in as little as 15 minutes. Bore straightness data can be taken and analyzed in 30 minutes or less in most cases. This means even the longest bore application can be measured in just minutes versus hours for optics, tight wire or other laser systems.

The L-703B laser has been designed with our standard Ø.4995 in. (Ø 12.69 mm) mounting stud, where the laser beam is concentric to the OD to within .0003 in. (0.008 mm). This allows the L-703B to be mounted in a spindle chuck, so an engine block can be checked while it's still on the boring mill.

With a variety of bore alignment target, bores from 1.18 (30 mm) up to 50 in. (1,270 mm) or more, can easily be measured with our bore laser system.

When used with our R-1307 Readouts and Bore9 Software, the system provides a resolution of .00002 in. (0.0005 mm). Under good environmental conditions, the laser is accurate to .0003 in. (0.0075 mm) over 10 feet.

Alignment System Features

- Fast and simple setup
- Built-in horizontal and vertical angular adjustments for quick referencing
- Simple fixturing to mount the laser into the reference bore
- Visible laser beam straight to .0001 in. in 10 ft. (0.0025 mm in 3 m) or .001 in. in 100 ft. (0.025 mm in 30 m)
- R-1307-2.4ZB Readout supports both wireless and cabled targets with a wireless range up to 150 ft. (45 m)
- Self-centering target, accurate to .0003 in. (0.0075 mm) , vastly simplifies measurement process
- The system handles a large range of bore IDs from 1.18 in. (30 mm) up to 50 in. (1,270 mm)
- Windows®-based Bore9 software with large color graphics to record and analyze bore straightness and alignment data.
- Dynamic or live display of component misalignment
- Laser has Li-Po rechargeable battery with over to 11 hours battery life
- Optional A-221 Small-Bore Target easily accommodates bores as small as 1.18 in. (30 mm)

Recommended System Configuration

- L-703B Bore Laser
- L-112 Laser Adjustment Stand
- L-103 Axis Laser Beam Translation Fixture
- A-512 2-Axis Bore Target
- A-514A Small-Bore, Self-Centering Adapter for 3.75 in. (95 mm) to 6.75 in. (172 mm) diameter bores
- A-514B Medium-Bore, Self-Centering Adapter for 6.5 in. (165 mm) to 17.5 in. (445 mm) diameter bores
- A-514GS Small Leg-Setting Gage for A-514 A and B Adapters
- R-1307B-2.4ZB 2-Axis Combination Readout
- A-814 Shipping Case

Optional Accessories

- A-514C Large-Bore, Self-Centering Adapter for 17.0 in. (432 mm) to 40.0 in. (1 m) diameter bores
- A-514GL Large Let-Setting Gage for A-514 A, B and C Adapters
- A-514CXL X-Large Bore Self-Centering Adapter for 17.0 in. (432 mm) to 50.0 in. (1.3 m) diameter bores
- A-510 2-Axis Bore Target
- A-510STA Self-Centering Adapter Hub
- A-510LTA Self-Centering Adapter Hub for Large Bores
- M-705CL Set of 4 Customized Legs for A-510STA
- A-221 2-Axis, Small-Bore Target and Adapter
- T-1218 2-Axis Bore Target with 20x20 mm PSD
- T-1220 2-Axis Bore Target with See-Through capability 20x20 mm PSD
- T-1240 2-Axis Self-Centering Bore Target with See-Through capability for Self-Centering Bore Adapters 20x20 mm PSD
- T-218 2-Axis Universal See-Through Target
- T-225L Large Bore Flange for T-218 Target
- T-231AL 25 ft/ Target Extension Cable
- A-910-2.4XBE Wireless Data Receiver
- S-1403 Bore9 Software

L-703B Self-Centering Bore Alignment - Hardware Overview

This section describes the equipment and procedures for aligning lathes and turning centers using Hamar Laser's L-703B Bore Alignment Laser System. The system includes targets, fixtures, readouts and software.

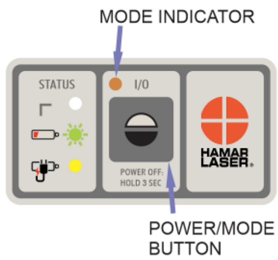
L-703B Laser - Features and Setup

- Operating range of 50 ft. (15 m).
- Pitch and yaw angular adjustments.
- A .4995 in. (12.69 mm) mounting stud with the laser beam concentric to < .0005 in. (0.013 mm).
- Under good environmental conditions, it is accurate to .0015 in. (0.075 mm) in 50 ft. (15 m).
- Accuracies of .0002 in. (0.005 mm) in 10 feet (3 m) can also be achieved.
- Rechargeable Li-ion battery with 11 hours of battery life.

The L-703B is mounted directly in the L-112 Laser Stand and mounted externally. It can also be inserted into a spindle's chuck or a collet, and, using Lathe10's Step 2 Laser Setup, it can be aligned to the rotation axis of the spindle. This is very useful if you want to check the bore alignment of a newly machined set of bores without taking it off the boring mill.

Laser Control Panel and Functions

The I/O and Status LEDs



- *Battery Status LED* – green – normally it is off.
  - Blinks when the battery is low.
  - Solid yellow when the battery is charging. Turns off when the battery is fully charged.

  Note on Charging: With a fully charged battery, the Battery Status LED will blink very quickly and then shut off. This means it's fully charged.

- *I/O LED* – indicates the laser is turned on. This is also the mode indicator for the laser mode - see Laser Modes on the next page.

The On/Off Button

Press the **I/O** button once to turn it on and press and *hold* for 3 seconds to turn it off. The I/O LED will illuminate when the power turns on.

L-703B Laser Modes

There are 2 laser modes:

1. **Single-Blink Mode** (default) –The I/O LED will blink to indicate the Single-Blinking Mode. This is used with the R-1307 and is the recommended mode to use since it eliminates background light.

   Note: the R-1307 needs to be set to "Pulsed" Mode (P10.10) – see pages 13-19.

2. **Fixed (Continuous) Beam mode** – the laser beam is turned on continuously and does not blink. This is used for legacy targets using the R-358 Computer Interface or R-307/R-307V Readouts. The I/O LED will be continuously on (no blinking).

To change the mode, press the **I/O** power button once – do <u>not</u> press and hold, just press one time.

The chart below indicates the operational modes for Readouts/Computer Interfaces that operate with the bore and spindle lasers.

Mode	Lasers	Targets	Readouts	Computer Interfaces
Blink (Pulse) supported by:	L-702SP, L-703, L-703B, L-705, L-706 and L-708	A-220, A-221, A-510, A-512, T-212, T-218, T-219, T-271	R-1307B-2.4ZB, R-1307BC, R-1307C, R-1307-900/2.4, R-1307-2.4ZB, R-1307+R	A-910-900/2.4 (when used with R-1307-900 or R-1307-2.4) A-910-2.4ZB
Double-Blink supported by:	L-702SP, L-703 and L-703S	T-1295, T-1296	R-1357-2.4ZB	Bluetooth + MultiTurn10 or Read16 Software
CONTinuous supported by:	L-700, L-702SP, L-703 L-703B, L-703B, L-705, L-706 and L-708	A-220, A-221, A-510, A-512, T-212, T-218, T-219 T-261, T-271	R-1307, R-1307B (R-307, R-307V – discontinued)	R-358 (R-355 – discontinued)

Notes:

1. *The T-261A+R-358 does not support the Single or Dual Pulsed-Beam Mode and the system purchased is factory-configured to operate in CONTinuous mode when using these targets.*
2. *When using the L-700 Laser with the R-1307 and a 2-Axis Target, the system is factory-configured to operate in CONTinuous mode.*
3.

A/C Connector

The L-703B comes with a rechargeable battery. The connector is shown in **Figure 2**. To connect it, line up the red dot on the A/C adapter plug with the red line on the connector.

Figure 2 - The L-703B - Laser A/C Adapter Connector

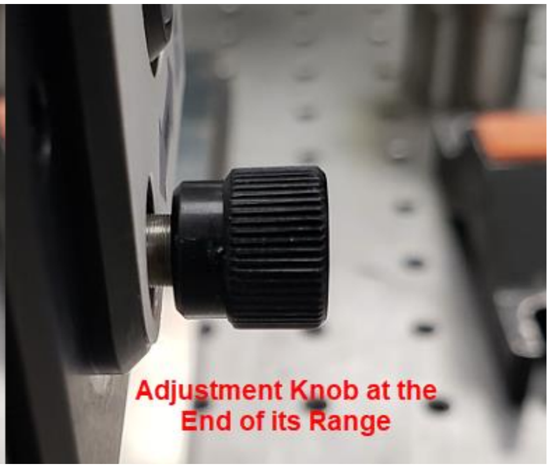
L-703B Angular Adjustments

Figure 3 - L-703B Laser showing Pitch & Yaw Adjustments

The L-703B comes with pitch (vertical) and yaw (horizontal) angular adjustments to adjust (tilt) the laser to align it to reference points or a rotation axis. The angular adjustments have a resolution of .00001 in/ft (0.000833 mm/m) and an adjustment range of ±0.36° (±.075 in/ft or ± 6.26 mm/m)

Returning L-703B Adjustments to the Center of their Range

To start an alignment, it is best to return the L-703B's angular adjustments to the middle of their range. The middle of the range is when the knob is flush with the overlay (see below). If the knob is unscrewed all the way, then knob will come out, but this will not harm the mechanism, so just screw it back in. If the knob is screwed in, then it will also go into the face plate about .25 in. (10 mm).



L-703B Level Vials

When using the L-703B in spindle applications, we typically will align the laser to the rotation axis using our NORMIN procedure, which requires taking 2 measurements: with the laser at 12:00 (NORMal) and with it rotated 180 deg. (Inverted) at 6:00. There are level vials on the *side* of the laser to help you know if the laser is directly at 12:00 or 6:00.

To use the level, rotate the laser 90 degrees so that the control panel is on the side (i.e. at 3:00 or 9:00). Then slowly rotate the spindle until the bubble is centered in the circle. This indicates the laser is ready to be aligned to the rotation axis.

Note: *when the laser is rotated by 90 degrees, the Vertical and Horizontal axis flip, so keep that in mind when making your adjustments.*

L-103 Optical Beam Translator

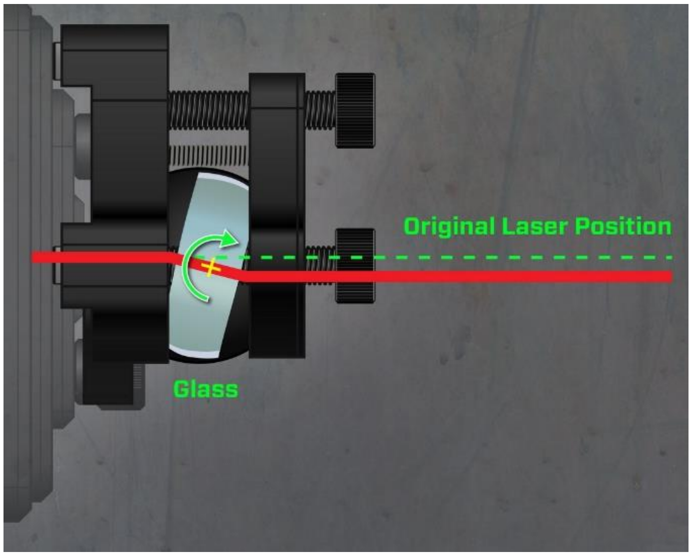


Figure 4 - L-103 Laser Beam Translator Showing Beam Position

The L-103 uses a parallel-sided piece of glass to redirect the laser beam to center it into a bore target without changing the laser beam angle. It works by the laser beam passing through the glass and reflecting off the entrance surface and going up/down, or left/right, and then reflecting in the opposite angle out of the exit surface. The result is the beam coming out parallel but offset from the input beam position. The angle of the beam is not affected by tilting the optic. The greater the tilt, the greater the position change of the laser beam. The resolution of the adjustment is .00005 in. (0.001 mm). It has a range of ±.040 in. (±1 mm)

The L-103 is attached to the L-703B Laser with powerful magnets. To translate the beam, there are 2 adjustment screws, one for horizontal movement and one for vertical. The L-103 features:

- X-Y Center Adj/ Resolution of .0001 in. (0.0025 mm)
- X-Y Center Adj. Range of ±.043 in. (±1.09 mm)

This means that if the target is centered in the near bore to within ± .040 in., then the L-103 can be used to finely translate the laser beam to the center of the target. This makes the laser setup go much faster and easier than trying to move the magnetic base or the laser up/down the posts.

Figure 5 - Installing the L-103 Optical Beam Translator on the L-703B

The L-103 fits onto the L-703B laser by using strong magnets – see **Figure 5**. Once L-103 is in place, simply turn either the vertical axis or horizontal axis knobs to change the position of the laser beam.

To return the L-103's to the center of their adjustment range, rotate the knobs until the gap between the 2 metal pieces is the same – **see Figure 6**.

Figure 6 - Returning L-103 to Center

L-112 Laser Stand

The L-112 Laser Stand is designed to mount the L-703B Laser outside of the bores being measured for high-accuracy bore alignment. The L-112 is used to buck-in (align) the laser to 2 reference points. It works with the L-103 Optical Beam Translator, which optically translates (changes the position) the laser beam in 2 axes to the near reference bore. The L-112 can also be used with the L-700 Laser.

The L-112 comes with 2 mounting orientations: a) on horizontal surface, or b) on a vertical surface, such as a flange of a bore. It has 11.4 in. (290 mm) posts that with optional extensions to position the laser near the center of bores from 2 in. (51 mm) to 24 in. (610 mm) in diameter.

Applications include:

- Compressor bore concentricity
- Cylinder straightness
- Engine-block bore concentricity
- Extruder-barrel straightness
- Gun-barrel straightness
- Guideway straightness & flatness measurements
- Locomotive engine-block bore concentricity
- Marine diesel engine-bore concentricity

Features of the L-112 Laser Stand:

- 275 lb. (125 kg) holding-force magnetic base and 11.4 in. (290 mm) posts
- Two mounting orientations:
  - Horizontal surfaces
  - Vertical surfaces, such as bore or gearbox flanges
- Coarse pitch (vertical) angular adjustments with a range of ±.61 in/ft (±50.8 mm/m) for Pitch (vertical) and resolution of ±.0006 in/ft (0.05 mm/m)
- Coarse horizontal angular adjustment by rotating the magnetic base.
- Coarse vertical translation of ±4.27 in. (108 mm)
- Coarse horizontal translation adjustment with a range of ±.20 in. (±5.1 mm) and resolution of .0001 in. (0.0025 mm)
- Uses the L-103 Optical Beam Translator for high-resolution laser beam centering to bore centerline.

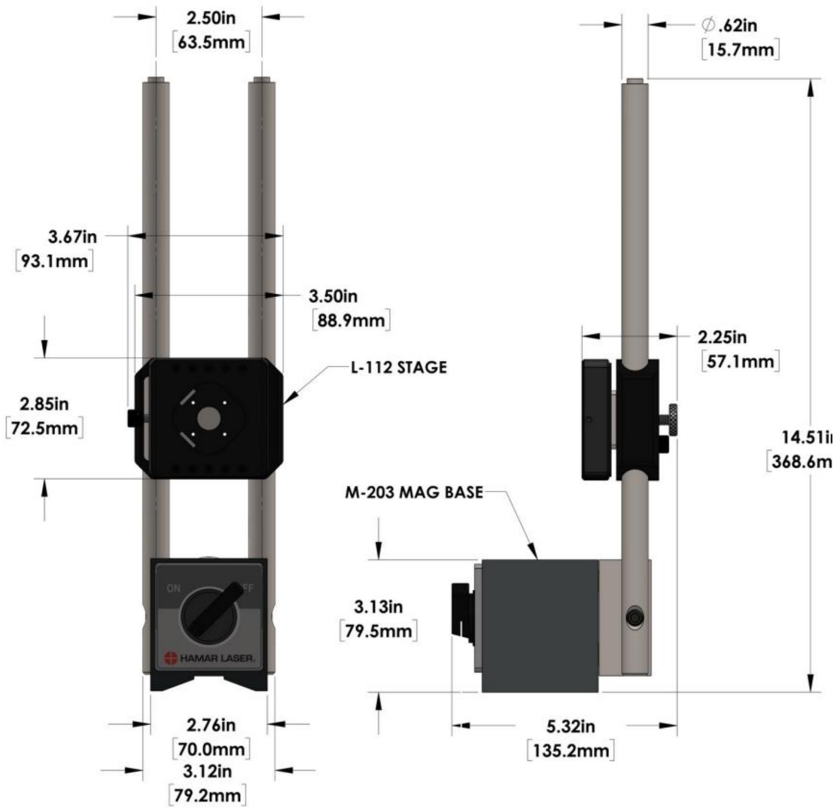


Figure 7 - L-112 Laser Stand with L-703B Laser

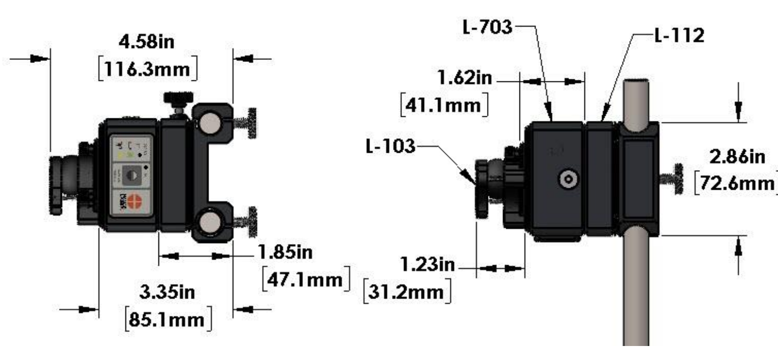
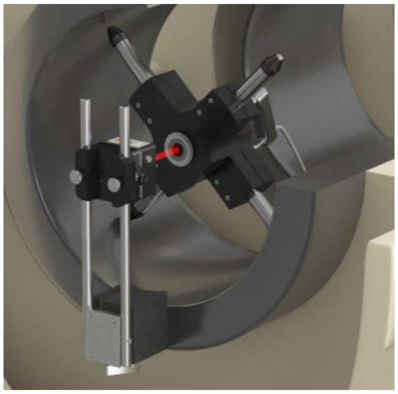


Figure 8 - L-112 Laser Stand Dimension

How to change the L-112 Laser Stand from a Horizontal Surface to a Vertical Surface

The L-112 has two mounting orientations: one for horizontal surfaces and one for vertical surfaces such as bore or gearbox flanges.

The following steps allow a user to change the L-112 from Horizontal-Mount Mode to Vertical-Mount Mode.



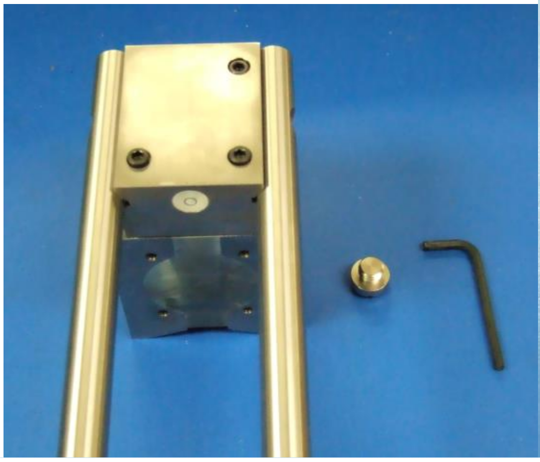
1. Using the provided Allen wrench, remove the 3 bolts that hold the L-112 post plate to the back of the magnetic base.

2. Using a screwdriver, remove the large, dustcover screw on top of the mag base. On top of the magnetic base, you will see the 4 attachment screw holes, however, you will only use 3 screws to attach the bracket to the magnetic base. This is a kinematic mount that stabilizes the laser base for accurate and stable measurements.

3. Attach the L-112 mounting block to top of the magnetic base, making sure that the level vial is facing opposite the bottom of the mag base switch. Make sure to tighten the bolts very tight to ensure there is no movement in the block when being used.

Note: *The level vial is used to "plumb up" the laser stand when using it on a vertical surface. This orients the vertical adjustment axis on the L-112 with the vertical axis on the L-703B Laser*.

Note: *The post-block can be rotated 90 degrees relative to the standard mounting holes if the v-block bottom of the mag base fits better on the surface.*



Model A-512 2-Axis Self-Centering Target

The A-512 Target *unit* is comprised of a target, a PSD sensor, a bore adapter, and an insertion handle (see Figure 11). The target is inserted into the bore to detect the position of the laser beam. Laser beam position data is displayed on a readout. As the bore is adjusted, the readouts display data in real time.

Figure 9 – *A-512 2-Axis Self-Centering Target and Insertion Handle*

The target cell is a position-sensing photocell, surrounded by a stainless-steel housing, which detects the center of energy of the laser beam using high-resolution electronics – see Figure 6. The resolution using the R-1307 is .0001 in. (0.001 mm) and the effective cell measuring range is ± .100 in. (2.5 mm).

The target housing has a milled keyway designed to slip-fit onto a location pin in the bore adapter for self- centering mode. Four matched and offset (90°) stainless steel legs serve to center the adapter in the bore. Adapters are available in many different sizes for use in specialized bores.

The A-512 2-Axis Bore Target has a 10x10 mm PSD and is designed specifically for our A-514 line of adjustable, self-centering bore adapters. This unique feature allows our target to be inserted into a bore without any mechanical setup, such as bore sweeping or the need to rotate the target to determine mounting errors (a common problem with most other systems). Simply insert the target into the bore, ensure it is oriented at 12:00, and in seconds you have a measurement. The target is concentric to its housing to within .0003 in. (0.0075 mm). When used with the A-514 adapters, the sensor is centered to the bore within .00075 in. (0.019 mm). Another unique feature of our A-514 adapters is they can handle a fairly large range of bore diameter changes of up to .040 in. (1.0) mm. This means you don't need to worry about bore diameter changes to get accurate measurements.

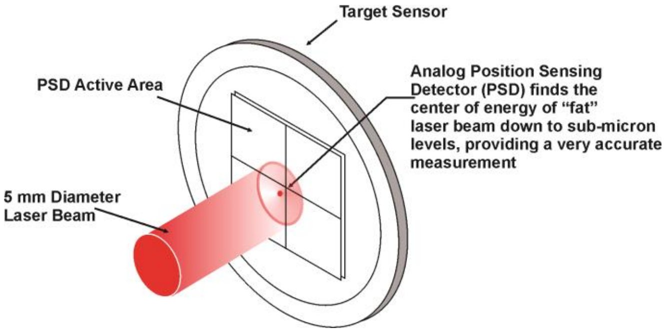


Figure 10 - The laser is detected, or intercepted, by position-sensing detectors (PSDs). The center of energy of the laser spot is detected and converted to an electrical signal proportional to its location on the surface of the target. This signal is converted into a calibrated reading, using a variety of hand-held readouts or computer interfaces for use with our software.

When using an A-510 Target with the A-510 adapters or the A-512 Target with the A-514A and A-514B adapters, two types of insertion handles may be used. One is a solid stainless-steel handle intended for individual bores. The other is a pole for long, continuous bores such as extruder barrels or gun barrels. The solid stainless-steel handle is designed for the weight of the handle to firmly lock the target into place. The pole type is designed with a spring and a universal joint at the rear of the target, which locks the target into place.

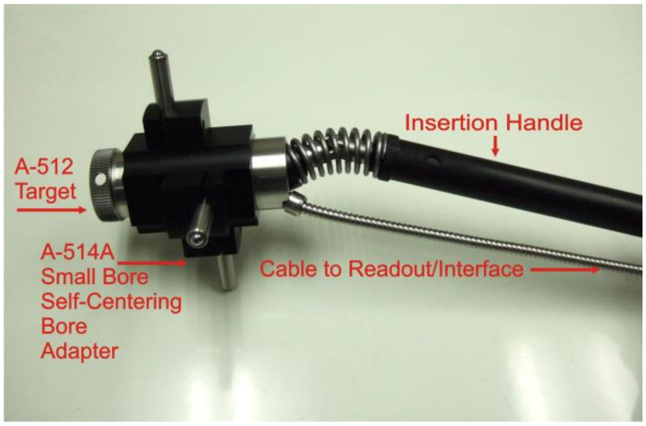


Figure 11 – *A-512 Target with A-514A Small Bore Self-Centering Bore Adapter*

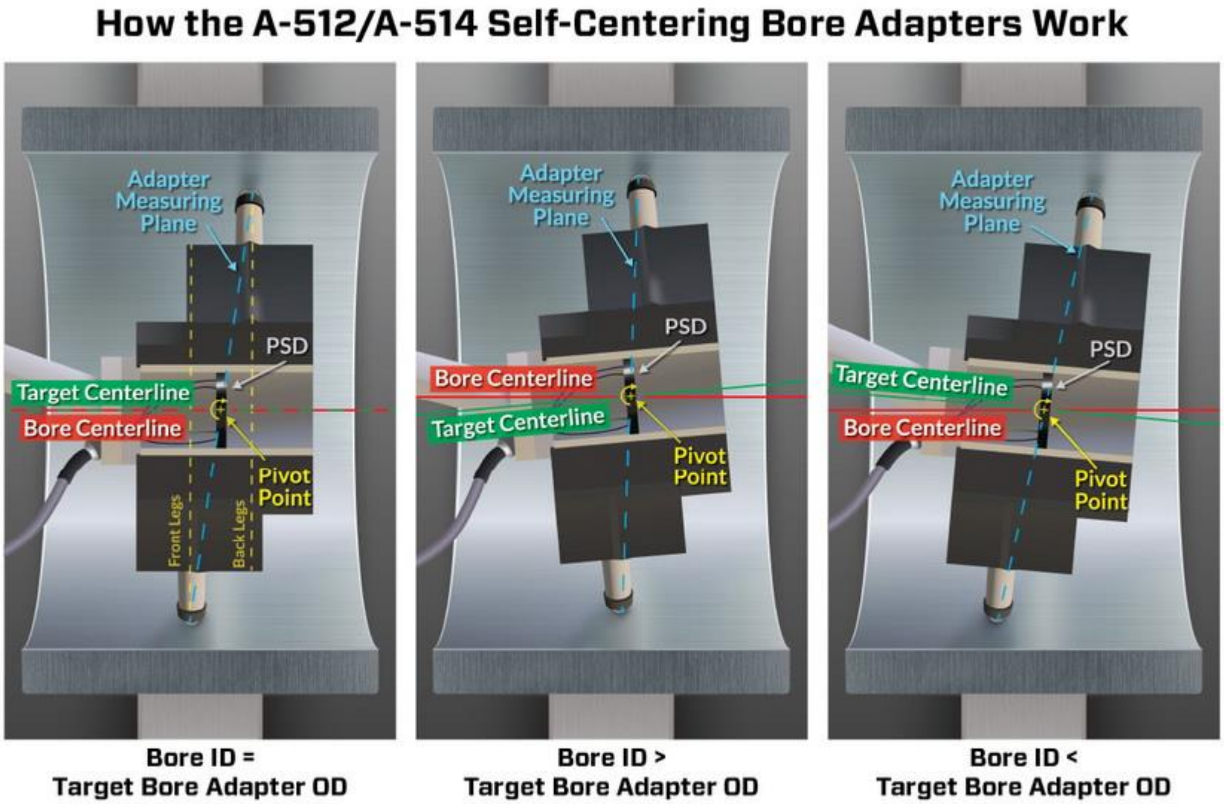
The A-514 A, B and C Self-Centering Laser and Bore Adapters for the A-512 Target

Note: *The A-514 Adapters are self-centering and therefore cannot be used with the A-512 for measuring bore diameter changes.*

The A-514 self-centering laser and bore adapters accurately and quickly position the laser and target on the bore centerline. The adapters can be centered to the bore to within .0005 in. (0.0127 mm). The adapters have adjustable legs that allow them to be used for bore diameters ranging from 3.75 in. (95 mm) to 40 in. (1 m) and the A-514B and A-514C come with counterweights to prevent the assembled system from tipping.

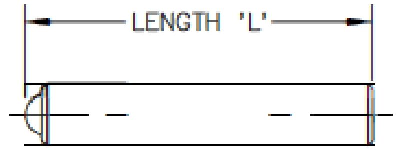
Three sizes are available, as follows:

- **A-514A** for bores from 3.75 in. (95 mm) to 6.75 in. (172 mm)
- **A-514A-EX** for bores from 3.75 in. 9.75 in. (95 mm to 248 mm)
- **A-514B** for bores from 6.5 in. (165 mm) to 17.5 in. (445 mm)
- **A-514B-EX** for bores from 6.5 in. to 25.75 in. (165 to 655 mm)
- **A-514C** for bores from 17.0 in. (432 mm) to 40.0 in. (1 m)



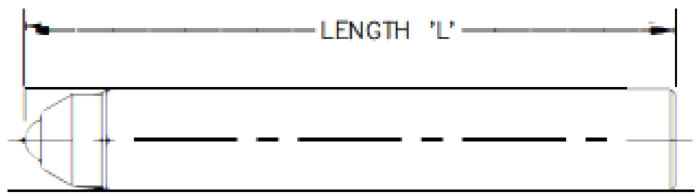
Bore Diameter Ranges for the A-514 Bore Adapters

HAMAR LASER ®



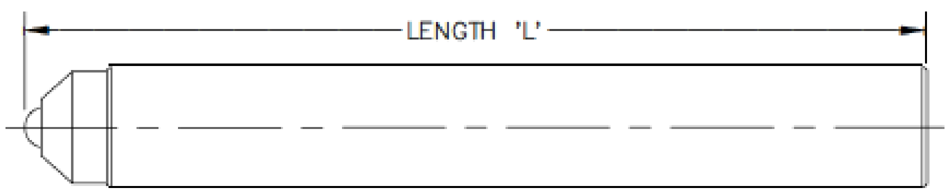
BORE DIAMETER RANGE,
A-514A-EX BORE ADAPTER

HLI PART NUMBER	LENGTH 'L'	BORE DIA RANGE
51403-1	1.22 (30.99mm)	3.750-4.750 (95.25-120.65mm)
51403-2	1.72 (43.69mm)	4.750-5.750 (120.65-146.05mm)
51403-3	2.22 (56.39mm)	5.750-6.750 (146.05-171.45mm)
51403-4	2.72 (69.08mm)	6.750-7.750 (171.47-196.85mm)
51403-5	3.22 (81.79mm)	7.750-8.750 (196.85-222.25mm)
51403-6	3.72 (94.49mm)	8.750-9.750 (222.25-247.65mm)



BORE DIAMETER RANGE,
A-514B-EX BORE ADAPTER

HLI PART NUMBER	LENGTH 'L'	BORE DIA RANGE
51414-1	2.60 (60.04mm)	6.500-9.250 (165.1-234.95mm)
51414-2	3.98 (100.97mm)	9.250-12.000 (234.95-304.8mm)
51414-3	5.35 (135.89mm)	12.000-14.750 (304.8-374.65mm)
51414-4	6.73 (170.82mm)	14.750-17.500 (374.65-444.5mm)
51414-5	8.10 (205.74mm)	17.500-20.250 (444.50-514.35mm)
51414-6	9.48 (240.67mm)	20.250-23.000 (514.35-584.20mm)
51414-7	10.85 (275.59mm)	23.000-25.750 (584.20-654.05mm)



BORE DIAMETER RANGE,
A-514C BORE ADAPTER

HLI PART NUMBER	LENGTH 'L'	BORE DIA RANGE
51425-1	5.50 (139.7mm)	17.000-24.000 (431.8-609.6mm)
51425-2	8.75 (222.2mm)	23.500-30.500 (596.9-774.7mm)
51425-3	12.00 (304.8mm)	30.000-37.000 (762-939.8mm)
51425-4	15.25 (387.4mm)	36.500- 43.500 (927.1-1104.9mm)

The A-514GS and A-514GL Leg-Setting Gage

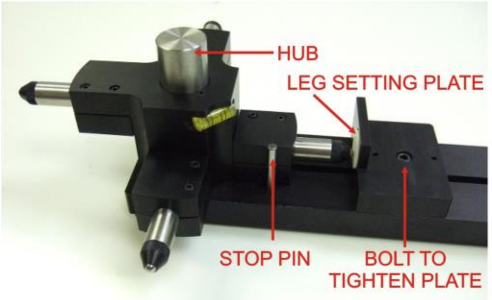
The -514GS and A-514GL Gages are used to set the A-514 Adapter legs to the correct bore diameter. The gages are available in two sizes, depending on the size of the bore being measured. The A-514GS is used with the small (A-514A) or medium (A-514B) bore adapters. The A-514GL can be used for all three adapters and must be purchased if using the large bore adapter.

Figure 12—*The A-514GL Leg Setting Gage*

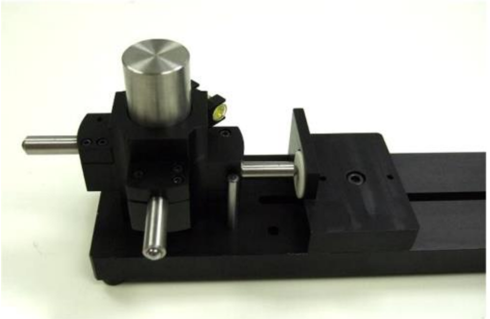
Setting the Legs for the A-514GS (Using Small and Medium Bore Adapters)

Example:

1. To measure a 9 in. bore, each leg must be set to 4.500 in.
2. Set the caliper to read 4.500 in. Twist the locking nut on the caliper so it does not slide,
3. Insert the caliper inside the *hub* on the leg setting fixture.



4. Slide the *leg setting plate* into position and tighten the bolt using the Allen wrench provided.
5. Slide the A-514A or A-514BB Bore Adapter over the *hub* and place the *stop pin* in the desired hole.
6. Rotate the bore adapter so one of the <u>lower</u> "legs" butts up against the *stop pin*.
7. Slide the measuring leg out so it pushes against the *leg-setting plate's* ceramic pad.
8. With a 7/64 Allen wrench, tighten the bolts on top of the part of the adapter that is holding the leg.
9. For the next "leg", remove the stop pin and turn the bore adapter 90 degrees, replacing the stop pin and repeat steps 6-8.
10. To set the remaining two legs (upper legs), the bore adapter must be removed from the hub and flipped 180 degrees, so the upper legs are now lower than the others you just set. Secure the legs again using the same method.



Note: *The caliper is used to set the legs to the nominal bore radius. The accuracy of the caliper's measurement of the radius is <u>not</u> important since the bore adapters can handle a small range of diameter changes (typically ± .020 - .040 in., depending on the adapter size). The most important part of the process is to ensure the legs are the <u>same</u> length, which is done with the Leg Setting Gage. If the digital caliper has an error of .0015 in., as long as the legs are set to the same length using the Leg Setting Gage, the bore adapter will self-center to .0005 in. (0.0127 mm) or better.*

Setting the Legs for the A-514GL (Using Large Bore Adapters)

The large leg gauge can be used for all three bore adapters. When setting the legs for the *large* bore adapter you must use the fixture extension.

Example: (see Figure 14)

1. To measure a 30 in. bore, each leg must be set to 15 in.
2. If using the 8 in. fixture extension, insert the extension into the hub and rest the other end in the slot.
3. Set the caliper to 7 in. and press one end of the caliper against the pin of the extension.
4. Slide the leg-setting plate up against the other end of the caliper.
5. After the leg setting fixture has been set to the correct length when using the large bore adapter, slide the hub spacer on the hub to balance the bore adapter.
6. Slide the large bore adapter over the hub on the spacer and follow the method described in *Setting the Legs for the A-514GS* (*Using Small and Medium Bore Adapters*) on Page 13.

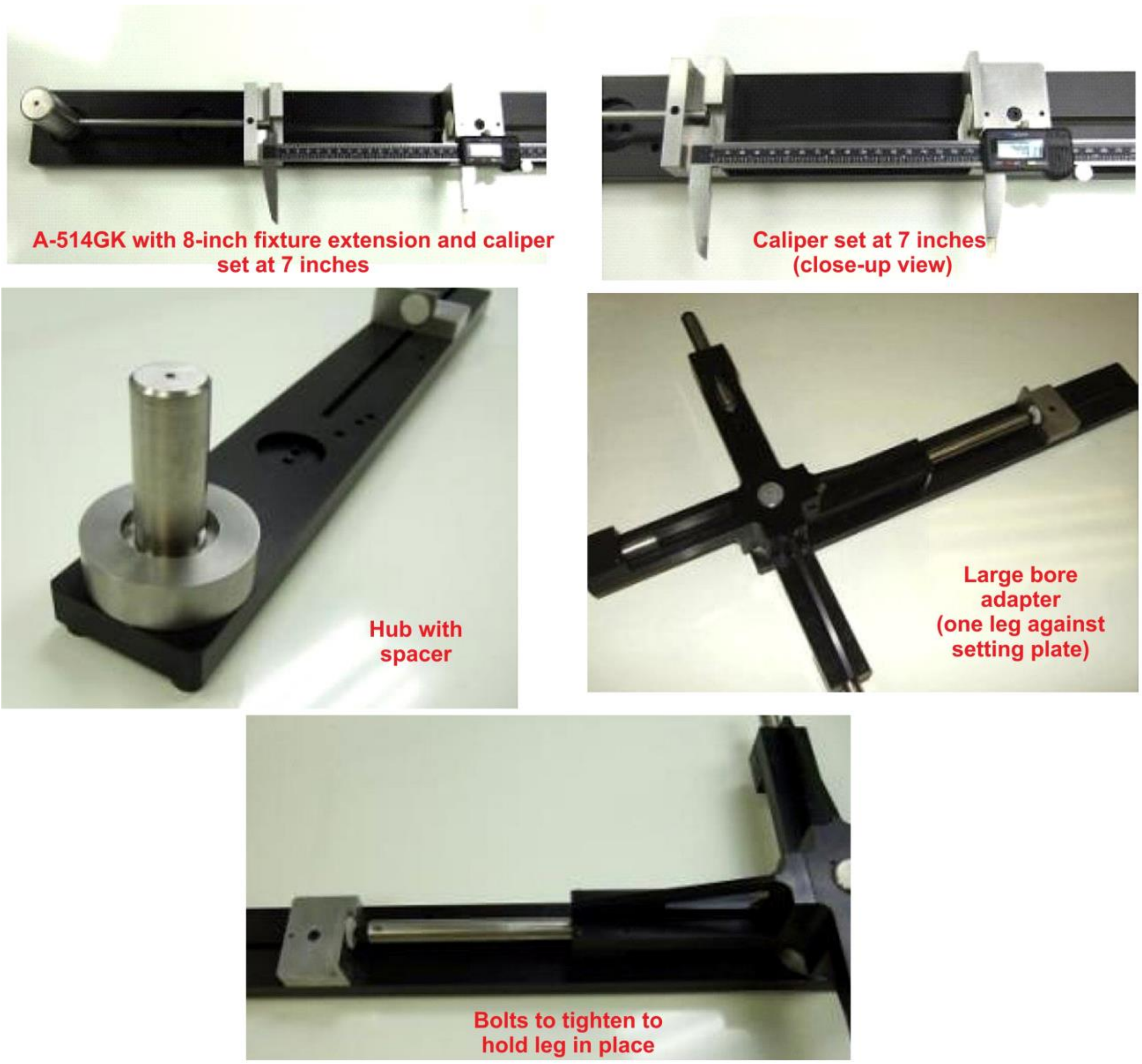


Figure 14 – *Setting the legs for the A-514GL*

The T-218 2-Axis See-Through Target/T-225L Large Bore Flange Adapter

Figure 15 – *T-218 2-Axis See-Through Target*

Hamar Laser's T-218 2-Axis "See-through" target is designed for multiple-target, bore centering applications. The T-218 has a prism that flips out of the way, allowing the laser beam to pass unobstructed through the target without removing it, which proves useful for aligning multiple bores over long distances.

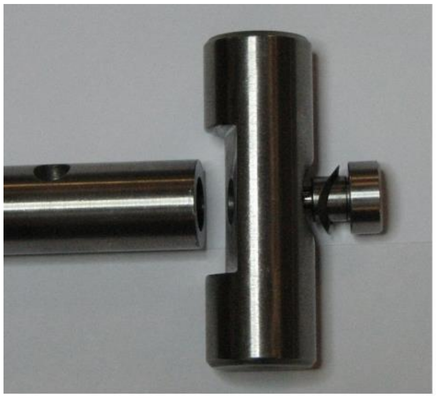
The T-218 Target includes a 10x10 mm PSD (position sensing device). It can be used with Hamar Laser's Bore Alignment Lasers, such as the L-700, L-705, L-706 and L-708 and is compatible with the R-1307 series of readouts, Hamar Laser alignment software and the T-230 Target Stand.

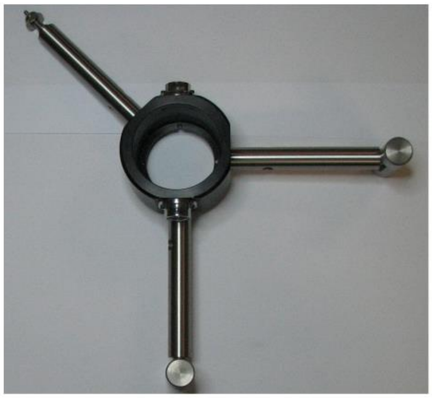
For bores over 1 m, half-bores, or where bore surfaces are worn or rough, the T-218 Target is used with the T-225L Large Bore Flange.

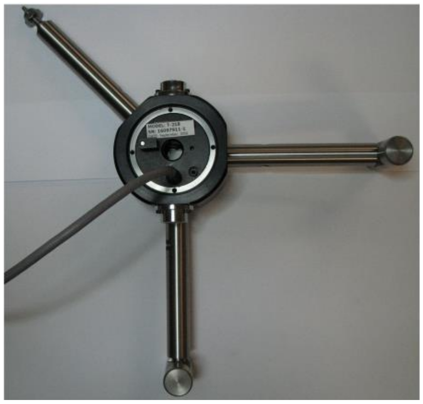
Assembling the T-225L for Use with the T-218

Figure 16 – *T-255L Large Bore Flange with T-218*

1. Attach the T-225L Large-Bore Flange Adapter to the T-218 2-Axis Bore Target using the cap screws provided.
2. Using shoulder screws (5) and spring washers (4), attach the RM-TGTAC-22504 Measuring Foot to each of the two customer-fabricated "Jam Rods" (see Appendix D on Page 52). For fabrication instructions, see Appendix E on Page 53.
3. Screw one Jam Rod assembly into the T-225L at 6:00 and a second assembly at 9:00, ensuring they are *firmly* screwed into place with the measuring feet parallel to each other and perpendicular to the face of the T-218 Target.
4. Screw in the Spring-Loaded Plunger (RM HDWRE-84765A63 – see Note 2 in Appendix D on Page 52) into the third customer-fabricated Jam Rod and attach to the third screw location at 10:30 (see Appendix D, Note 2 on Page 52).







R-1307 Readout Features

(see the R-1307 Operations Manual for more details)

Figure 17 – *R-1307 Readouts*

As with all of our laser alignment systems, the A-220, A-221, A-510 and A-512 Bore Targets provide live alignment data via our R-1307 readouts. This means once the target is installed in a bore and you are ready to align it, you just watch the readout continuously update as you adjust the bore, supporting pillow blocks or bearing sleeves.

The R-1307 Readouts are simple H & V axis readouts that are extremely easy to use. There is no complicated software to learn to use the system. However, for those who want to document the alignment and produce a report, we offer our easy-to-use our Bore9 software.

To check for bore angle relative to the centerline, just take a measurement at the front or back of the bore and any difference shows the angle. Adjust the front and back of the bore to read zero and it's aligned. Also, with our unique design, our target only needs a few inches of bore width to take a measurement.

Figure 18 – *A-910-2.4XBE Computer Interface*

Figure 19- *R-1307KS Readout Stand*

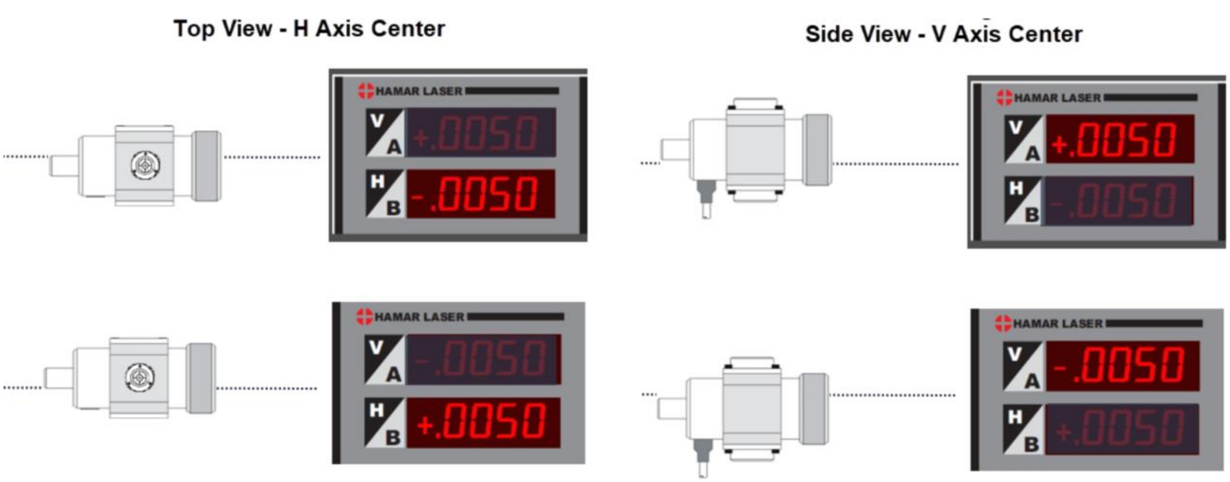
Model R-1307C

- Supports cabled (local) targets only
- Supports both pulsed-beam and continuous laser modes
- Functional replacement for the R-307 Analog Readout

Model R-1307-2.4XBE, R-1307B-2.4XBE

- Supports both wireless targets or cabled (local) targets
- Supports both pulsed-beam and continuous laser modes
- Radio frequency available is 2.4 GHz ISM band
- Can also be used as an additional readout to receive data alignment data transmitted from another R-1307 unit in master (poll) mode.
- The R-1307-2.4XBE can be used with the A-910-2.4XBE Computer Interface to perform as a wireless readout.

Interpreting Target Data Signs (+, -)



Model R-1307B-2.4ZB and Model R-1307BC – Control Panels

The R-1307B-2.4ZB and the R-1307BC Basic Series target readouts are available in two configurations. The R-1307BC supports 2-axis cabled targets and the R-1307B-2.4ZB is a combination readout for cabled targets with the capability to wirelessly transmit target data to a second R-1307 or to the A-910-2.4ZB computer data receiver. Both models support blinking and continuous laser modes. Power is provided by a 2500 mAh Lithium-Polymer rechargeable battery for 7-22 hours of continuous use, depending on the model, radio type and display brightness settings.

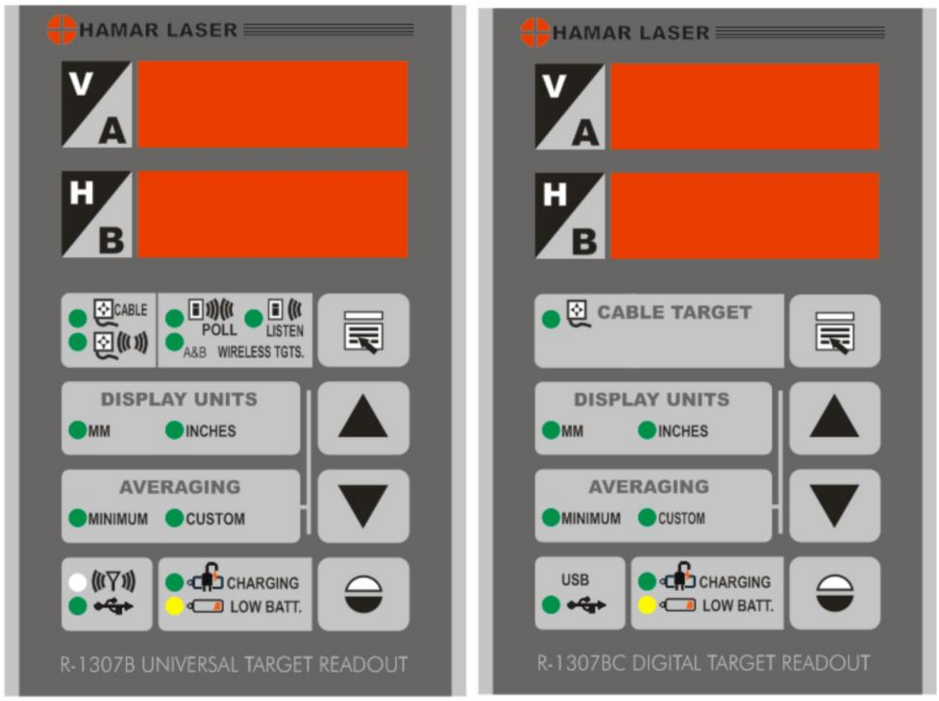


Figure 20 – *R-1307B and R-1307BC Models Control Panel Features*

The following chart lists the items available from the menu for each unit:

R-1307B-2.4ZB	R-1307BC
Display Units allows the selection of either inches or millimeters to display readings.	**Display Units** allows the selection of either inches or millimeters to display readings.
Resolution (selected from the MENU button) allows the selection of display digits up to a maximum of .0001 in. or 0.001 mm.	**Resolution (selected from the MENU button)** allows the selection of display digits up to a maximum of .0001 in. or 0.001 mm.
Averaging allows the selection of 2 to 64 samples for difficult atmospheric conditions.	**Averaging** allows the selection of 2 to 64 samples for difficult atmospheric conditions.
Up and **Down** arrow keys switch between the minimum number of sample (8 samples) and the menu-selectable number of sample (custom).	**Up** and **Down** arrow keys switch between the minimum number of sample (8 samples) and the menu-selectable number of sample (custom).
Channel Selection (selected from the MENU button) sets the System ID (radio channel).	

Model R-1307 Readouts – Control Panel

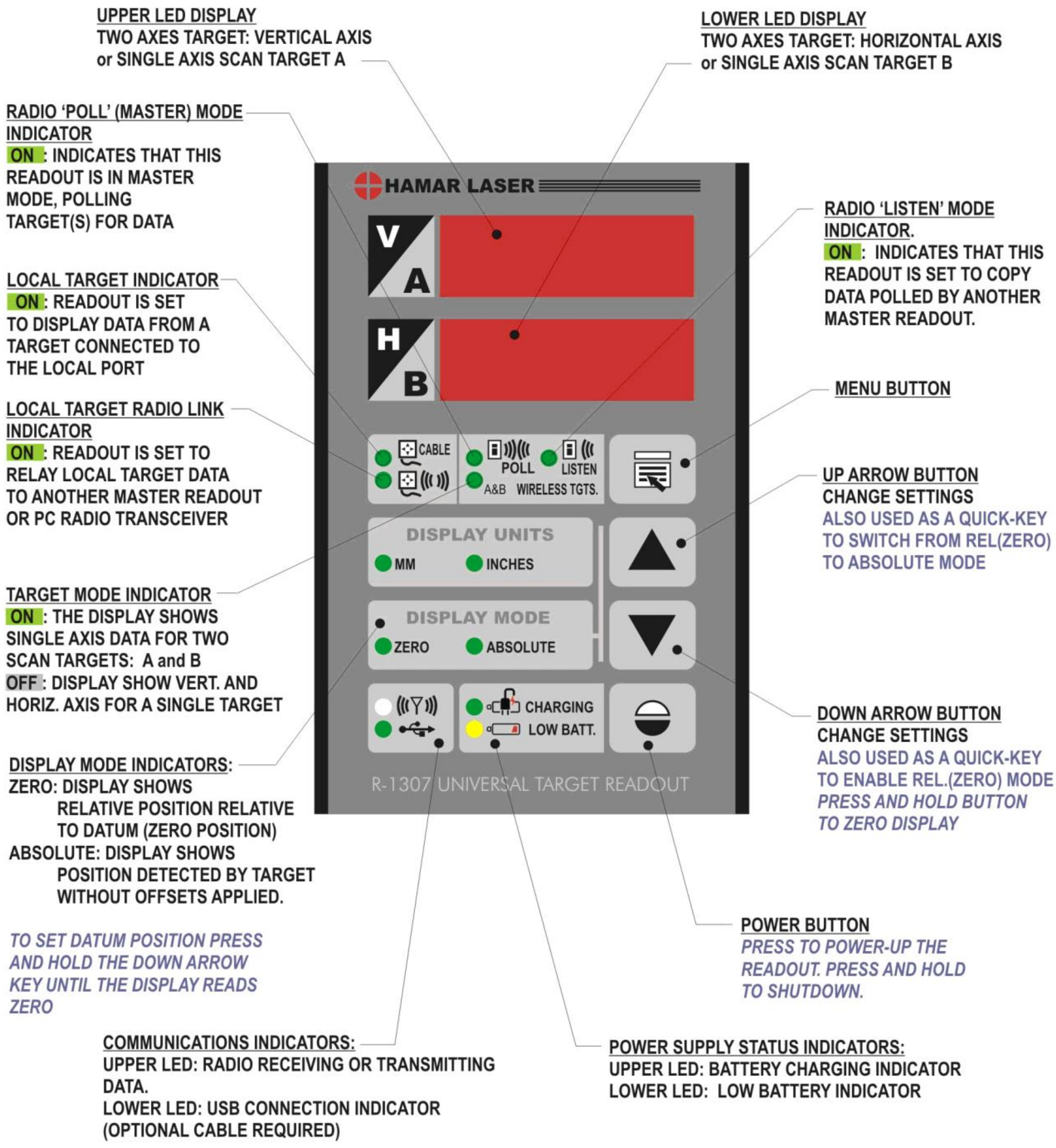


Figure 21 – *R-1307 Models Control Panel Features*

Model R-1307W Readout – Control Panel

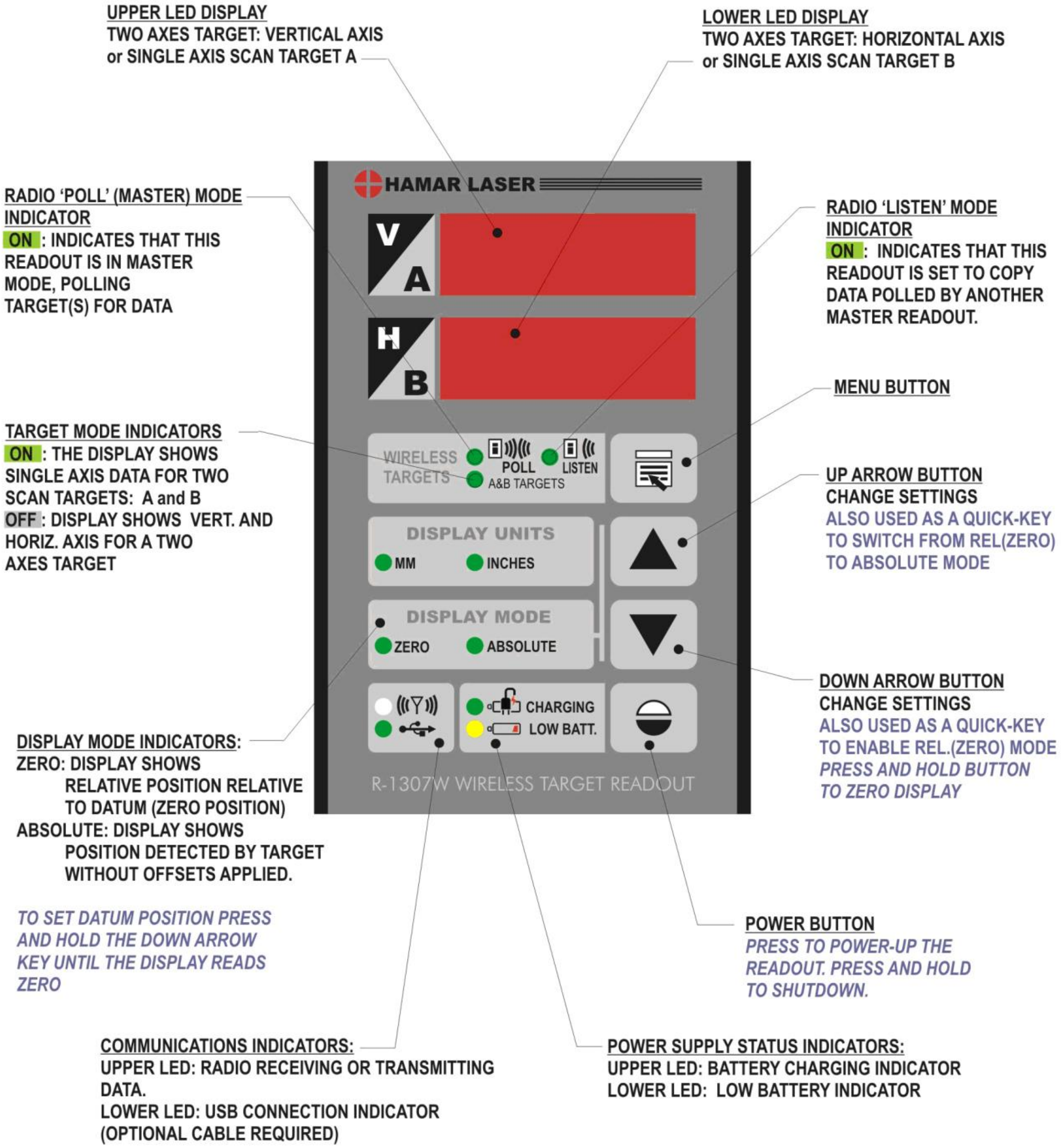


Figure 22 – *R-1307W Readout Control Panel Features*

Model R-1307C Readout – Control Panel

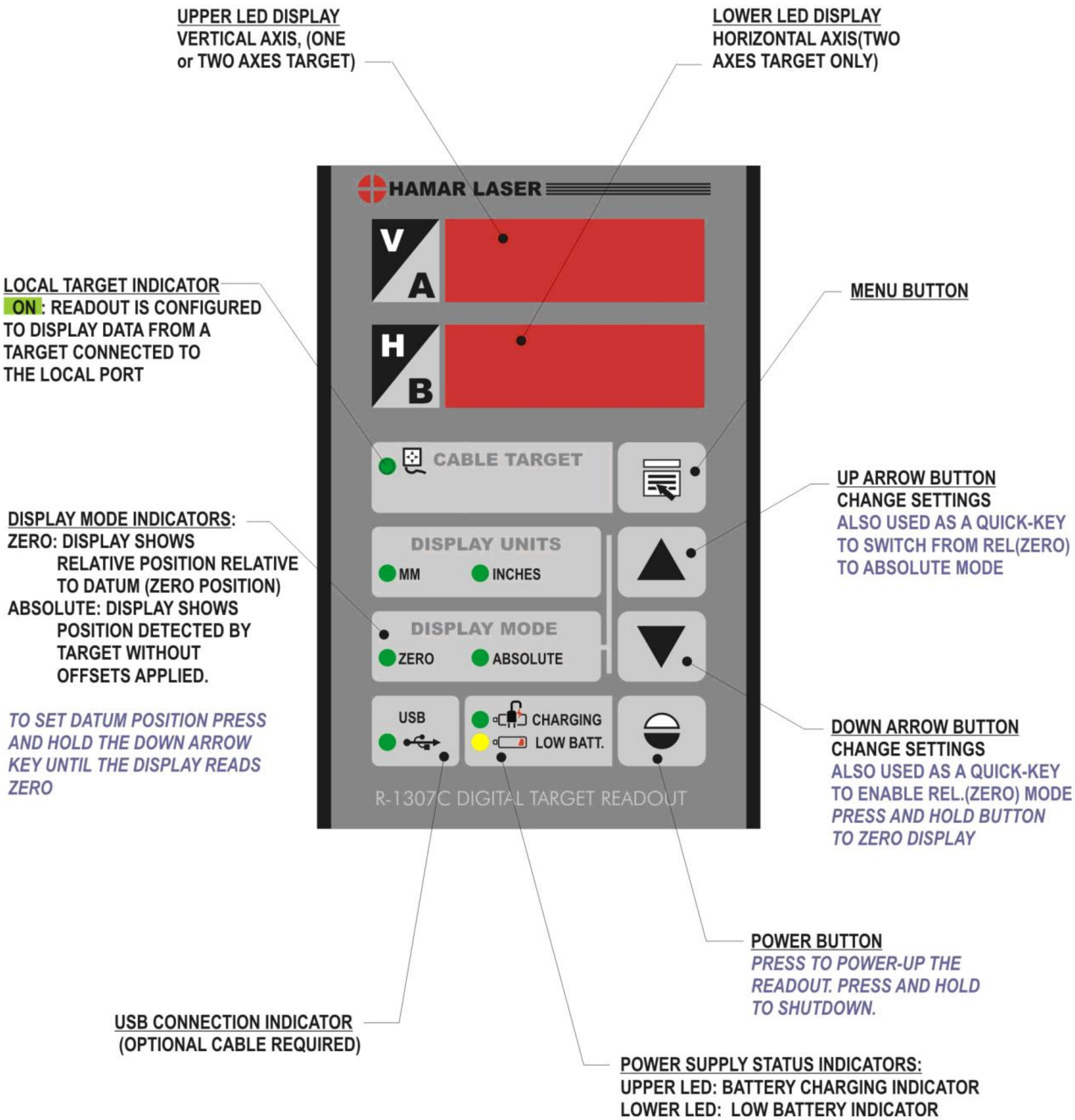


Figure 23 – *R-1307C Readout Control Panel Features*

Warning!

Targets are matched to specific calibration records in the R-1307 Readouts. For example, Target #1 must be connected to Calibration Record #1 in the R-1307 or the calibration is void. Up to nine different target calibration records can be stored in each R-1307. When there are multiple calibration records, the record ID must match the target ID, so if you have Target #1, you should select TGT=01 to select the matching calibration factors.

The R-1307B version of the readouts can only save one target calibration record, so each R-1307B readout must be matched up the target the calibration factors were generated with.

Target Calibration Factors

When receiving a new system, the target calibration factors are pre-programmed into the R-1307 Readouts. For the R-1307B Basic Readout, only 1 record can be stored. For the R-1307 (full) Readout, up to 9 calibration records can be stored. Each record stores 2 factors:

Span Error – This is the amount of error the readout has when the target is moved by a known amount, using a micrometer as the gauge. The normal amount of movement of the micrometer is ±.0250 in. (0.635 mm). Once this error is measured a calibration factor is calculated and uploaded into the R-1307.

Center Error – This is the amount of error the centering the target has when measured in a v-block using our NORMIN method. When properly done, the remaining error after applying the calibration records is normally under .0003 in. (0.0075 mm) but the specification is < .0005 in. (0.012 mm).

Matching Laser Modes and Target IDs in the R-1307 Readouts

When configuring the R-1307 Readout, it is important to match the target ID setting in the Menu with the target ID identified on the serial number of the target so the R-1307 Target ID record matches the target's actual calibration factors.

For example, if the target ID on the target serial number label is 2, then the R-1307 must also be set to number 2 (**see Figure 24**). If the target and readout and not matched, a centering error of up to .002 in. (0.05 mm) can occur.

In addition, the laser switch setting (CONT. *or Fixed* vs. PULSE) must also agree with the R-1307 Readout setting. To set the readout for:

- CONTinuous (Fixed) Mode - set the readout to F10.10; and
- Pulsed Mode - set the R-1307 to P10.10.

See page 16 above for details.

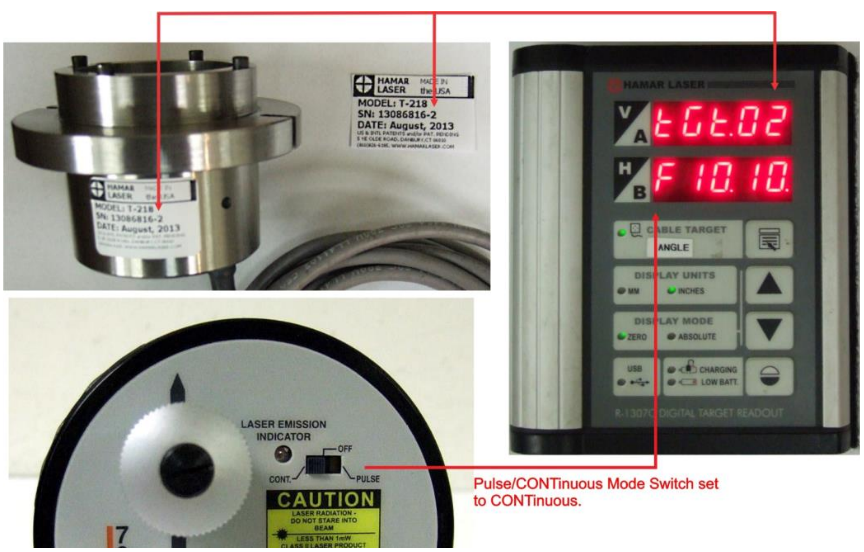


Figure 24 - R-1307 Target Settings

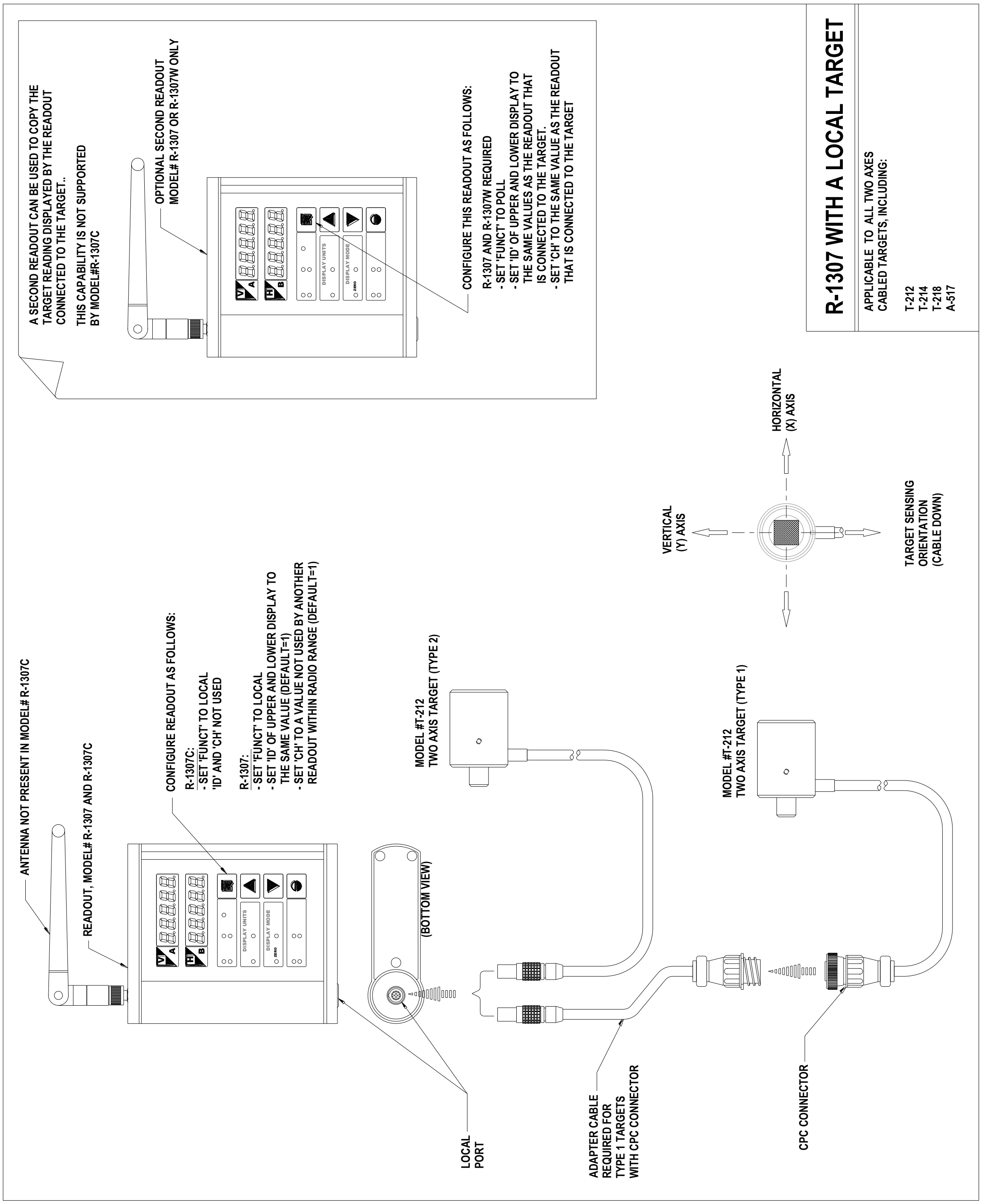


Figure 25 -- *Connecting a Local Target to the R-1307*

Bore9 Software

Bore9 features an easy 5-step process, described briefly below, that guides the user through the alignment process from setup to results. These results can be plotted, saved, and exported to an Excel spreadsheet.

Note: *For complete instructions for using the Bore9 Software, refer to Hamar Laser's Bore9 manual.*

- In **Step 1 – Bore Setup**, the user enters setup information for the alignment check such as number of bores, distance between bore, bore diameters and bore straightness tolerances.

- In **Step 2 - Target Mounting Error**, an easy procedure is followed to remove mounting errors. Mounting errors must be compensated for in order to achieve accurate results in bore and spindle work. Bore9 uses the NORMIN method developed by Hamar Laser to quickly and precisely cancel out these errors and eliminate the need for complicated, expensive fixtures. The word NORMIN is a contraction of **NORM**al-**IN**verted, which briefly describes the method.

- In **Step 3 – Laser Setup**, on-screen instructions guide the user through setting up the laser and making it parallel to reference points.

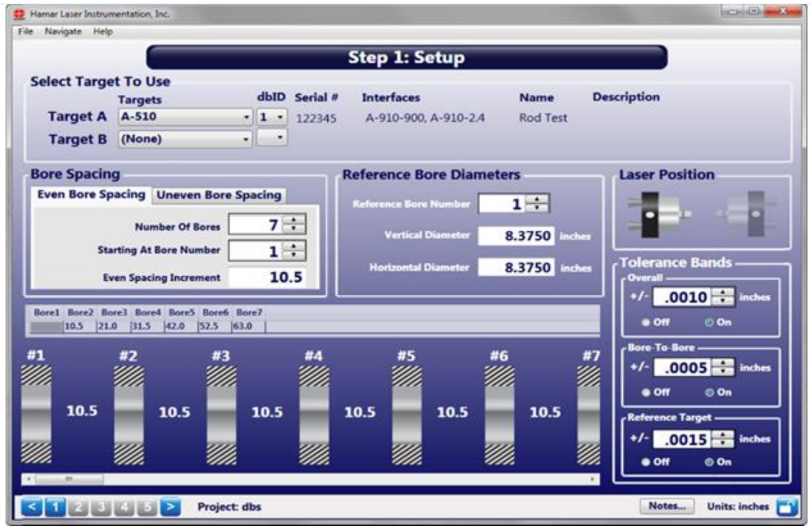
- In **Step 4 – Record Data**, bore straightness data is recorded. There are several different sets of data that can be taken in this step.

- In **Step 5 –Results**, results of the recorded data are plotted on a graph and a least-squares, best-fit data algorithm is applied to generate the straightness results and to determine if they are in or out of tolerance. Plot data can be changed to reflect the position of the centerline of the bores relative to the end bores, selected bore numbers, the laser beam or a "Best Fit" line. The data for each point is recalculated automatically based upon which references are chosen. Reports are also generated in this step and can be customized to the four different bore references. Comments may be added and the report can be printed with a summary, a graph of the vertical and horizontal straightness, comments and a table showing the recorded data.

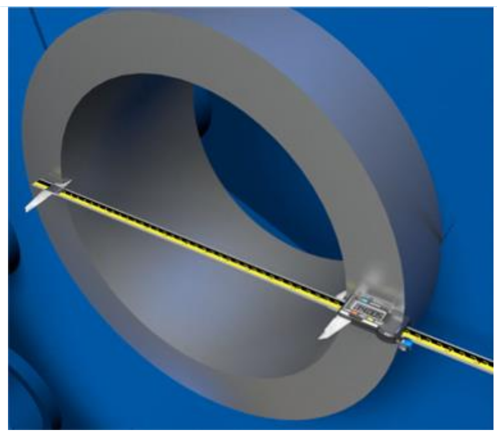
Bore Alignment using the L-703B/L-112/L-103 and A-512/A-514 Software Method

Step 1: Bore9 Setup

a. Open Bore9 and select the target and computer interface.
b. Enter the number of bores, the distance between the bores, the bore diameters, and select the alignment tolerances.



c. Measure the nominal bore ID using the provided calipers.

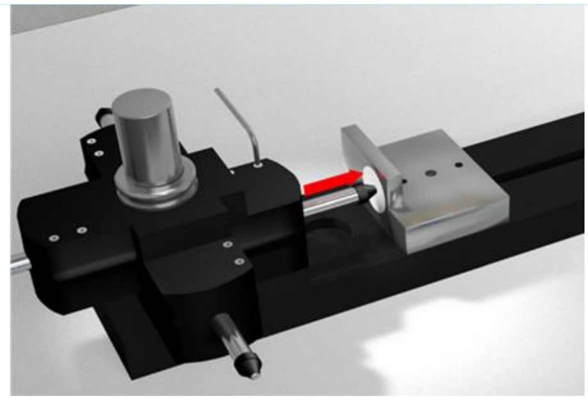


d. Then use the A-514G Leg-Setting Gage to set the length of the legs to the nominal ID for the A-514 Bore Adapter.

***Note**: If using the A-220, A-221, A-510 Targets and Self-Centering Bore Adapters, then the matching customized set of bore adapter tooling would be assembled with the target.*

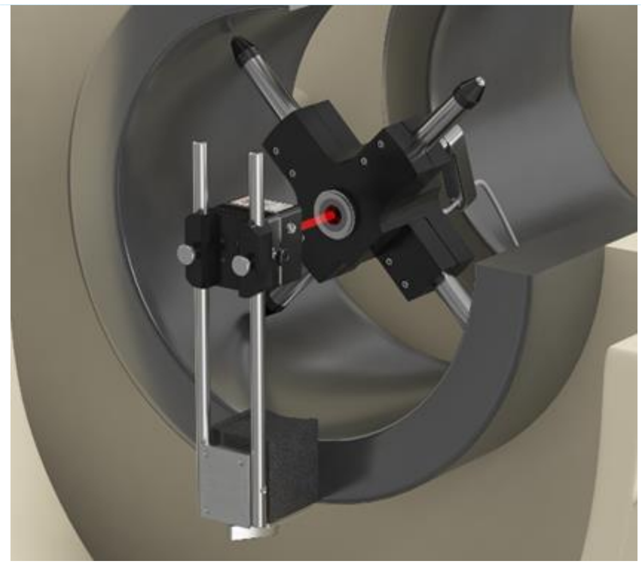
A-514GS Leg-Setting Gauge for A-514 Bore Adapters

e. Slide the A-514A, B or C onto the A-514GS gage. Insert the stop-pin and insert a leg into one of the mounting holes. Push the leg against the stop and tighten the set screw. Repeat for all four legs. This sets all 4 legs to the same length to a high degree of accuracy – usually below .0002 in. (0.005 mm).



A-514GS Leg-Setting Gage - positioning the legs of A- 514B Bore Adapter

f. Insert the A-512 into the A-514 Adapter and insert them both into the near bore, making sure the adapter's level vial is level, which aligns the target's V&H measurement axes with the bores V & H axes.



L- 703 Laser with A-512/A-514 Target in near bore

g. Adjust the L-103 Beam translator to zero the R-1307 Readout and center the laser into the first reference bore (see the graphic on page 2 that shows how the L-103 moves the height of the laser beam, but not the angle).

h. The laser beam is now centered to the A-512 Target located in the near reference bore.

L-103 Laser Beam Translator Adjustments

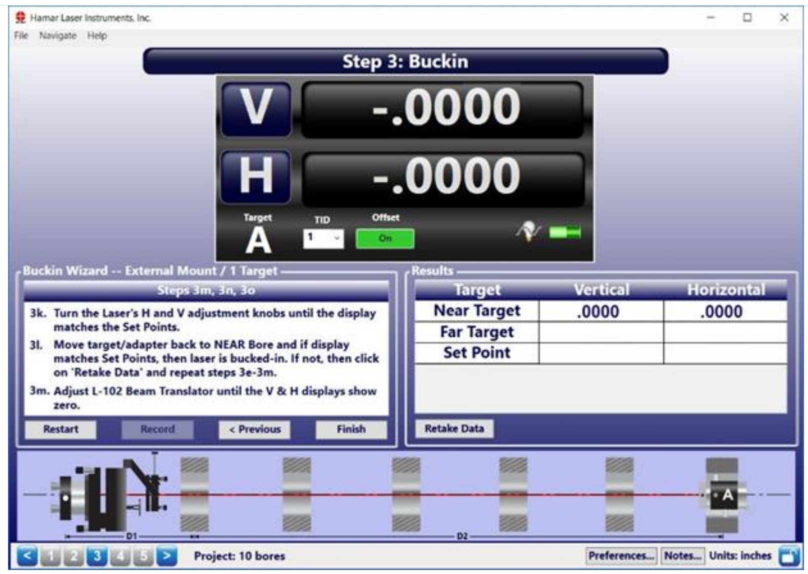
Step 2: Remove Target Mounting Error (optional)

***Note**: Step 2: Remove Target Mounting Error of the Bore9 program is usually skipped if measuring bore straightness only, or if aligning bores to .0005" (0.013 mm) or less.*

Press Record to record data for the target in the NORMAL position. Rotate the target 180 degrees (INVERTED position) and reinsert into the near bore. Press Record to record data for the target in the INVERTED position. Rotate target 180 degrees again back to the NORMAL position and reinsert into the near bore. The TSCE Mounting Error Offset is calculated and applied to each target reading. This removes any remaining centering errors in the target and adapter.

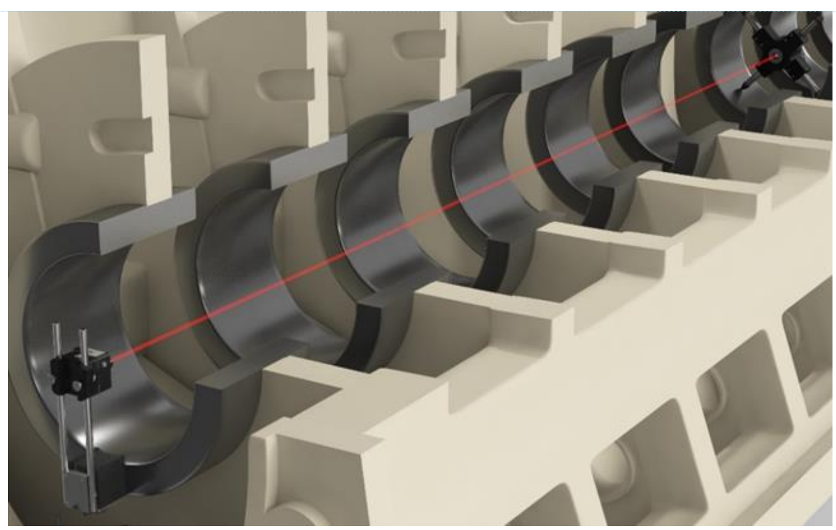
Step 3: Laser Buckin (Setup)

a. Follow the on-screen instructions to enter distances from the laser *pivot point* to the near bore (D1) and from the near bore to the far bore (D2). With the target in the *near* bore and zeroed, press *Record* to record data for the near bore.

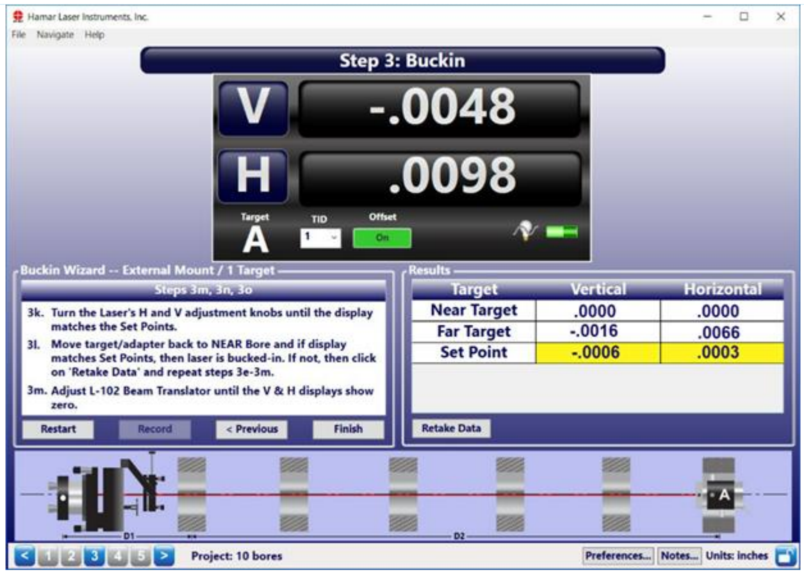


Bore9 - Step 3: Data Taken Near Bore

b. Move the target to the *far* bore and press Record. A calculation of the laser *Set Points* will be made to aid the laser setup. The *Set Points* are the values that you want to steer the laser beam to, which will make the laser beam parallel, but not on center, to the centerline as defined by the 2 end bores.

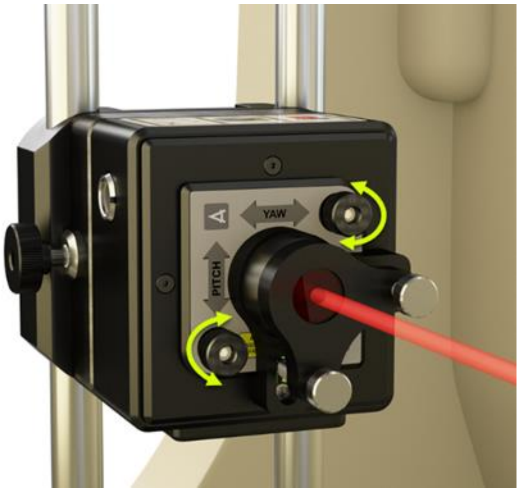


A-512/A-514 Target/Adapter Moved to Far End Bore

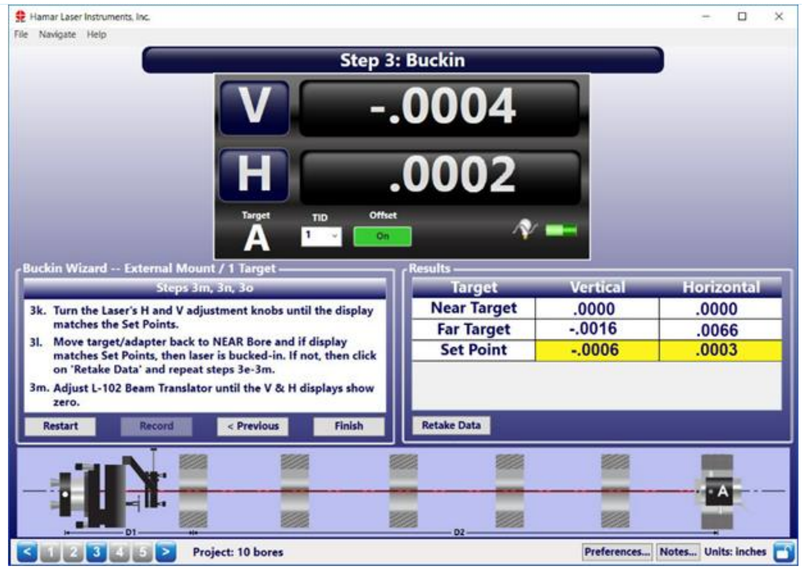


Bore9 - Step 3: Data Taken Far Bore and Set Points Calculated

c. With Buckin Offsets applied in the Bore9 software, tilt the laser beam using the Pitch and Yaw knobs (angular adjustment) on the L-703B until the H and V displays equal the *Set Point* or are very close.



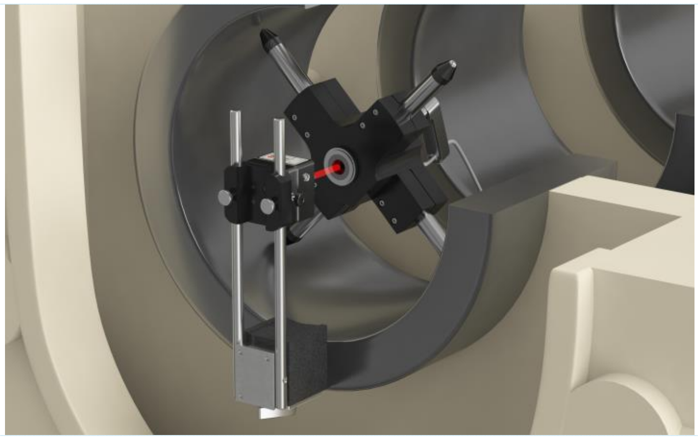
Adjusting the H & V angles on the L-703B to center it at the far bore



Bore9 - Step 3: Laser Steered to Near Zero (Bucked-In to within .0001 in.)

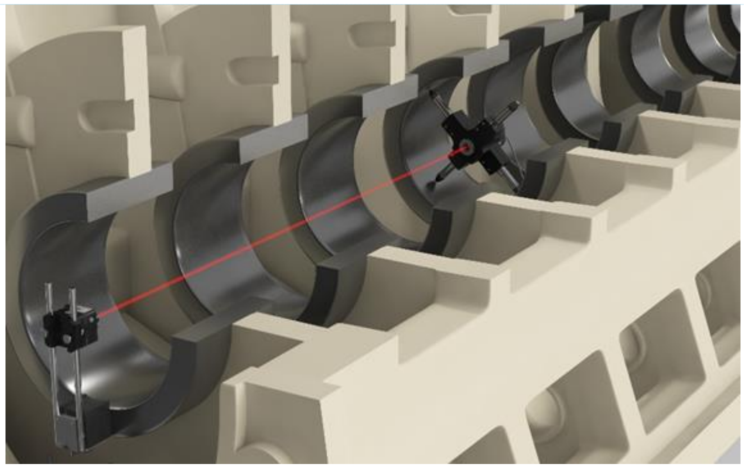
d. Move the target back to the near bore to confirm the values are the same as they were at the far bore.

e. If needed, repeat the process to confirm the same value at both end bores. The laser is now "bucked in" (aligned or concentric) to the centerline of the near and far reference bores.



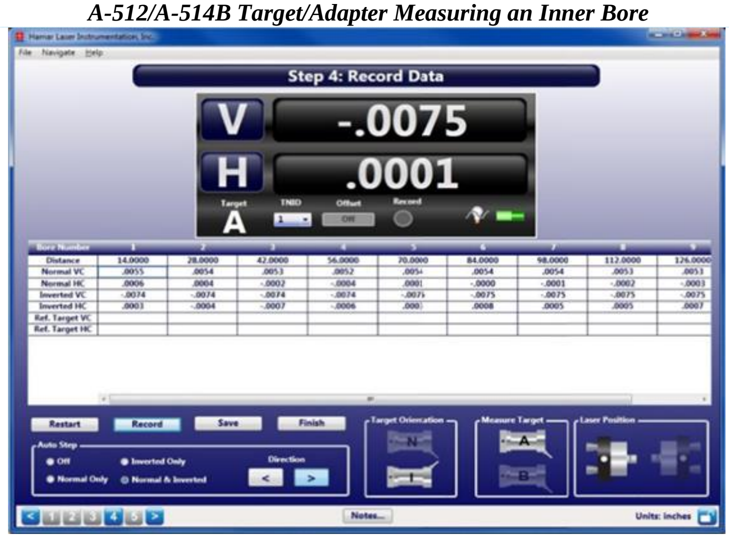
Step 4: Record Data

f. Move the target to the first bore you want to measure for alignment and press Record. Inserting the target and taking a measurement only takes 5-10 seconds.



A-512/A-514B Target/Adapter Measuring an Inner Bore

g. Continue moving the target to each bore until all data is taken.



Bore9 – Step 4 – Data Recorded for All Bores

Step 5: Results

Step 5: Results displays a graph of the results and a summary of the alignment. There are several different options to view the data and whatever plot reference is chosen is printed in the report:

a. *Concentricity Plot* – Bores: this plot converts the Vertical & Horizontal values into one concentricity value and shows the angle of the radius for each bore. The user can choose any combination of bores to use as the reference and Bore9 will replot the data and alignment results.

b. *Straightness Plot* – Bores: this plot shows the V & H values for each bore and plots them individually. The user can choose any combination of bores to use as the reference and Bore9 will replot the data and alignment results.

c. *Straightness Plot* – Best Fit: this plot shows the V & H values for each bore and plots them individually. The

Bore9 – Step 5: Results – Concentricity Plot using the End Bores as a reference.

summary data and graph are plotted relative to the least-squares, best-fit line calculated by Bore9. The best fit calculation removes any remaining slope error in the data due to the laser not being perfectly bucked in to the end bores.

d. *Straightness Plot* – Laser: this plot shows the V & H values for each bore and plots them individually. The summary data and graph are plotted relative to the laser beam (raw data).

Bore9 – Step 5: Results – Straightness Plot using the Best Fit line as a reference

Bore Alignment Using the L-706/L-111/L-102 and A-512/A-514 - Manual Method

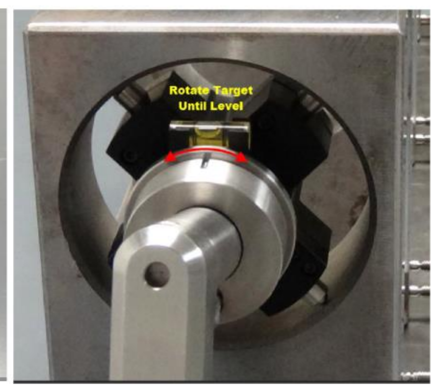
In this procedure, we'll show how to use the L-706/L-111/L-102 laser and accessories and the A-512/A-514A Target and self-centering adapters to check the alignment of a set of bores without using Bore9 software.

2-Point Buck-In Procedure

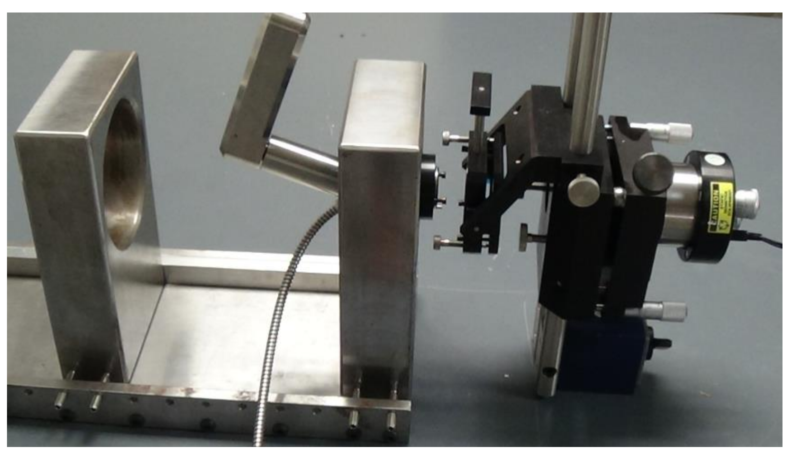
Step 1: Insert the Target in the *Near* Bore
Measure the nominal bore ID. Use the A-514G Leg-Setting Gage to set the legs of the A-514 Bore Adapter to the nominal bore ID (see Page 13 for a detailed procedure on how to set the legs). Insert the target mounted in the self-centering adapter into the *Near Bore* and carefully mark the placement of the target in the bore. *The target must be placed in the bore at the exact location and exact orientation each time it is inserted.*

Note: *Ensure that the level on the back of the A-514A/B/C adapters is level. If the level is broken or not available, ensure that the cable is at 6 o-clock when orienting the target.*

Step 2: Insert the Laser in the L-111 Laser Stand
Insert the laser into the L-111 Laser Stand with the level on the top, centered from left to right.



Step 3: Position the L-111 Assembly
Position the L-111 assembly as close to the near reference bore as possible and power on the laser.

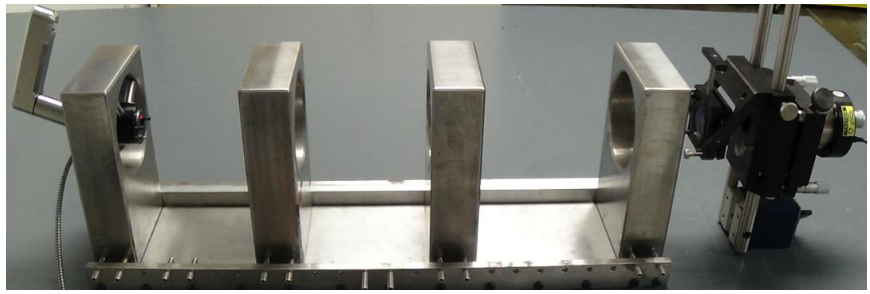


Step 4: Laser Rough-in -- Position the laser until it is on target at the *Near Bore*
Loosen the thumb screws on the L-111 stand and slide the assembly up or down until the laser beam is *visually* near the center of the target (you do not need the R-1307 for this). Tighten the thumb screws.

Note: *To aid in seeing the laser, tape a small piece of paper over the target window and trace an outline of the target opening. Put a dot in the center of the circle to represent the target center.*

Unlock the magnet holding the L-111 assembly and slide the whole assembly left or right until the laser beam is *visually* near the center of the target. Turn the magnet back on.

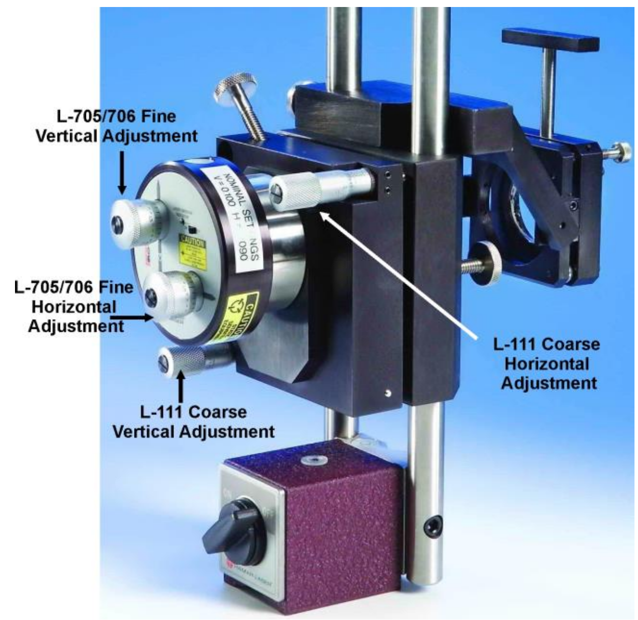
Step 5: Laser Rough-in --
Move the target to the *Far Bore*
Remove the target from the *Near* reference bore and insert it into the *Far* reference bore, carefully marking the placement of the target in the bore with the cable at 6 o'clock.



Step 6: Laser Rough-in -- Steer the Laser to the Center of the Target in the *Far Bore*
Using the long micrometers on the L-111 stand, steer the laser beam vertically and horizontally until it is *visually* near the center of the target (you do not need the R-1307 for this).

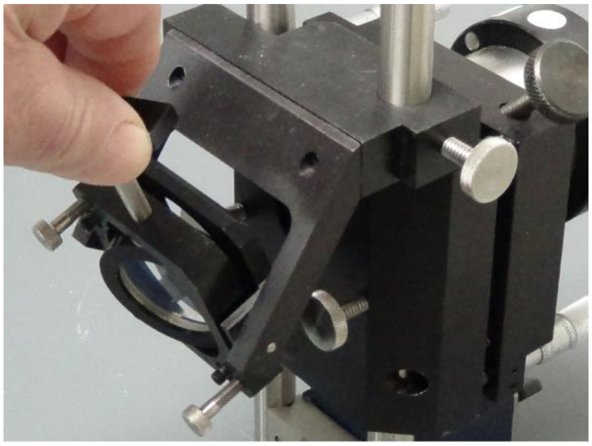
Repeat Steps 4-6 until the laser is centered in the target window (or the window outline on the paper taped over the window).

***Note**: You will find it much easier to set up the laser by adding a second mag base or some other "stop" to the front of the magnet base to allow the L-111 assembly something to slide along so that it slides in a parallel manner. When in the near position, you want to translate the laser without changing its angle.*



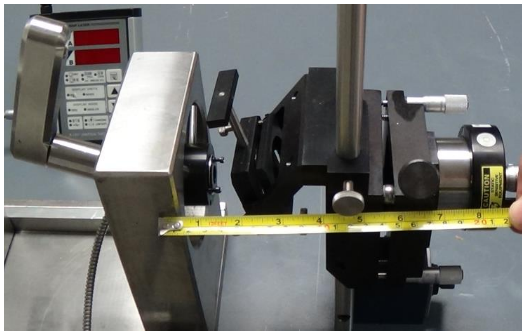
Step 7: Place the L-102 over the post of the stand
Ensure the L-102 is seated against the opposite post of the stand and tighten the thumb screw.

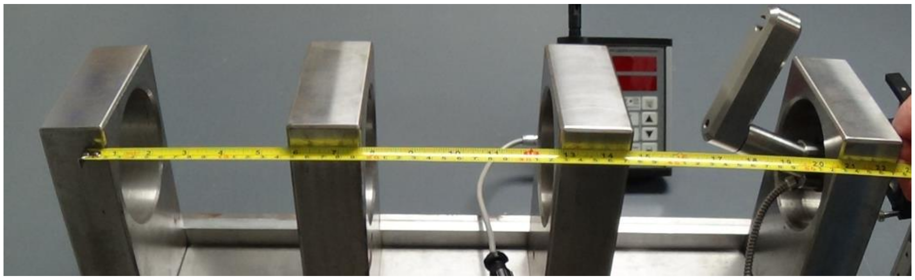
Step 8: Move the Target Back to the *Near Bore*
Remove the target from the *Far* reference bore and reinsert it into the *Near Bore*. Be sure to place the target in the *exact* location that it was in previously, with the cable at 6 o'clock. Plug the target into the readout and power on the readout. Using the coarse adjustment of the L-102 beam translator, adjust the laser beam until the readout displays less than .001 (0.02 mm) in. both vertically and horizontally.



L-102 Horizontal Coarse Adjustment

Remote Buck-in Note: *If the distance from the laser to the target in the Near Bore is more than 10 percent of the distance from the target in the Near Bore to the target in the Far Bore, it will be necessary to follow the Remote Buck-In procedure* (see Appendix C on Page 50).





Step 9: Translate the Laser to .0000 in. in the *Near Bore*

Using the fine adjustments on the L-102 beam translator, adjust the laser beam until the readout displays .0000 in. (0.00 mm) both vertically and horizontally.

Figure 26 - L-102 Coarse Adjustment

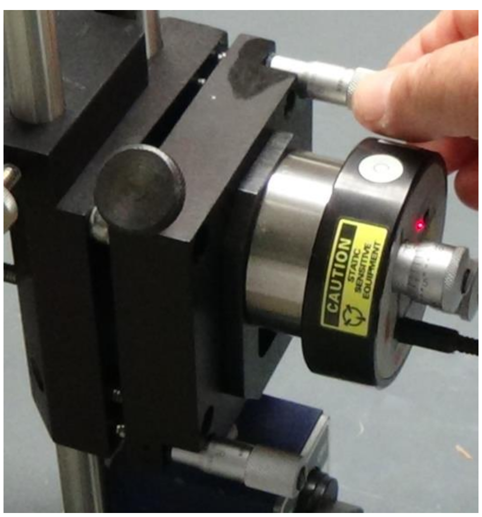
Figure 27 - L-102 Fine Adjust

Step 10: Steer the Laser Beam to .0000 in. in the *Far Bore*

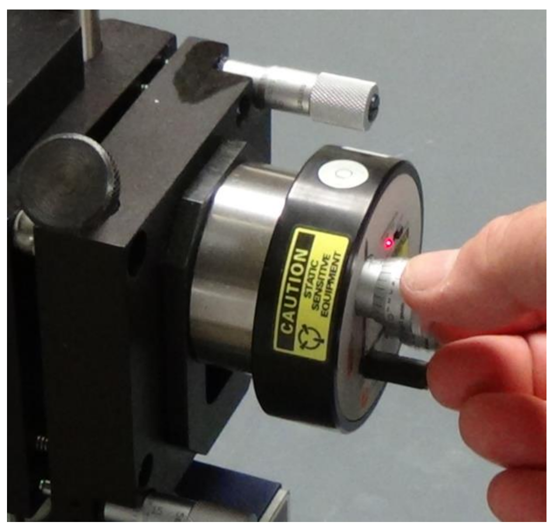
Remove the target from the *Near Bore* and reinsert it into the *Far Bore* in the *exact* location it was previously, with the cable at 6 o'clock. Using the long (coarse) angular micrometers on the L-111 stand, steer the laser beam until the readout displays less than .003 in. (0.075 mm).

Use the micrometers on the back of the laser (fine micrometers) and steer the laser beam until the readout displays .0000 in. (0.002 mm) both vertically and horizontally.

Note: *This procedure can be performed much faster if the Remote Buck-in Formula is used every time you do the Laser Buck-in. See Appendix C beginning on Page 50.*



Coarse adjust - uses the long micrometers on the L-111 Stand.



Fine adjust – uses the L-706 Micrometers.

Step 11: Move the Target Back to the *Near Bore*

Remove the target from the *Far Bore* and reinsert it into the *Near Bore*. If the readout doesn't display .0000 in. both vertically and horizontally, repeat Steps 9 and 10 until the readout displays .0000 in. vertically and horizontally in the *near* and *Far Bore*.

Note: *If using the Remote Buck-In formula, when you move the target back to the Near Bore, the V and H values should be equal to the V and H Laser Set Points. This means the laser is bucked in. If not, then repeat Steps 7-9.*

Step 12: Check the Remaining Bores for Alignment to the Reference Bores

The remaining bores can now be checked for concentricity to the reference bores by placing the target in each of the remaining bores. The readout displays the misalignment (concentricity error) both vertically and horizontally.

In the picture above, the misalignment of Bore 2 is being measured with the R-1307. The target is in Bore 2 and the R-1307 shows a vertical reading of -.0021 in. and a horizontal reading of .0012 in. This indicates that Bore 2 is .0021 in. lower than the reference bore centerline because the vertical reading is negative, and .0012 in. to the right of the reference bore because the horizontal reading is positive.

Bore Alignment Using the L-706/L-111/ L-102/Bore9 - Software Method

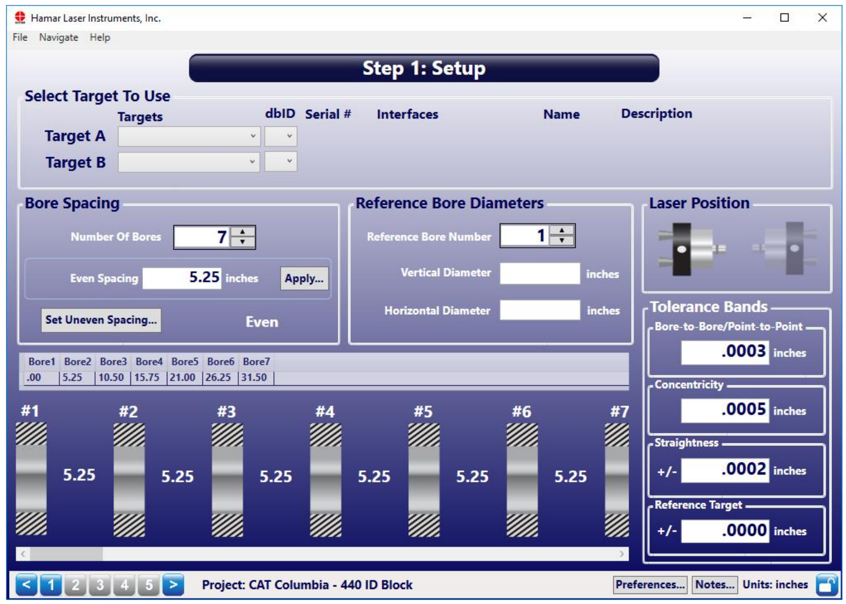
Note: *A visual buck-in (determining visually that the laser beam is near the center of the target without using the readout or the beam translator) should be done* ***before*** *attempting to buck-in using the readout and beam translator. The beam translator is limited to the amount it can shift the laser beam up, down, and from side to side. The laser beam needs to be on target, preferably closer than .060 in. before adjusting the beam translator.*

If the distance from the laser to the near reference bore is greater than 10 percent of the distance from the Near Bore to the Far Bore, the remote buck-in procedure should be used (see Appendix C on Page 50).

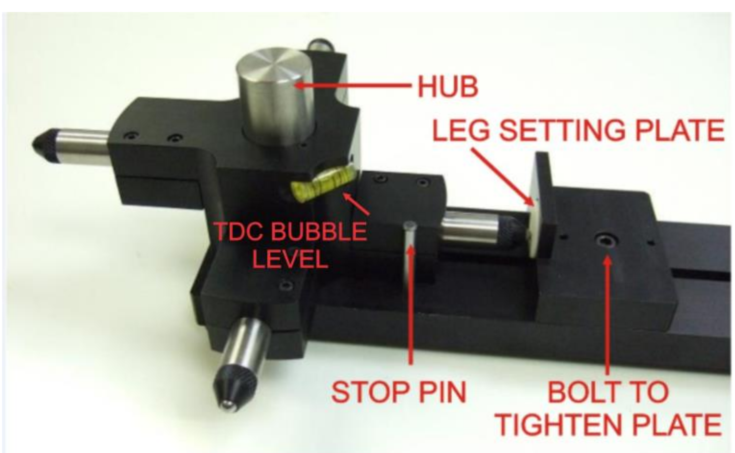
Step 1: Setup

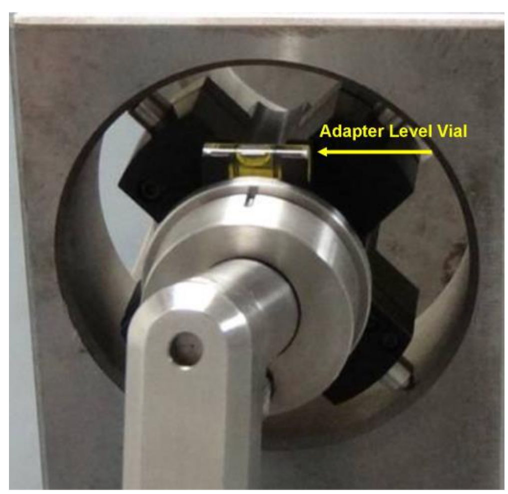
a. Open Bore9 and select the target and computer interface.

b. Enter the number of bores, the distance between the bores, the bore diameters, and select the alignment tolerances.



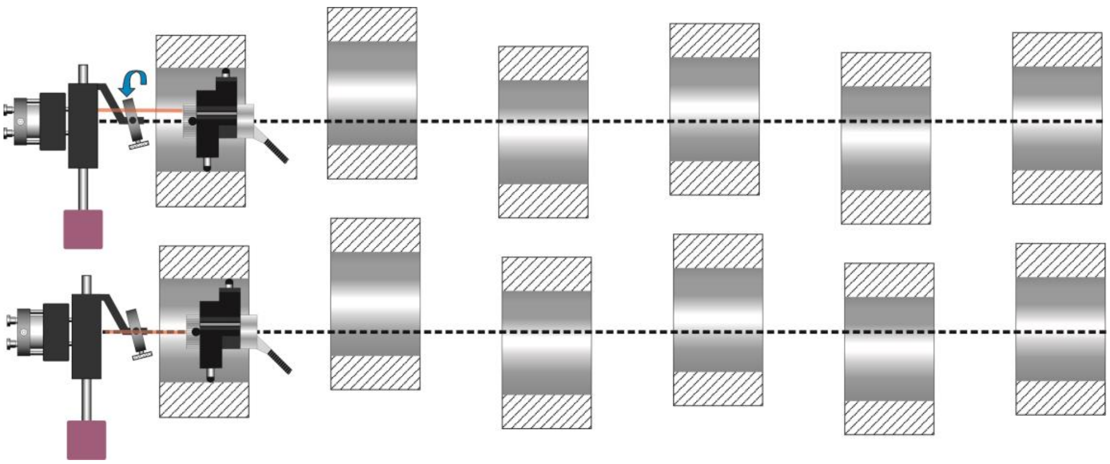
c. Measure the nominal bore ID. Use the A-514G Leg-Setting Gage to set the legs of the A-514 Bore Adapter to the nominal bore ID (see Page 13).



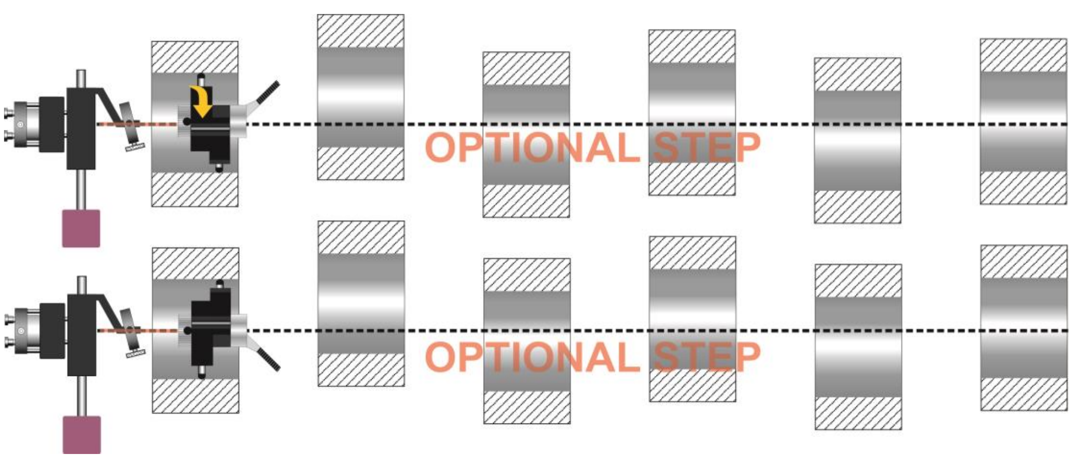


Step 2: Target Mounting Error

a. Insert the A-512 into the A-514 Adapter and insert them into the *Near Bore*, making sure the adapter's level vial is level. Then adjust the L-102 to zero the display and center the laser into the first reference bore (the graphic below shows how the L-102 moves the height of the laser beam, but not the angle).

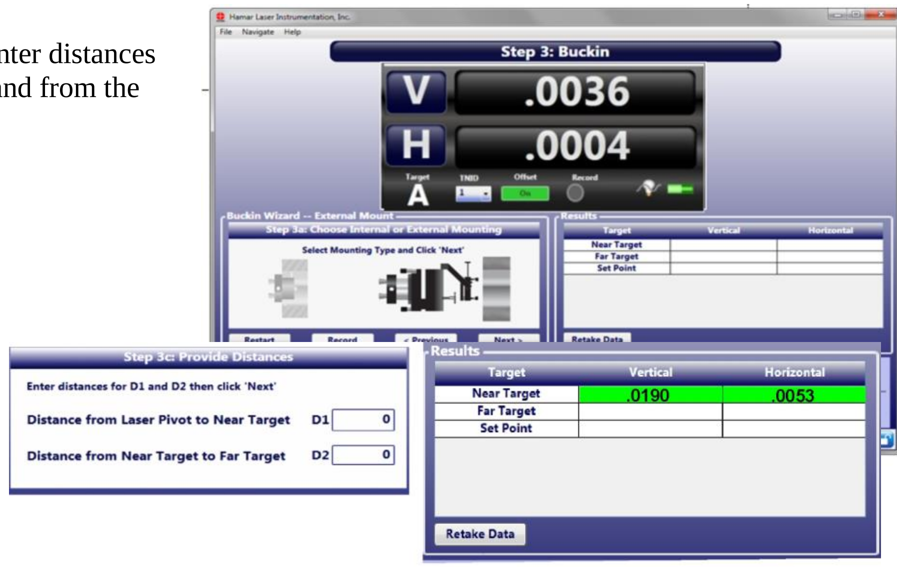


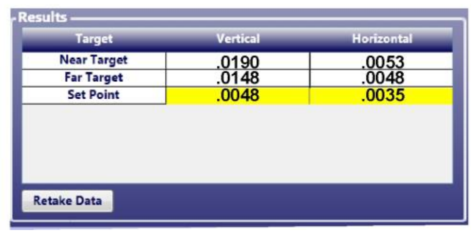
b. Press **Record** to record data for the target in the NORMal position. Rotate the target 180 degrees (INverted position) and reinsert into the *Near Bore*. Press **Record** to record data for the target in the INverted position. Rotate target 180 degrees again back to the NORMal position and reinsert into the *Near Bore*. The TSCE Mounting Error Offset is calculated and applied to each target reading. This removes any remaining centering errors in the target and adapter. **Note:** *Step 2: Target Mounting Error of the Bore9 program may be skipped if measuring bore straightness or alignment tolerances are greater than .0005 in. (0.013 mm).*



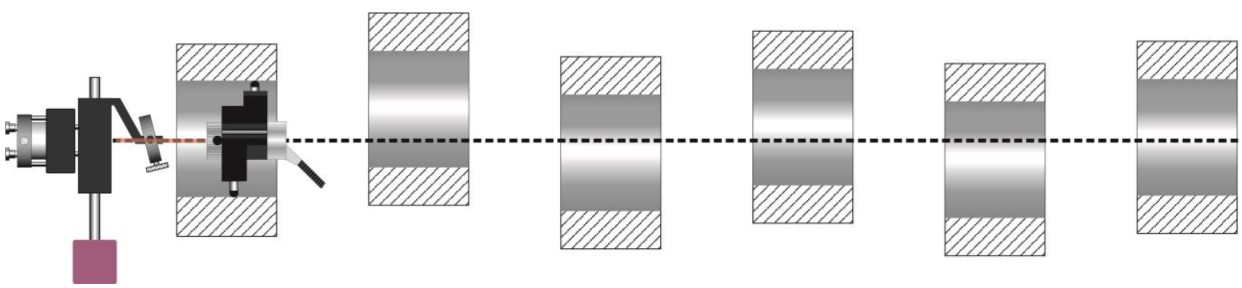
Step 3: Laser Buck-in

a. Follow the on-screen instructions to enter distances from the laser to the *Near Bore* (D1) and from the *Near Bore* to the *Far Bore* (D2).

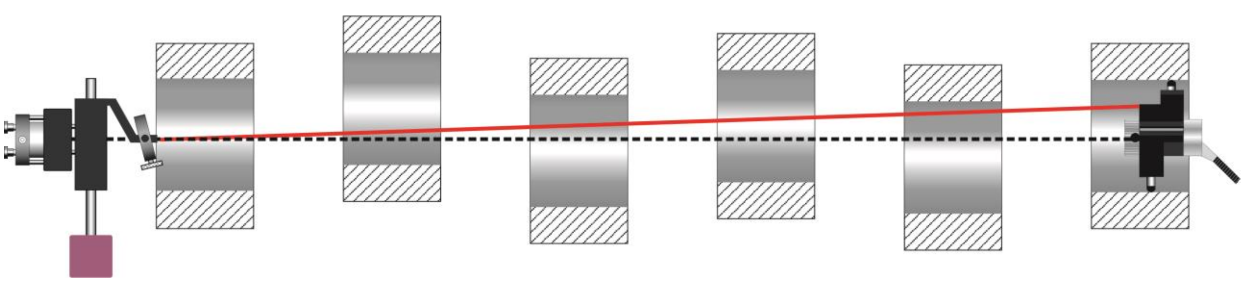




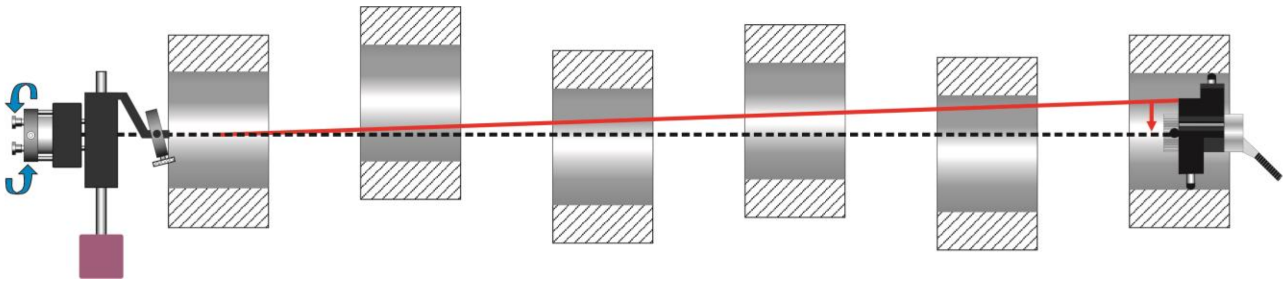
b. Insert the target into the *Near Bore* and re-adjust the L-102 to zero the display and center the laser into the bore. Press **Record** to record data for the *Near Bore*.



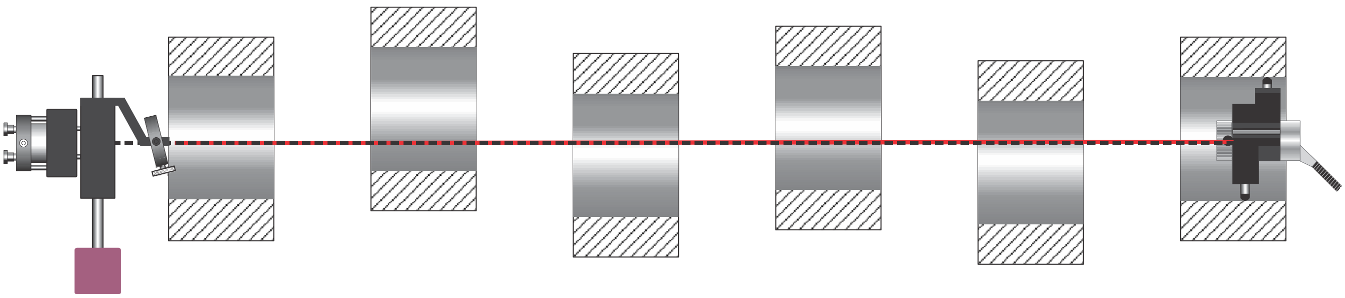
c. Move the target to the *Far Bore* and press **Record**. A calculation of the laser Set Point will be made to aid the laser setup and offsets will be applied to on-screen live data.



d. With buck-in offsets applied in the Bore9 software, steer the laser using the Pitch and Yaw knobs (angular adjustment) on the L-706 until the **H** and **V** displays are zero.

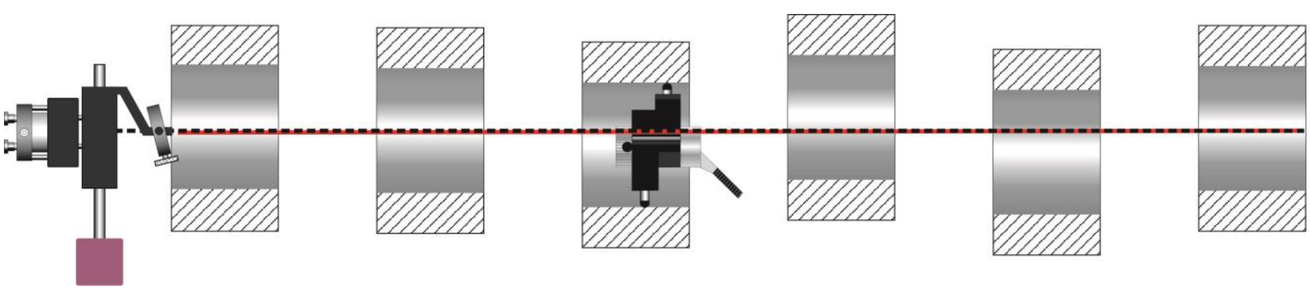


e. Repeat the process to confirm zero at both end bores. The laser is now "bucked in" (concentric) to the centerline of the near and far reference bores.



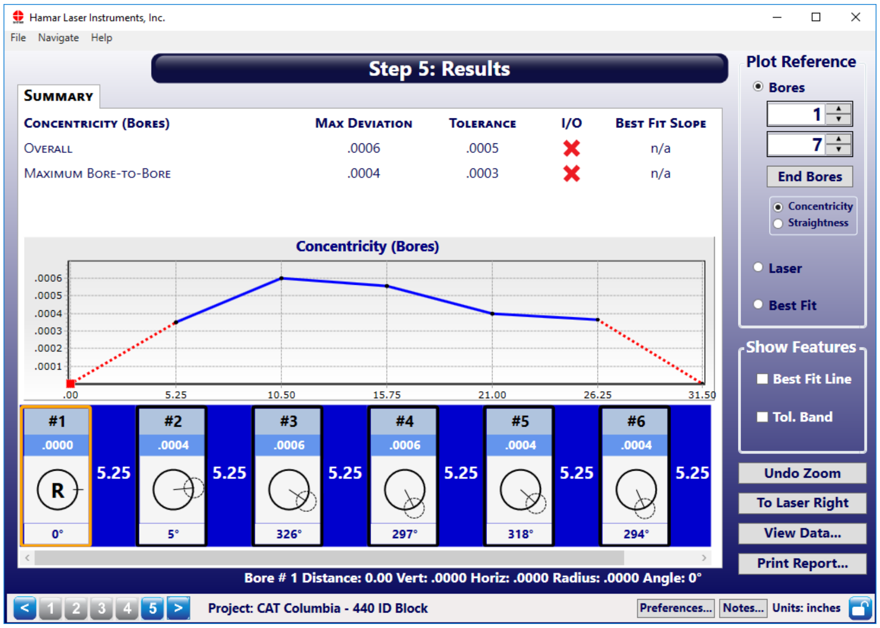
Step 4: Record Data

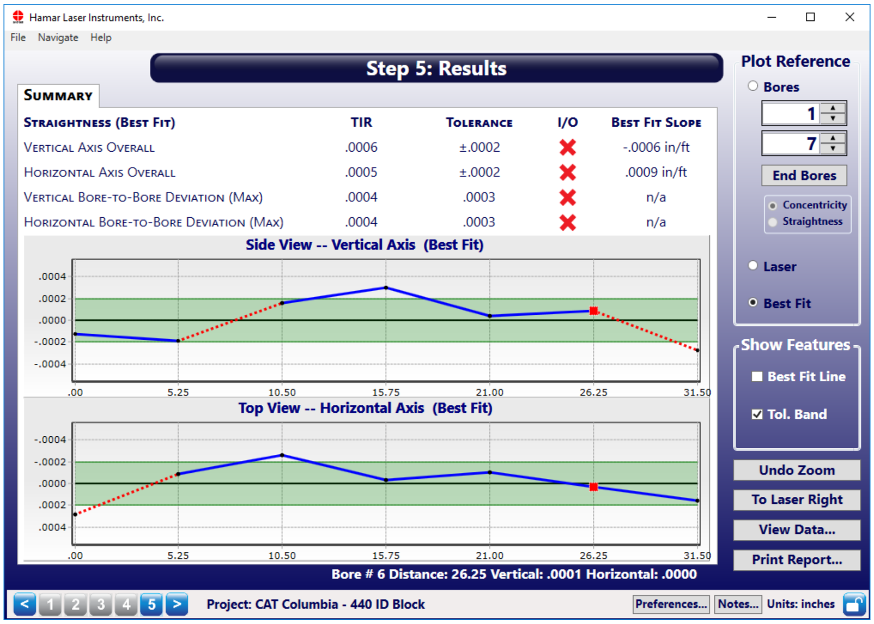
a. Move the target to the first bore you want to measure for alignment and press **Record**. Continue moving the target to each bore until all data is taken.



Step 5: Results

a. Step 5: Results display a graph of the results and a summary of the alignment. There are several different options to choose from. See the Bore9 Software Manual for details.





Bore Alignment Using the T-218 Target/T-255 Bore Fixture

Laser Buck-In Using the T-218 Target/T-225L Bore Fixture

1. Place the T-218/T-225L Target in the *Near Bore* in the NORMal position (see Figure 28).
2. Insert the laser into the L-111 Stand with the level on the top, centered from left to right (see Figure 29).
3. Place the L-102 over the post of the stand but keep it at the top of the post during the rough-in part of the setup.

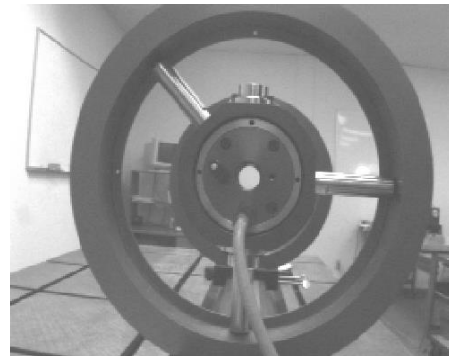


Figure 28 -- *Bore Target in the NORMal position (target cable trailing downward from the bottom of the target).*

Rough-align the laser beam to the bore targets so it goes into the window of the T-218 in both the *Near* and *Far Bore*s.

4. Turn on the L-706 and move the switch to **CONT** mode, which turns off the pulsing of the laser and provides a continuous beam that is easier to see.
5. Tape a piece of paper over the face of the target. Trace an outline of the target window and make a dot in the center of the circle. This makes it easier to see where the laser beam is hitting the target window.
6. Roughly slide the L-111/L-706 horizontally and move it up/down the posts vertically until the laser beam hits the dot in the center of the circle on the paper.
   Note: *To help translate the L-111 horizontally, clamp a straight-edge on the surface behind the magnet to give it something to slide against without changing the angle (yaw).*
7. Move T-218/T-225L to the *Far Bore* in the NORMal position and note where the laser beam hits the circle on the paper.
8. Turn the L-111 Coarse Angular Pitch and Yaw adjustment knobs until the laser beam is centered in the circle on the paper.
9. Repeat Steps 7 and 8 until the laser beam hits the center dot on the paper in both the *Near* and *Far Bore*s. Now the laser is roughly aligned to the two end bores.

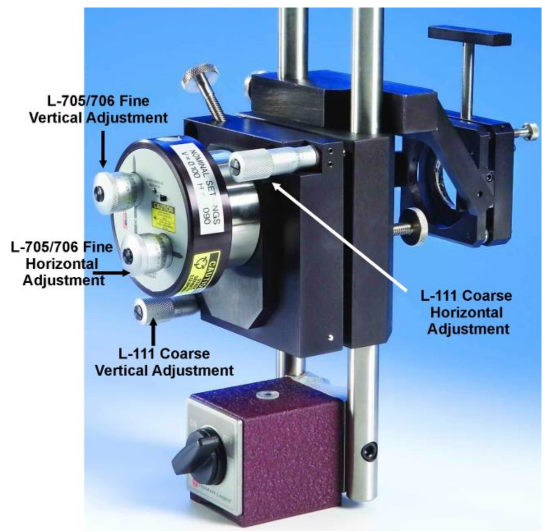


Figure 29 – *L-706 Laser and L-102 Beam Translator on L-111 Laser Stand*

The final buck-in is needed to align the laser to the true center of both the *Near* and *Far Bore*s.

10. Insert the T-218/T-225L back into the *Near Bore* in the NORMal position (see Figure 28).
11. Slide down the L-102 so it is in front of the laser, ensure it is seated against the opposite post of the stand and tighten the thumb screw. Also ensure that it is approximately perpendicular to the laser beam.
12. Switch the L-706 to **PULSE** Mode, (see Page **Error! Bookmark not defined.**) connect the R-1307 readout and power it on.
13. Write down the **V** and **H** readings (NORMal).
14. INvert the T-218/T-225L and take another reading (see Figure 30). Write down the **V** and **H** readings (INverted).
15. Add the two **V** readings together and divide by 2 (average the two **V** values). Add the two **H** readings together and divide by 2 (average the two **H** values). These are the **V** and **H** *Near*-Bore *target* Set Points.
16. Using the L-102 Beam Translator, adjust the laser beam until the R-1307 displays the target **V** and **H** *Near Bore Target* Set Points. The laser is now centered to the *Near Bore* and any mounting errors have been eliminated by the NORMIN method.

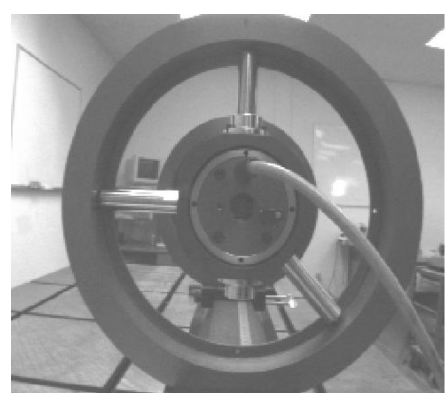


Figure 30 – *Bore Target in the INverted position (target cable trailing downward from the top of the target).*

17. Move the T-218/T-225L to the *Far Bore* and insert it in the normal position. Write down the **V** and **H** readings (NORMal).
18. Invert the target and take another reading. Write down the **V** and **H** readings (INverted).
19. Average the two **V** values and the two **H** values to create the **V** and **H** *Far-Bore Target* Set Points.
20. Measure the distance from the L-111 posts to the midpoint of the T-218 in the *Near Bore*. This is **D1**. Then measure the distance from the mid-point of the T-218 in the *Near Bore* to the mid-point of the T-218 in the *Far Bore*. This is **D2**.
21. Calculate the **V** and **H** *Laser* Set Points using this formula: -1*(D1/D2) Target Set Point *Far Bore* (from Step 19).
22. Turn the L-111 Coarse *Angular* Pitch and Yaw adjustment knobs (see Figure 29) until the R-1307) reads close to the **V** and **H** *Laser* Set Points. When the adjustment becomes too difficult with the L-111, use the **V** and **H** angular adjustments on the L-706 (see Figure 31) until the values equal the **V** and **H** *Laser* Set Points from Step 21.
23. Move the T-218/T-225L back to the *Near Bore* and repeat Steps 15 and 16.
24. Repeat Steps 13-20 until the **V** and **H** target Set Points are zero at the *Near* and *Far Bore*s. The laser is now aligned (bucked-in) to the two end bores.

    Remote Buck-in Note: *This procedure can be performed much faster if the Remote Buck-In Formula (Set Point = -1*(Far reading * (L1/L2) is used each time you do the Laser buck-in. If the distance from the laser to the target in the Near Bore is more than 10 percent of the distance from the target in the Near Bore to the target in the Far Bore, it will be* ***necessary*** *to follow the Remote Buck-In procedure (see Appendix C on Page 50).*

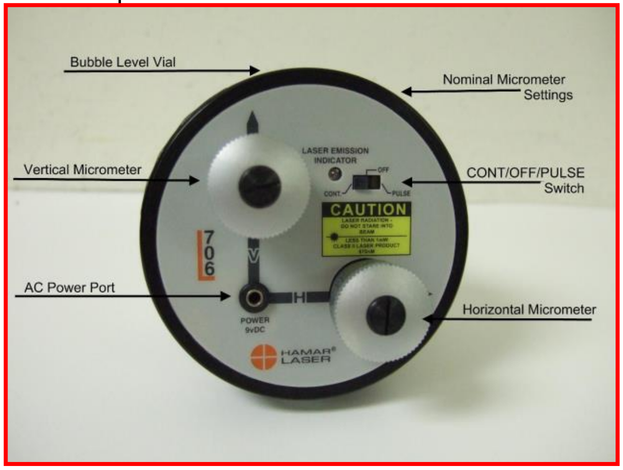


Figure 31 – *L-706 Laser*

Figure 32-- *D1 Distance Measurement: Center L-111 posts to mid-point of the target in* ***Near Bore***

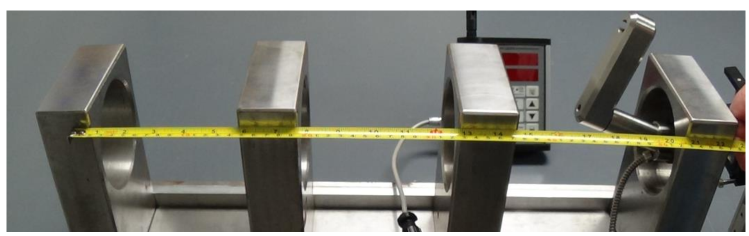


Figure 33 – *D2 Distance Measurement: Mid-point of target in* ***Near Bore*** *to center of target in* ***Far Bore***

Taking a measurement for each inner bore

1. Take a reading on the near target with the target in the normal position (see Figure 28). Write down the **V** and **H** Readings (NORMal).
2. Invert the target and take another reading (see Figure 30). Write down the **V** and **H** Readings (INverted).
3. Add the two **V** readings together and divide by 2 (average the two V values). Add the two **H** readings together and divide by 2 (average the two **H** values). The **V** and **H** averages are True Bore Alignment values (see Appendix A – The NORMin Method, beginning on Page 45).

Target Set Point Example:

Formula: (N+I) /2
NORMal readings V: .0089 H: -.0056
INverted readings V: .0140 H: .0015

Target Set Points:

V: (.0089 + .0140) /2 = **.0115**
H: (-.0056 + .0015) /2 = **-.0021**

Laser Set Point Example:

Formula: -1*(D1/D2)*Target Set Point Far Bore (from Step 19)

D1= 4.5
D2= 24.25
Far Bore Target Set Points: V=.0115
(from Target Set Point example) H=.0021

Laser Set Points:
V: -1*(4.5/24.25) * .0115 = -.19 * .0115 = **-.0022**
H: -1*(4.5/24.25) * -.0021 = -.19 * -.0021 = **+.0004**

Bore9 Report

HAMAR LASER

Project: 30bores

Report Issued By

Company Name:
Address:
City, State Zip:
Phone/FAX:
Company EMail:

Machine Information

Factory Name:
Machine Information:
Notes:

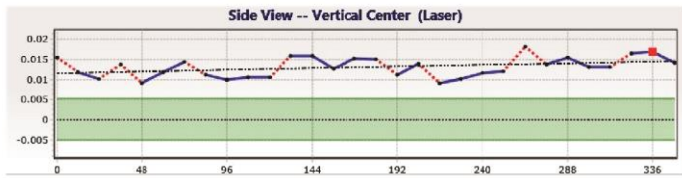
Alignment Results

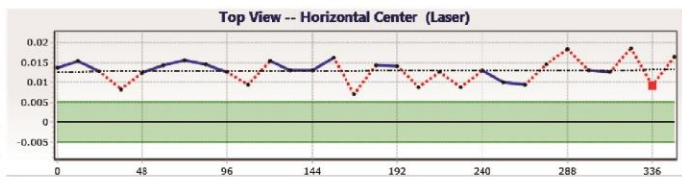
Alignment Check	Value	Tolerance (+/-)	BF Slope	Best Fit I/O	Plot I/O
Vertical Straightness (TIR)	.0085	.0051	.0001	✓	✗
Horizontal Straightness (TIR)	.0114	.0051	.0000	✗	✗
Vertical Bore To Bore (Max)	.0061	.0031		✗	N/A
Horizontal Bore To Bore (Max)	.0093	.0031		✗	N/A

Setup Information

Number of Bores	30
Distance between bores	12.00
Units	inches
Overall Tolerance	.0051
Bore to Bore Tolerance	.0031
Target / Interface	R-1307-900, R-1307-2.4
Serial Number	
Calibration Date	1/1/0001

Result Graphs





Alignment Data

Bore #	Dist	V Raw	H Raw	V Plot (Raw)	H Plot (Raw)	V Diam	H Diam	Rad	Ang P
1	0	.0154	.0137	.0154	.0137	0	0	.0206	228
2	12.0000	.0118	.0155	.0118	.0155	0	0	.0195	217
3	24.0000	.0101	.0129	.0101	.0129	0	0	.0164	218
4	36.0000	.0138	.0083	.0138	.0083	0	0	.0161	239
5	48.0000	.0091	.0124	.0091	.0124	0	0	.0154	216
6	60.0000	.0118	.0144	.0118	.0144	0	0	.0186	219
7	72.0000	.0144	.0156	.0144	.0156	0	0	.0212	223
8	84.0000	.0112	.0146	.0112	.0146	0	0	.0184	217
9	96.0000	.0099	.0127	.0099	.0127	0	0	.0161	218
10	108.0000	.0106	.0095	.0106	.0095	0	0	.0142	228
11	120.0000	.0106	.0153	.0106	.0153	0	0	.0186	215
12	132.0000	.0158	.0130	.0158	.0130	0	0	.0205	231
13	144.0000	.0158	.0131	.0158	.0131	0	0	.0205	230
14	156.0000	.0127	.0162	.0127	.0162	0	0	.0206	218
15	168.0000	.0152	.0070	.0152	.0070	0	0	.0167	245
16	180.0000	.0150	.0143	.0150	.0143	0	0	.0207	226
17	192.0000	.0112	.0141	.0112	.0141	0	0	.0180	218
18	204.0000	.0139	.0088	.0139	.0088	0	0	.0165	238
19	216.0000	.0092	.0126	.0092	.0126	0	0	.0156	216
20	228.0000	.0102	.0088	.0102	.0088	0	0	.0135	229
21	240.0000	.0117	.0130	.0117	.0130	0	0	.0175	222
22	252.0000	.0120	.0101	.0120	.0101	0	0	.0157	230
23	264.0000	.0181	.0094	.0181	.0094	0	0	.0204	243
24	276.0000	.0137	.0146	.0137	.0146	0	0	.0200	223
25	288.0000	.0153	.0184	.0153	.0184	0	0	.0239	220

Alignment Data (Continued)

Bore #	Dist	V Raw	H Raw	V Plot (Raw)	H Plot (Raw)	V Diam	H Diam	Rad	Ang Pos
26	300.0000	.0130	.0130	.0130	.0130	0	0	.0184	225
27	312.0000	.0130	.0126	.0130	.0126	0	0	.0181	226
28	324.0000	.0164	.0186	.0164	.0186	0	0	.0248	221
29	336.0000	.0168	.0093	.0168	.0093	0	0	.0192	241
30	348.0000	.0141	.0165	.0141	.0165	0	0	.0217	221

Appendix A – The NORMIN Method (Bore and Spindle)

The NORMIN method was developed by Hamar Laser Instruments as a way of compensating for laser or target mounting errors in bore or spindle work. The word is a contraction of "NORMal-INverted," which briefly describes the method. It is 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.

There are three centers involved in bore alignments: the True Bore Center, the Target Center, and the 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 34.

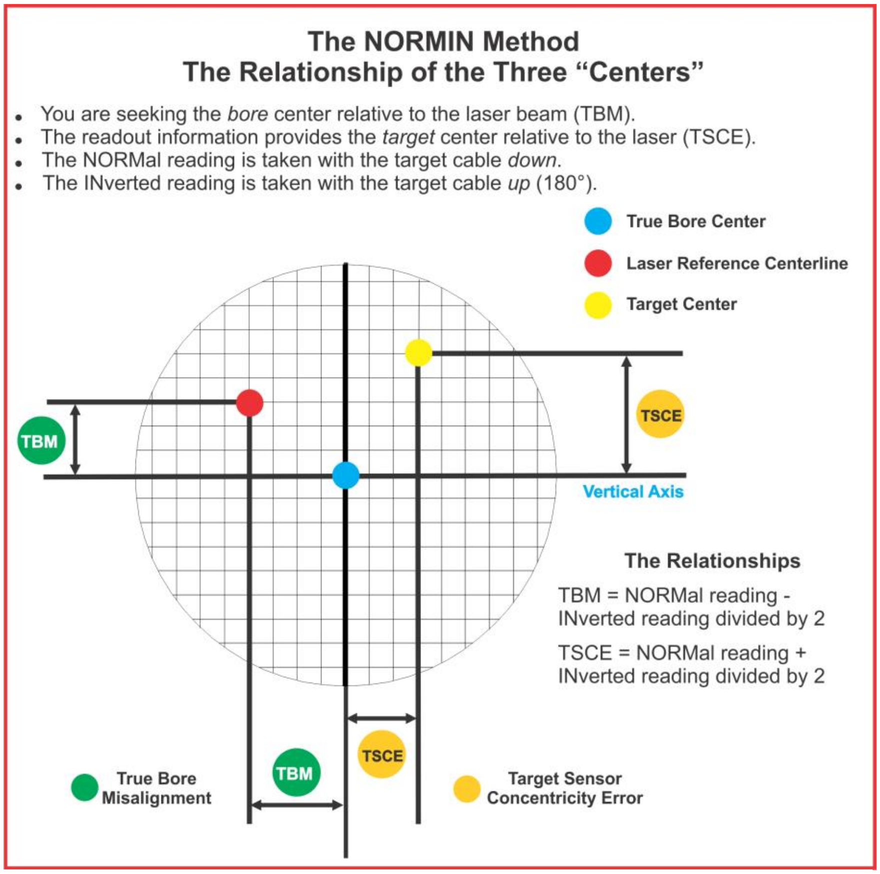


Figure 34 -- *Three centers of bore alignment*

Two relationships can be calculated from these three centers and two sets of NORMIN readings: the Target Sensor Concentricity Error (TSCE) and the 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 35 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.).

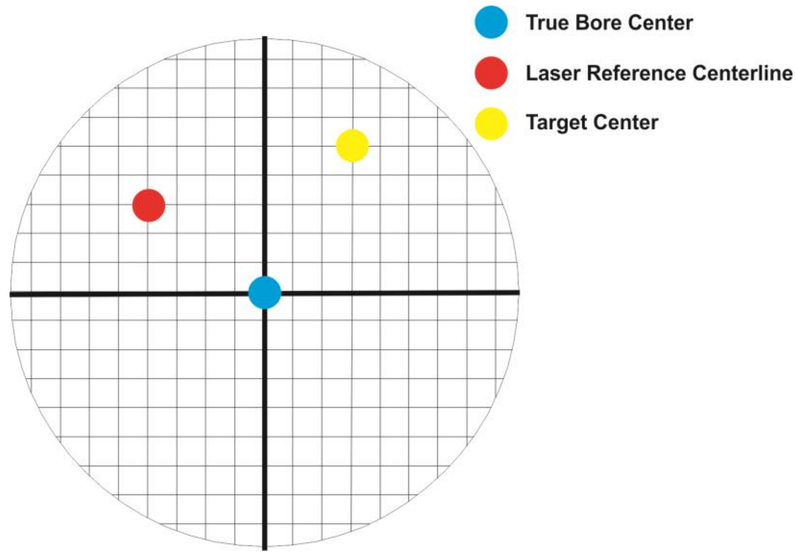


Figure 35 – *Target in the NORMal position*

Figure 36 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 36, the vertical readings will be positive and the horizontal readings will be negative. When the vertical TCE is calculated, (NORMal+INverted divided by 2) the Target Center is .004 in. higher and .003 in. to the right of the True Bore Center in the NORMal position.

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

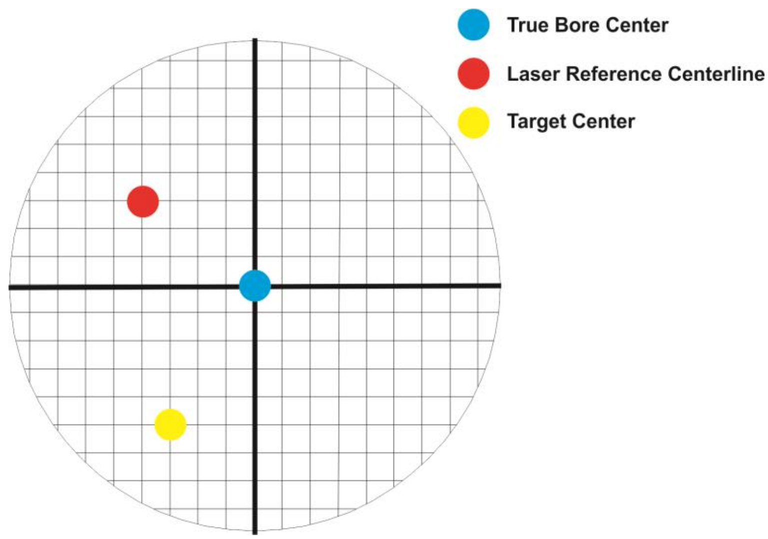


Figure 36 – *Target in the INverted position*

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

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

Appendix B – Calculating Bore Diameters

Once the measurements have all been taken, a few simple calculations will provide detailed information on the internal diameter of the bore. Due to the design of the target and the NORMIN procedure, it is necessary only to know the reference diameter in order to calculate bore size at each measured point.

To track change in diameter, the user calculates the offset between the target center and the bore center (the Target Centering Error or TCE) for each point measured. When TCEs from two measured points are compared, the difference between them is an accurate measure of the difference in their diameters.
Note: *These equations apply to any bore target.*

1. **Calculate the Reference Diameter TCE (RDT).**
   The target centering error for the reference location using the NORMIN readings taken at the reference location is the *Reference Diameter TCE* (**RDT**). The formula is:

   $$\textbf{RDT} = \frac{\textbf{Normal Reading + Inverted Reading}}{\textbf{2}}$$

2. **Calculate the Measured Diameter TCE (MDT).**
   The target centering error for each measured point using the NORMIN readings from each measured point is the *Measured Diameter TCE* (**MDT**). The formula is:

   $$\textbf{MDT} = \frac{\textbf{Normal Reading + Inverted Reading}}{\textbf{2}}$$

3. **Calculate the difference in diameter between each measured point and the reference location.**
   The difference in diameter between each measured point diameter and the reference location diameter. The formula is: **(RDT - MDT) × 2**

   Note: *If the result of the above formula produces a negative number larger than that of the RDT, then the measured point diameter is larger than the reference location diameter.*

   To find the actual diameter of each measured point, measure the reference location diameter and use the formula below:

   Measured Point Diameter = Reference Location Diameter + (MDT - RDT) × 2

Bore Size Measurement

In this application, the offset represents the RDT for the reference location and represents the MDT for each measuring point.

Location	Normal	Inverted	Offset	Diameter
Reference Location	0.008	-0.006	0.001	4.500 in
Measuring Point 1	0.012	-0.008	0.002	4.498 in.
Measuring Point 2	0.004	-0.002	0.001	4.500 in.
Measuring Point 3	0	-0.008	-0.004	4.510 in.
Measuring Point 4				
Measuring Point 5				
Measuring Point 6				

$$\textbf{Reference Diameter TCE (RDT)} = \frac{\textbf{Normal Reading + Inverted Reading}}{\textbf{2}}$$

$$\textbf{Measured Diameter TCE (MDT)} = \frac{\textbf{Normal Reading + Inverted Reading}}{\textbf{2}}$$

Difference in Diameter = Reference Diameter + ((MDT – RDT) x 2)

Plotting Measured Data

The following chart and calculations are provided to help record, calculate, and plot bore diameter data. The chart can be expanded to record as many measurement points as are required. Formulas for calculating offsets and diameter are provided, as well as a sample plot of readout data (see Figure 38 on Page 49).

LOCATION	NORMAL	INVERTED	OFFSET	DIAMETER
Reference Location				
Measuring Point 1				
Measuring Point 2				
Measuring Point 3				
Measuring Point 4				
Measuring Point 5				
Measuring Point 6				

Figure 37 -- *Chart for Readout Data*

$$\text{Reference Diameter TCE (RDT)} = \frac{\textbf{Normal Reading + Inverted Reading}}{\textbf{2}}$$

$$\text{Measured Diameter TCE (MDT)} = \frac{\textbf{Normal Reading + Inverted Reading}}{\textbf{2}}$$

Difference in Diameter = Reference Diameter + ((MDT – RDT) × 2)

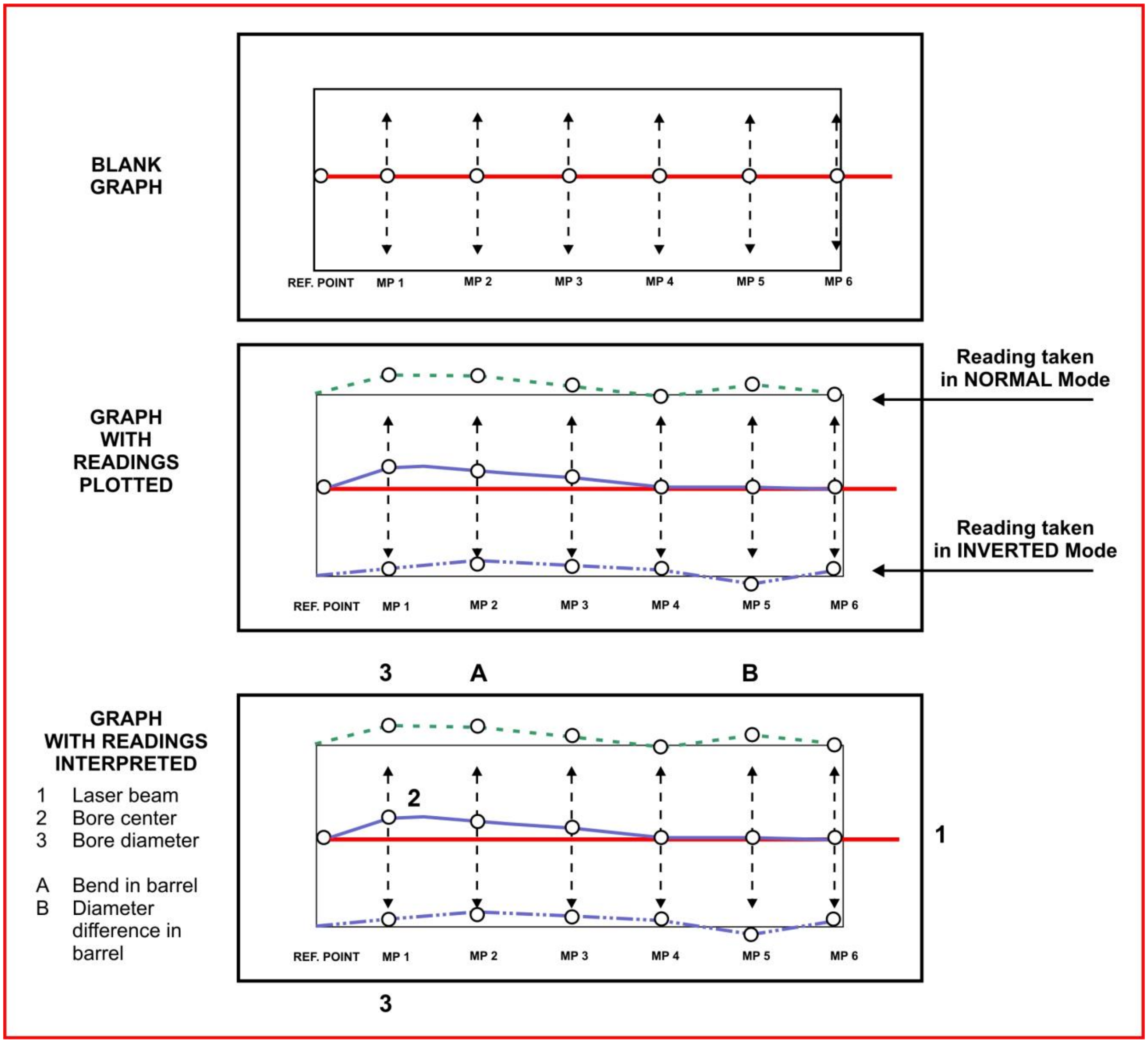


Figure 38 – *Sample plot of readout data*

Appendix C – 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 39 illustrates how the remote method works.

Unlike normal 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." The set distance is the offset between the parallel laser beam and the target centerline.

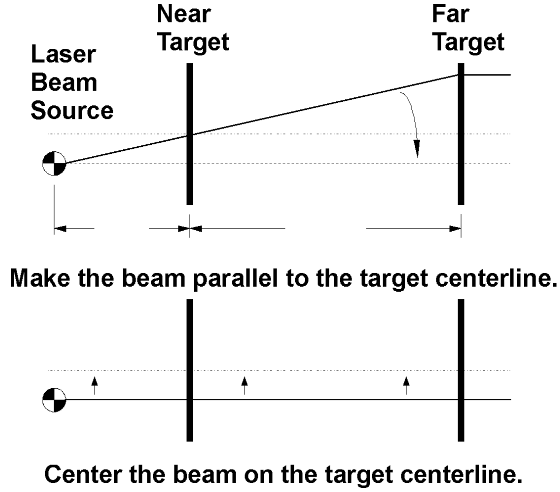


Figure 39 – *Remote Buck-in*

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 40).

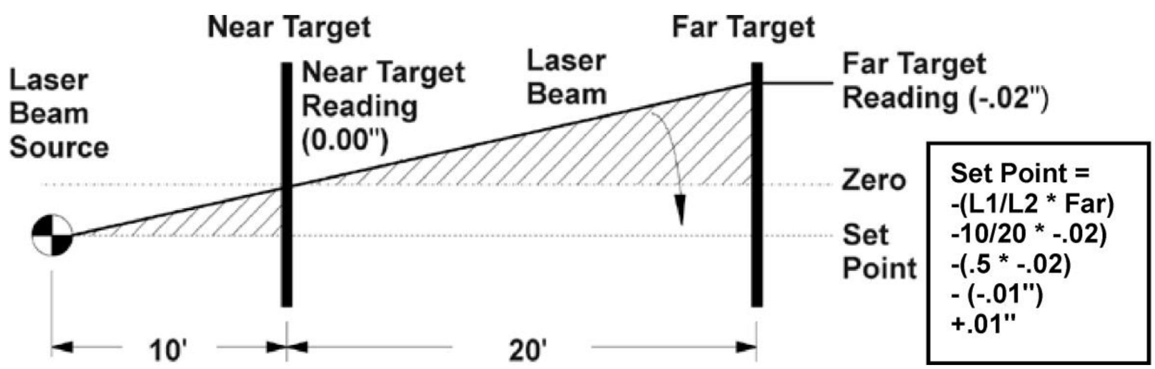


Figure 40 - *Calculating the Set Point*

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 Point = -1 * (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 40 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) ***the laser unit itself must be moved*** by the Set Point amount. New measurements must then be retaken for both targets, and a new set calculated.

Figure 41 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).*

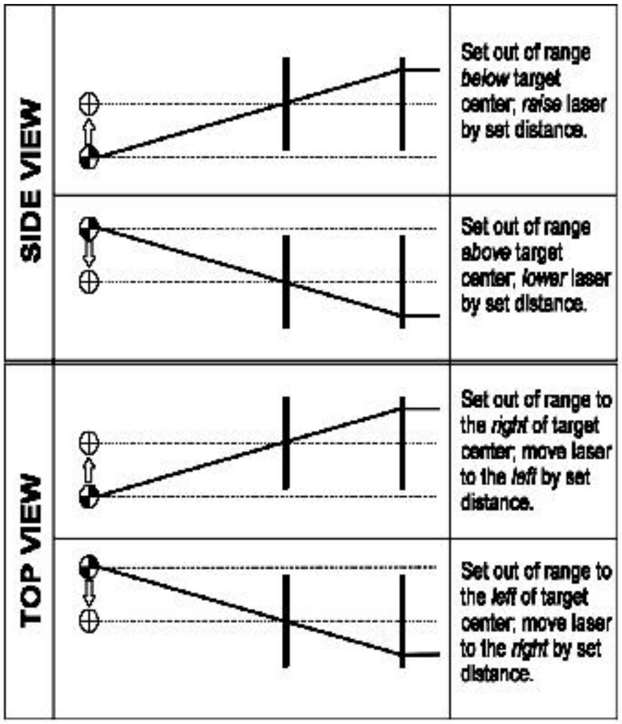


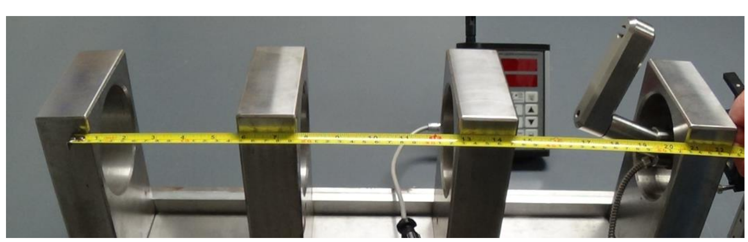
Figure 41 - *Moving the laser when the Set Point is out of range of the target cell*

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).

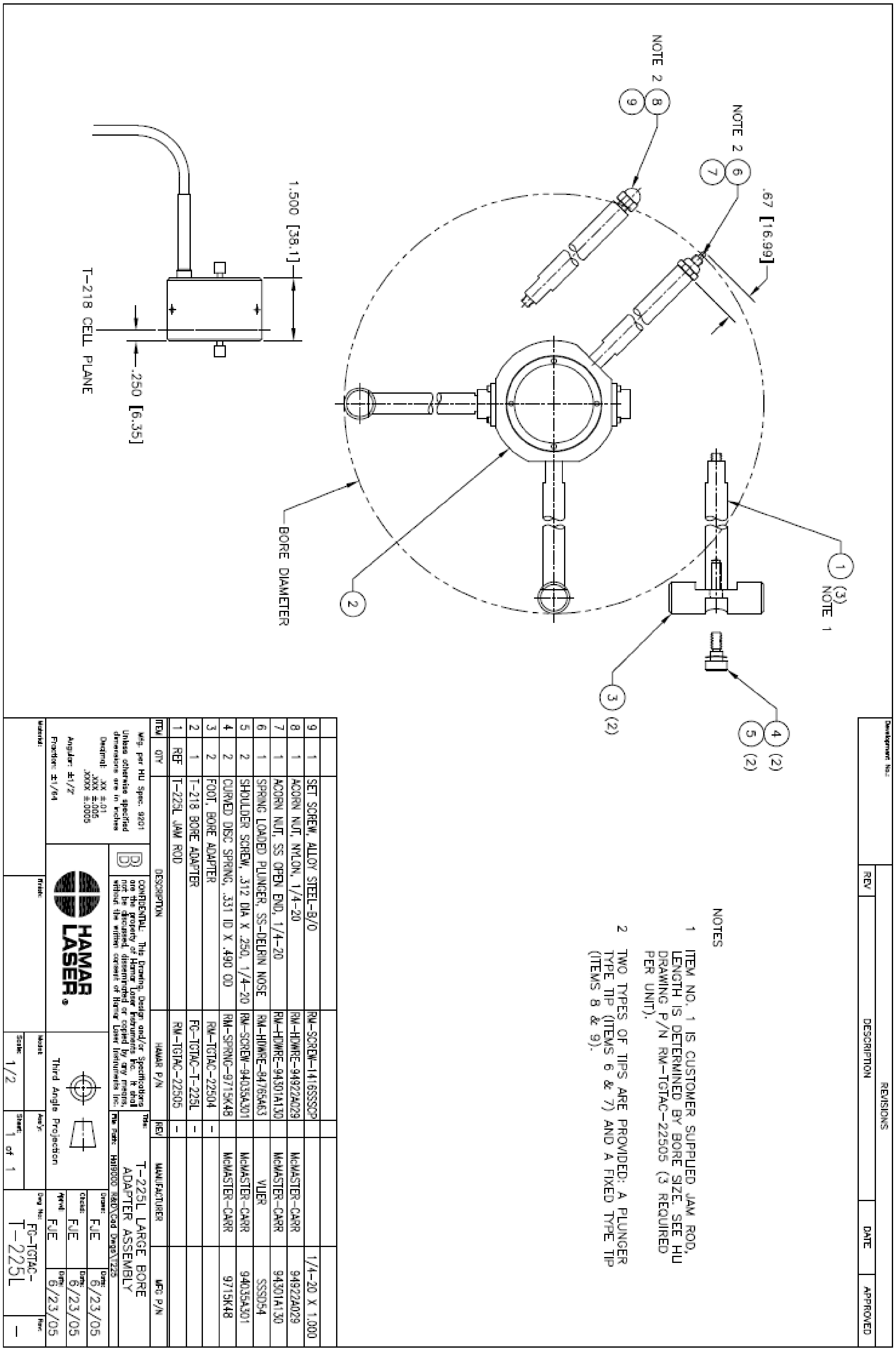
The determining factor for which method to use can be summed up as follows:

- Use Normal Buck-in if the distance from the laser to the first target is less than one-tenth of the distance between the two targets. When using normal buck-in, the rule is: **Zero Near, Point Far**. Buck in the laser beam by zeroing it on the *near* target, and then "pointing" the laser beam using the appropriate adjustment knobs to *center* on the far target. The two steps are repeated until both targets show zero readings.

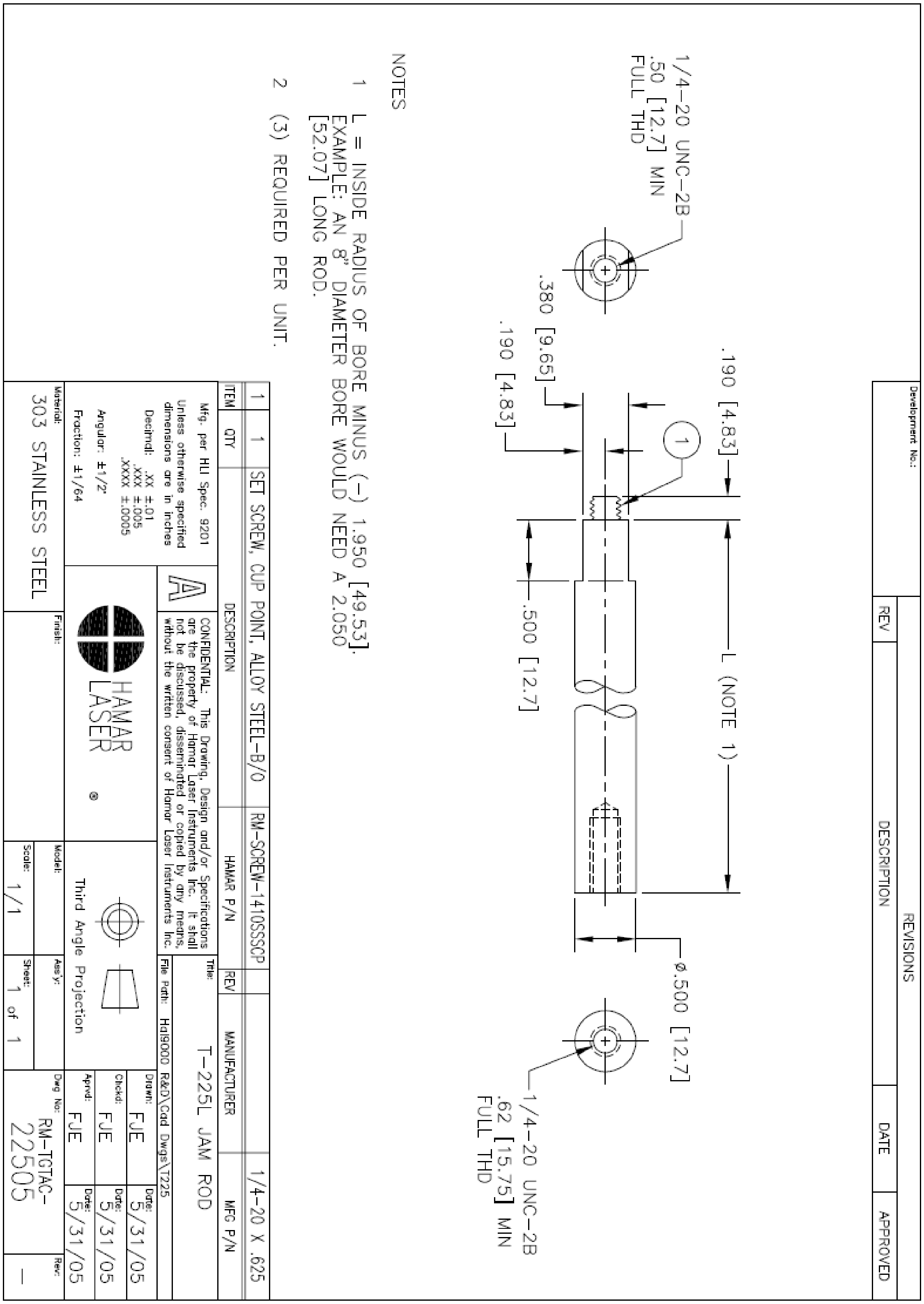
- Use Remote Buck-in if the distance from the laser to the first target is more than one-tenth of the distance between the two targets, or if normal buck-in method is not effective. When using remote buck-in, the rule is: **Point Through Zero to Set Point**. Zero the near target, determine the Set Point (making sure the sign is correct), and adjust the laser beam using the appropriate adjustment knobs to point to set rather than zero on the far target. Repeat if necessary, until both targets read zero. The laser beam is now bucked in to the reference points defined by the two targets.



Appendix D – T-218/T-225L Dimensions (Model 3)



Appendix E – T-225L Leg Dimensions/Instructions



Appendix F – 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 optic 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 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.