L-705/L-706 Laser Bore Alignment System

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HAMAR LASER
ALIGN WITH THE BEST

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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.

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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.

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Critical Note on Calibration

When configuring the R-1307 Readout, it is critical to match the target ID 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 the number 2. 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. For CONTinuous (Fixed) Mode, set the readout to F10.10 and for Pulsed Mode, set the R-1307 to P10.10.**

For example: tGt=02 F. 10. 10 or tGt=02 P. 10. 10 for R-1307 #2

For more information on the Pulse/CONTinuous modes on the laser, see *Pulse/Continuous Modes (L-705, L-706 and L-708 Lasers)* on Page 6. For complete information on matching the target to the readout, see *Configuring the R-1307 or R-1307C for a Local Target* on Page 17.

Introducing the L-705/L-706 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. A laser is placed in an L-111 stand outside of the series of bores and the laser beam is adjusted so it passes through the center of the two reference bores. This is accomplished by doing what is referred to as a 2 point buck-in. Once the laser beam is adjusted to pass through the two 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 L-705/L-706 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, this 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 variety of bore alignment applications, including: 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 laser has been designed with a standard aerospace tooling diameter of 2.25 in. (57.15 mm). Since the laser beam is concentric to the OD to within .0005 in. (0.0127 mm), a simple flat face and .750 in. (19.05 mm) hole on center is all that is needed to hold the laser (powerful magnets hold the laser flush to the face).

Any bore, from 3.75 in. (92.25 mm) up to 50 in. (1,270 mm) or more, can easily be measured with our Bore Laser System. The system offers three bore adapters and a leg-setting gage to set the adapters to the nominal bore ID. For bores from 2.0 in. (50.8 mm) to 3.75 in. (92.3 mm), we offer our A-510 Target and A-510STA Self-Centering Adapter Hub and M-705CL Customized Measuring Legs.

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 .004 in. (0.1 mm) over the whole range. By carefully following the NORMIN procedure, (see Appendix A beginning on Page 38) accuracies of .0003 in. (0.0075 mm) in 10 ft. (3.1 meters) can be achieved.

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
- System handles a large range of bore IDs from 3.75 in. (92.25 mm) up to 40 in. (1,016 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
- Portable enough to fit into small carrying case. Complete system weighs less than 15 lbs. (6.804 kg).
- Laser runs for up to 8 hours on a standard, replaceable 9-volt battery
- Optional A-510SM Small-Bore Target easily accommodates bores as small as 1.5 in. (38.1 mm)

Recommended System Configuration

- L-706 Long Distance Bore Laser
- L-111 Laser Adjustment Stand
- L-102 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-514A Small-Bore, Self-Centering Adapter for 3.5 in. to 6.75 in. diameter bores
- A-514B Medium-Bore, Self-Centering Adapter for 6.5 in. to 17.5 in. 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-510SM Customized, 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-910-2.4ZB Wireless Data Receiver
- S-1403 Bore9 Software

The Laser Bore Alignment System Components

Model L-705 Laser

The L-705 Bore Laser is a battery-operated, visible light laser that mounts magnetically in a bore fixture or mounting. It is suitable for almost all bore applications. The laser has two mounting surfaces: 0.7498 in. (19.04 mm) and 2.2498 in. (57.14 mm). The laser beam is centered to both mounting ODs to within .0003 in. (0.08 mm). The L-705 laser beam is designed to shoot up to 110 ft. (33 m) but has an angular adjustment resolution of .001 in. (0.025 mm) in 50 ft. (15 m) and is best used under 50 ft.

Model L-706 Long Distance Laser

For long-distance applications that exceed the range of the L-705, the L-706 Laser is equipped with the finer angular adjustments necessary to set the laser beam to the center of the far reference target. It is used for applications up to 110 ft. (33 m). The finer angular adjustments mean there is less adjustment range, which make the L-706 difficult to use in shorter distances.

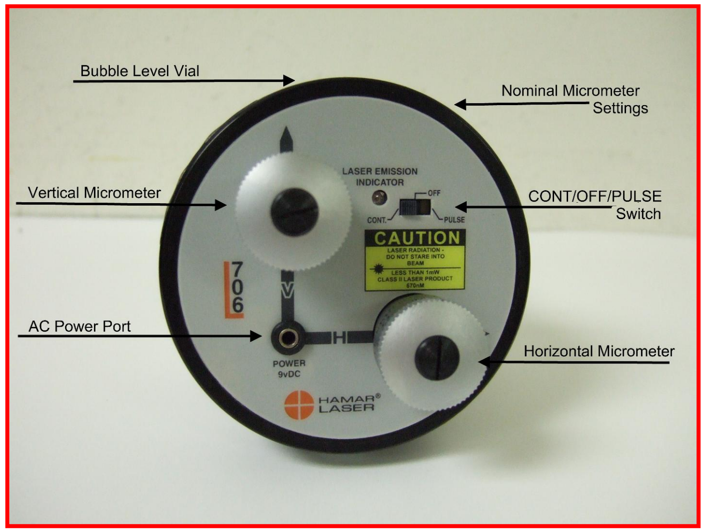


Figure 1 – *The L-706 Laser*

The following describes the operational features of the laser. These features include bubble level vial orientation, micrometer values and settings, ON/OFF switches and the external battery pack.

- **The ON/OFF slide switch** has a lighted LED to indicate that power is ON.
- **The Pulse/Continuous switch** selects the laser mode compatible with the readout/interface being used (see Page 6 for more information about Pulse/Continuous modes and the readouts used for each mode).
- **Battery Pack connector** accepts a slip-fit probe with a flexible cord.
- **Bubble level vials** on the laser mounting flange are used for rotational accuracy. When the bubbles in the level vial are centered horizontally, all micrometer adjustments (controlling laser beam angle) will shift the laser beam vertically or horizontally with reference to the bore/target axis. If the bubbles are not centered, any micrometer adjustment to one laser axis will change the laser beam position in both axes. The levels also provide fixture mounting repeatability (assuming the laser is hard-mounted to fixture).
- **Micrometer controls** are provided for the adjustment of the angle at which the laser beam emerges from the precision ground, mutually concentric steel laser housing. Each laser has a NOMINAL setting for both the V-Vertical and the H-Horizontal micrometer controls. The nominal settings are determined at the factory and correlate to values for the laser beam when it is perpendicular to both the 2 in. and 4 in. mounting faces. When the bubble in one of the level vials is centered, a nominal setting of each micrometer squares the laser beam to that specific axis. For example, if the nominal vertical setting is .120, then setting the micrometer to .120 sets the laser beam square to the vertical axis. When a laser is mounted in the gearbox or bore adapter, vertical and horizontal micrometers should be *set in the nominal positions* to facilitate the alignment and measurement process.

Adjusting the Laser

The laser beam is factory-adjusted to be concentric to the mounting diameters (2.25 in. or 57.15 mm and .75 in. or 19.05 mm) within ±.0005 in. (.0127 mm). With the adjusting micrometers set at the nominal position, (see the **Nominal Settings** label on the outer flange), the laser beam is perpendicular to the front mounting surface and parallel to the mounting diameters within ±.0003 in/ft.

In a typical bore measuring application, the laser is mounted concentric to one end of the bore by means of a fixture ring or plate. Because fixtures are seldom perfect, the laser beam requires angular adjustment to make it concentric to the bore. This is accomplished by placing the self-centering measuring target at the other end of the bore and adjusting the micrometers on the laser until the laser beam is centered on the target.

Figure 2 – *Laser Micrometer Adjustments*

The circular level vial on the laser mounting flange is used to reference the orientation of the vertical and horizontal axes of the laser. When the bubble in the level vial is centered, all micrometer adjustments (controlling laser beam angle) will shift the laser beam vertically or horizontally with reference to the bore/target axis. If the circular level bubble is *not* centered, any micrometer adjustment to one laser axis *will make the laser beam position appear to change in both axes*. The level vial also provides fixture mounting repeatability (assuming the laser is hard mounted to the fixture). Only minor readjustments of the laser to the bore and fixture surfaces are required in situations where frequent alignment is expected.

Attaching the Battery Pack

The L-705 Laser battery pack is a stand-alone unit that attaches magnetically to an extruder gearbox. The battery pack has a detachable cord with a probe at each end. One probe attaches directly to a jack on the battery pack and the other probe is inserted in the control panel of the L-705 Laser.

1. **Turn off the main power switch.**
   The main power switch ***must*** be off before attaching the battery pack.
2. **Insert the probe into the battery power input jack.**
   The jack is located on the end panel of the battery pack. Insert the plug gently until it snaps into place.
3. **Insert the probe into the laser power input jack.**
   The jack is located on the micrometer control, at the apex of the **V** and **H** axis arrows. Insert the plug gently until it snaps into place.

Figure 3 – *Attaching the Battery Pack*

Replacing the Batteries

The battery pack uses two 9-volt batteries. The batteries are housed in a two-part case which is held together by flathead screws. Hamar Laser recommends using alkaline or nickel-cadmium (NiCad) cells for best performance.

1. **Unplug the battery pack from the laser.**
   Pull the probe out of the laser jack and gently set aside.
2. **Unscrew the cover of the battery pack.**
   Locate and loosen the two captive flathead screws and remove the cover.
3. **Replace the two batteries.**
   Remove the old batteries and replace them with new 9-volt cells, being careful to orient them with the *negative terminal out (or up)*.
4. **Re-attach the cover.**
   Put the cover back on and secure it to the battery pack with the screws.

Pulse/Continuous Modes (L-705 and L-706 Lasers)

The L-705 and L-706 Lasers are now equipped with a PULSE/CONTinuous switch, which manually switches the laser beam between *Pulsed* and *Fixed Beam Modes*. *Pulse Mode* automatically removes the effects of excess (ambient) background light for the R-1307 readouts, providing a more accurate reading. The R-1307 Readout is capable of supporting both Pulse Mode and Continuous Mode as well as storing up to nine different target calibration factors for multiple target users. These capabilities must be specified when ordering a system.

The chart below indicates the operational modes for Readouts/Computer Interfaces that operate with the L-705/L-706 Lasers:

Mode	Readouts	Computer Interfaces
Pulse	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
CONTinuous	R-307, R-307V	R-358

Notes:

1. *The T-261A and T-266 Targets do not support the 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.*

Model A-512 2-Axis Self-Centering Target

The A-512 Target *unit* is comprised of a target cell, a bore adapter, and an insertion handle (see Figure 5). The target is inserted into the bore to sense 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 4 – *A-512 2-Axis Self-Centering Target*

The target cell is a position-sensitive photo cell surrounded by a stainless steel housing. When light contacts the photo cell, the continuous flow of current across the cell is altered. The location of the contact is recorded as a change in voltage, which the digital readout or computer interface displays as an *offset* from the target center. The effective cell sensitivity range is ± .100 in. (2.5 mm), and changes in the x and y axis positions of the target can be displayed on a digital readout to within .0005 in. (0.0127 mm) over 50 ft. (15 m).

The target cell has a milled keyway designed to slipfit 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.

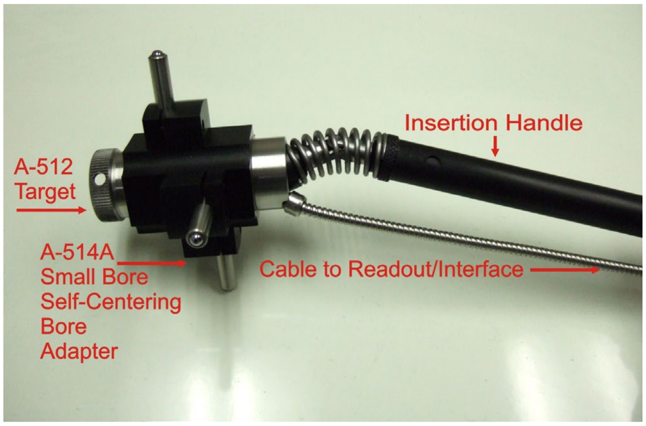
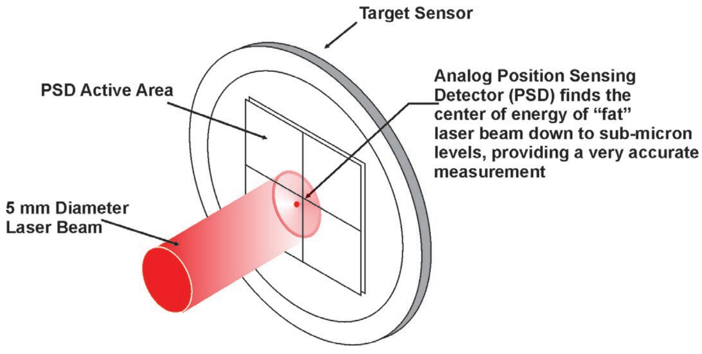


Figure 5 – *A-512 Target with A-514A Small Bore Self-Centering Bore Adapter*

The A-512 2-Axis Bore Target has a 10x10 mm PSD and is designed specifically for our A-514 line of 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). 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 .0006 in. (0.015mm). Another unique feature of our A-514 adapters is they can handle a fairly large range of bore diameter changes of up to .020 in. or 0.5 mm. This means you don't need to worry about bore diameter changes to get accurate measurements.



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.

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* ***diameters****.*

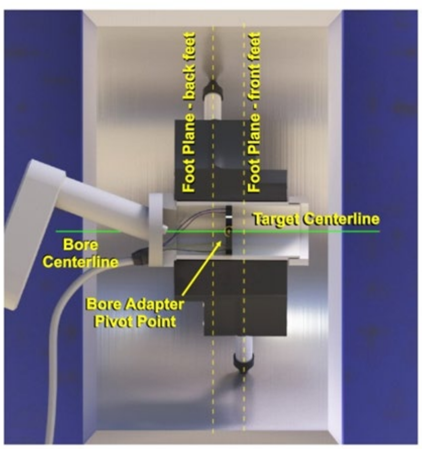
The A-514 self-centering laser and bore adapters accurately and quickly position the laser and target on the bore centerline. The adapters can be centered to the bore to within .0005 in. (0.0127 mm). The adapters have adjustable legs that allow them to be used for bore diameters ranging from 3.75 in. (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:

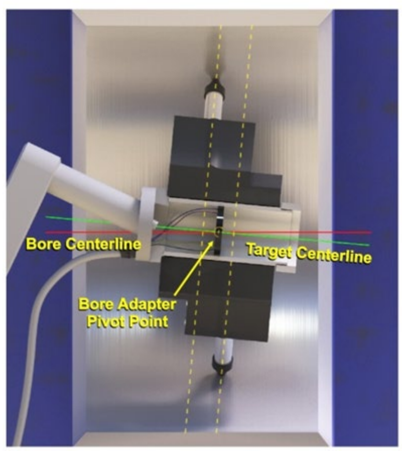
- **A-514A** for bores from 3.75 in. (95 mm) to 6.75 in. (172 mm)
- **A-514B** for bores from 6.5 in. (165 mm) to 17.5 in. (445 mm)
- **A-514C** for bores from 17.0 in. (432 mm) to 40.0 in. (1 m)

Note: *For bores over one meter, half-bores, or where bore surfaces are worn or rough, the T-218 Two-Axis Universal Target and T-225L Large Bore Flange are used. 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. For half-bores, the T-218 is used with the A-502A Half-Bore and A-501A Bore Sweep Fixtures.*

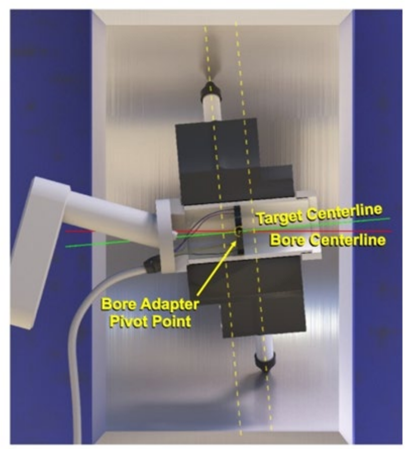
How the A-512 and A-514 Self-Centering Adapters Work



A-512/A-514 Target & Adapter
Adapter OD = Nominal Bore ID

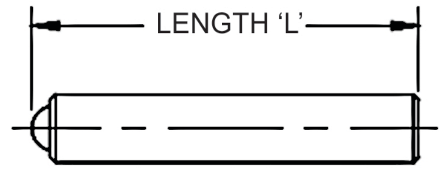


Bore ID > Nominal ID
Target Tilts Forward
PSD Is Still Centered



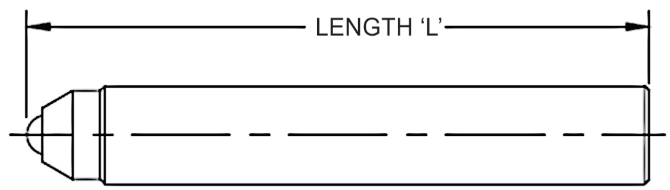
Bore ID < Nominal ID
Target Tilts Back
PSD Is Still Centered

Bore Diameter Ranges for the A-514 Bore Adapters



Bore Diameter Range
A-514A Bore Adapter

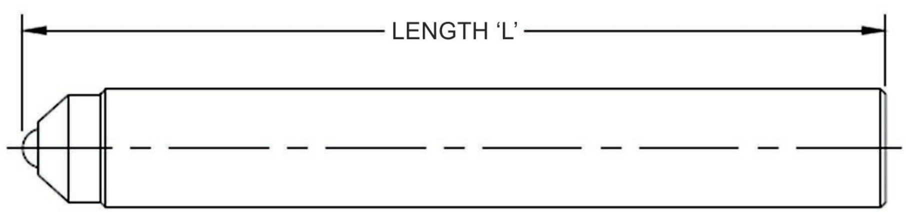
HLI PART NUMBER	LENGTH 'L'	BORE DIAMETER RANGE
51403-1	1.22 (30.99 mm)	3.750 – 4.750 (95.25 – 120.65 mm)
51403-2	1.72 (43.69 mm)	4.750 – 5.750 (120.65 – 146.05 mm)
51403-3	2.22 (56.39 mm)	5.750 – 6.750 (146.05-171.45 mm)



Bore Diameter Range
A-514B Bore Adapter

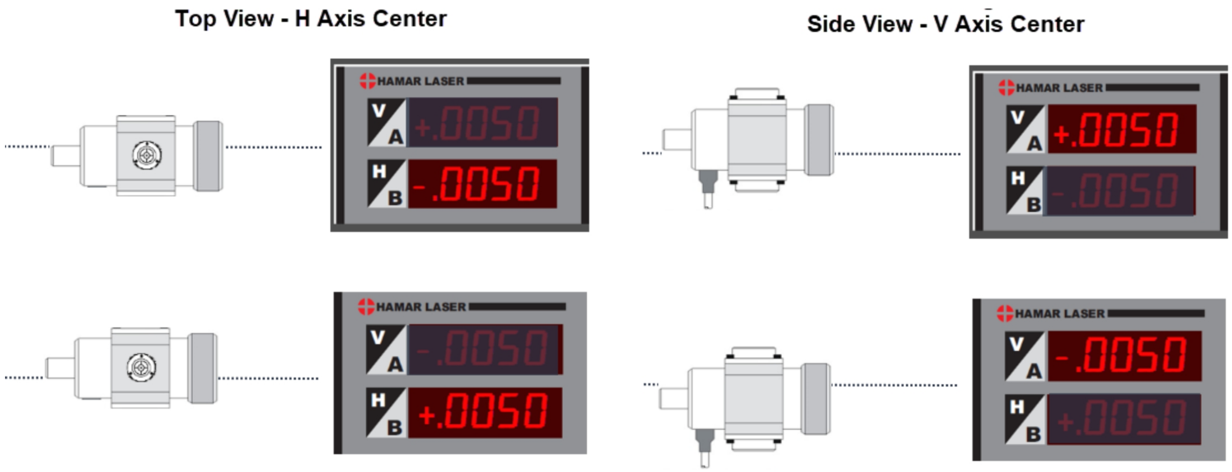
HLI PART NUMBER	LENGTH 'L'	BORE DIAMETER RANGE
51414-1	2.60 (60.04 mm)	6.500 – 9.250 (165.1 – 234.95 mm)
51414-2	3.97 (100.84 mm)	9.250 – 12.000 (234.95 – 304.8 mm)
51414-3	5.35 (135.89 mm)	12.000 – 14.750 (304.8 – 374.65 mm)
51414-4	6.72 (170.69 mm)	14.750 – 17.500 (374.65 – 444.5 mm)

Bore Diameter Range
A-514C Bore Adapter



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

Interpreting Target Data Signs (+, -)



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

The 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 6—*The A-514GL Leg Setting Gage*

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

Example: (see Figure 7)

1. To measure a 6 in. bore, each leg must be set to 3 in.
2. Set the caliper to read 3.000 in.
3. Twist the locking nut on the caliper so it does not slide, then insert the caliper inside the hub on the leg setting fixture.
4. Slide the leg setting gage into position and tighten the bolt using the Allen wrench provided.
5. Slide the bore adapter over the hub and place the stop pin in the desired hole.
6. Turn the bore adapter so it's up against the stop pin and slide the leg out so it rests against the leg setting ceramic plate.
7. Tighten the bolts with a 7/64 Allen wrench.
8. Remove the stop pin and turn the bore adapter one more time, replacing the stop pin. Repeat the process for the next leg.
9. To set the remaining two legs, the bore adapter must be removed from the hub and flipped. 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 not important since the bore adapters can handle a small range of diameter changes (typically ± .010 in. to .025 in., depending on the adapter size). The most important part of the process is to ensure the legs are the same length, which is done with the Leg Setting Gage. Iif 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.*

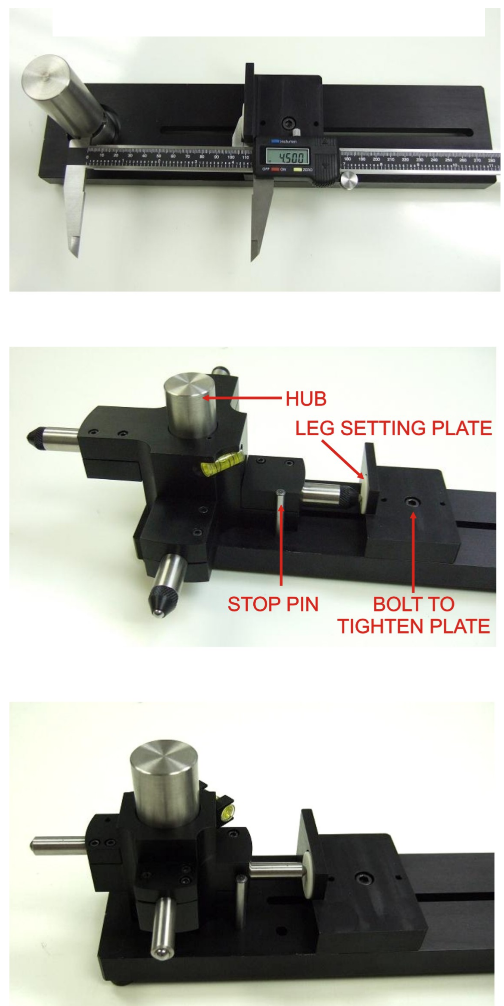


Figure 7 – *Setting the legs for the A-514GS*

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

The large leg gage 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 8)

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 10.

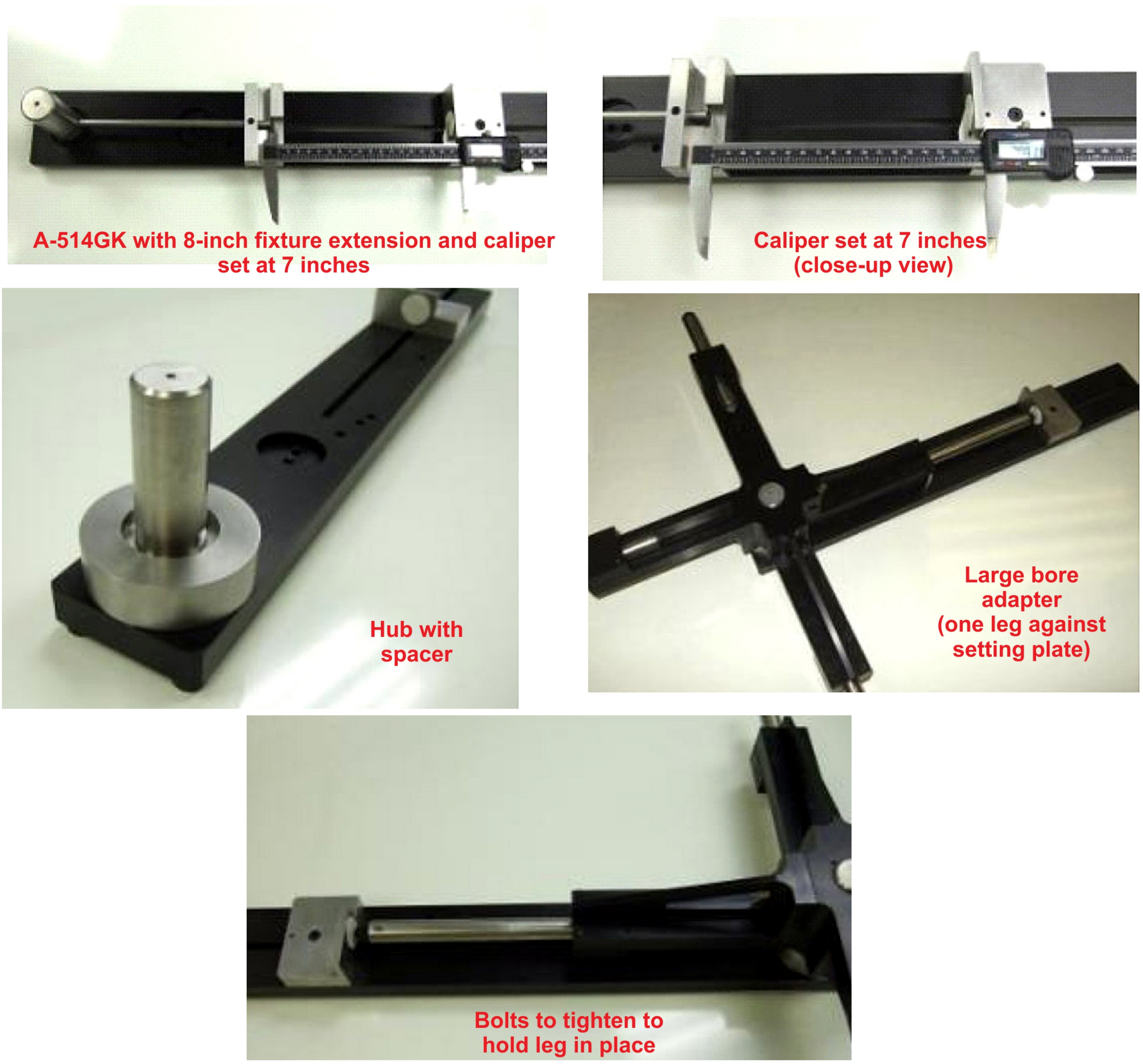


Figure 8 – *Setting the legs for the A-514GL*

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

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.

Figure 9 – *T-218 2-Axis See-Through Target*

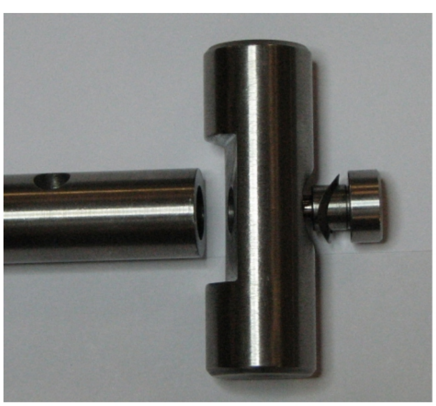
The T-218 Target includes a 10x10 mm PSD (position sensing device). It can be used with Hamar Laser's Bore Alignment Lasers, such as the L-700, L-705, L-706 and L-708 and is compatible with the R-1307 series of readouts, Hamar Laser alignment software and the T-230 Target Stand.

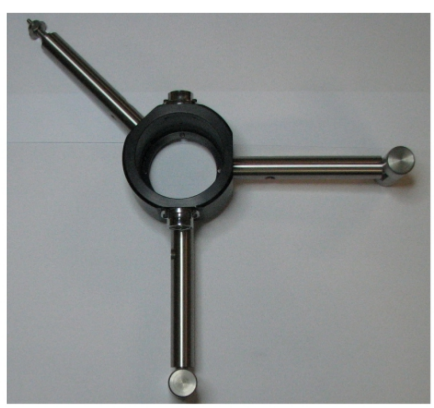
For bores over 1 m, half-bores, or where bore surfaces are worn or rough, the T-218 Target is used with the T-225L Large Bore Flange.

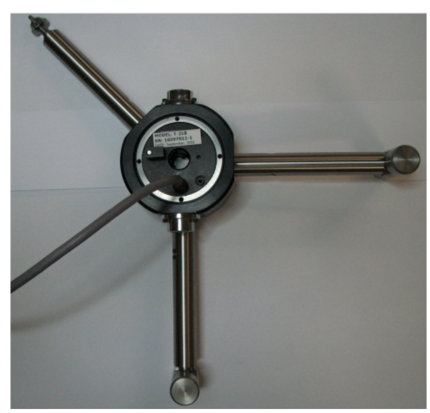
Figure 10 – *T-255L Large Bore Flange with T-218*

Assembling the T-225L for Use with the 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 45). For fabrication instructions, see Appendix E on Page 46.
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 45) into the third customer-fabricated Jam Rod and attach to the third screw location at 10:30 (see Appendix D, Note 2 on Page 45).







The Model R-1307 Readouts

As with all of our laser alignment systems, the 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 in order to use the system. However, for those who want to document the alignment and produce a report, there is no easier bore alignment program to use than 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 11 – *R-1307 Readouts*

Note: *Below is a brief description of The Model R-1307C and Model R-1307-900/2.4 and R-1307-2.4ZB. For detailed information and instructions for your specific model, please see Hamar Laser's R-1307 operations manual.*

Model R-1307C

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

Figure 12- *R-1307KS Readout Stand*

Model R-1307-900/2.4 and R-1307-2.4ZB

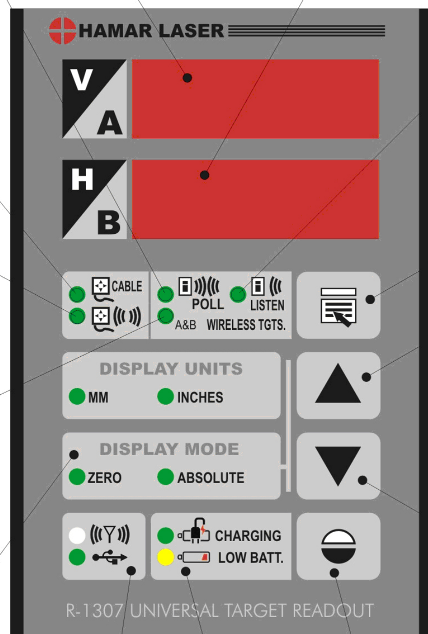
- Supports both wireless targets or cabled (local) targets
- Supports both pulsed-beam and continuous laser modes
- Radio frequency available in either 900 MHz or 2.4 GHz ISM band
- Can also be used as an additional readout to receive data alignment data transmitted from another R-1307 unit in master (poll) mode.
- The R-1307-2.4ZB can be used with the A-910-2.4ZB Computer Interface to perform as a wireless readout.

Figure 13 – *A-910-2.4ZB Computer Interface*

Model R-1307 Readout -- Control Panel

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

LOCAL TARGET INDICATOR
ON : READOUT IS SET TO DISPLAY DATA FROM A TARGET CONNECTED TO THE LOCAL PORT

LOCAL TARGET RADIO LINK INDICATOR
ON : READOUT IS SET TO RELAY LOCAL TARGET DATA TO ANOTHER MASTER READOUT OR PC RADIO TRANSCEIVER

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

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

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

MENU BUTTON

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

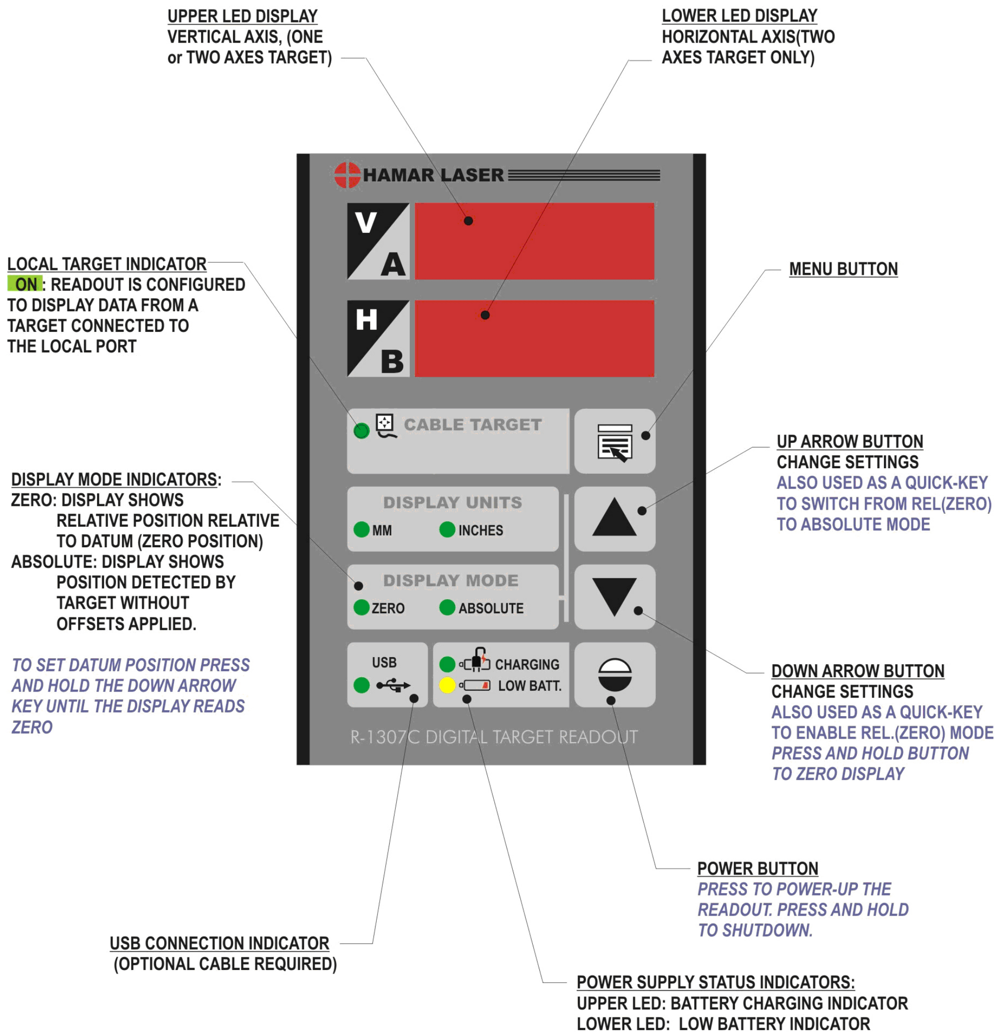
DOWN ARROW BUTTON
CHANGE SETTINGS
ALSO USED AS A QUICK-KEY TO ENABLE REL.(ZERO) MODE
PRESS AND HOLD BUTTON TO ZERO DISPLAY

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

Model R-1307C Readout -- Control Panel



Configuring the R-1307 or R-1307C for a Local Target

Before connecting and configuring a readout, make sure to mount the3 laser and install the target.
Note: *Shut off power to the readout before connecting or disconnecting a target from the local port.*

1. **Connect the cabled target to the local port of the readout, as shown in Figure 14.**
   Refer to the R-1307 and R-1307C Control Panel drawings for the control panel buttons and indicator functions applicable to your unit or to the R1307 manual for menu settings and further information.
2. **Set the Measurement Units**
   Press the MENU button until the upper display shows Unit:_ Use the UP and DOWN arrow keys to select either inch for inches or mm for millimeters.
3. **Set the Dampening Level**
   Press the MENU button until the upper display shows AvG:. Use the UP and DOWN arrow keys to set the number of averages. Four (4) is the default setting. Adjust this value as required to suit the application.
4. **Set the Readout Function to Local Target**
   Press the MENU button until the upper display shows FUnct:. Use the UP and DOWN arrow keys to select FUnct: LOCAL.
5. **Select the PSD descriptor applicable to your target.**
   Press the MENU button until the upper display shows tGt: nn. Use the UP and DOWN arrow keys to select the Target Number. Refer to the R-1307 manual for more information regarding PSD descriptors.

The following is applicable to the R-1307 only:

To make the unit visible to all other radio-enabled devices, you must set the Target Network ID and the System ID for the readout.

1. **Set the Local Target Network ID**
   Press the MENU button until the *upper* display shows id_: nn with the current Target ID (nn) blinking. Use the UP and DOWN arrow keys to set the Target ID (the default is 01).

   Press the MENU button again until the lower display shows id_: nn with the current Target ID (nn) blinking. Use the UP and DOWN arrow keys to set the Target ID to the same value as that of the upper display's Target ID (the default is 01).

   The upper display will show the vertical (Y) axis position of the local target.
   The lower display will show the Horizontal (X) axis position of the local target.
2. **Set the System ID (Radio Channel)**
   Press the MENU button until the upper display shows ch_: nn, with the current System ID (nn) blinking. Use the UP and DOWN arrow keys to set the System ID (the default is 01).

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.

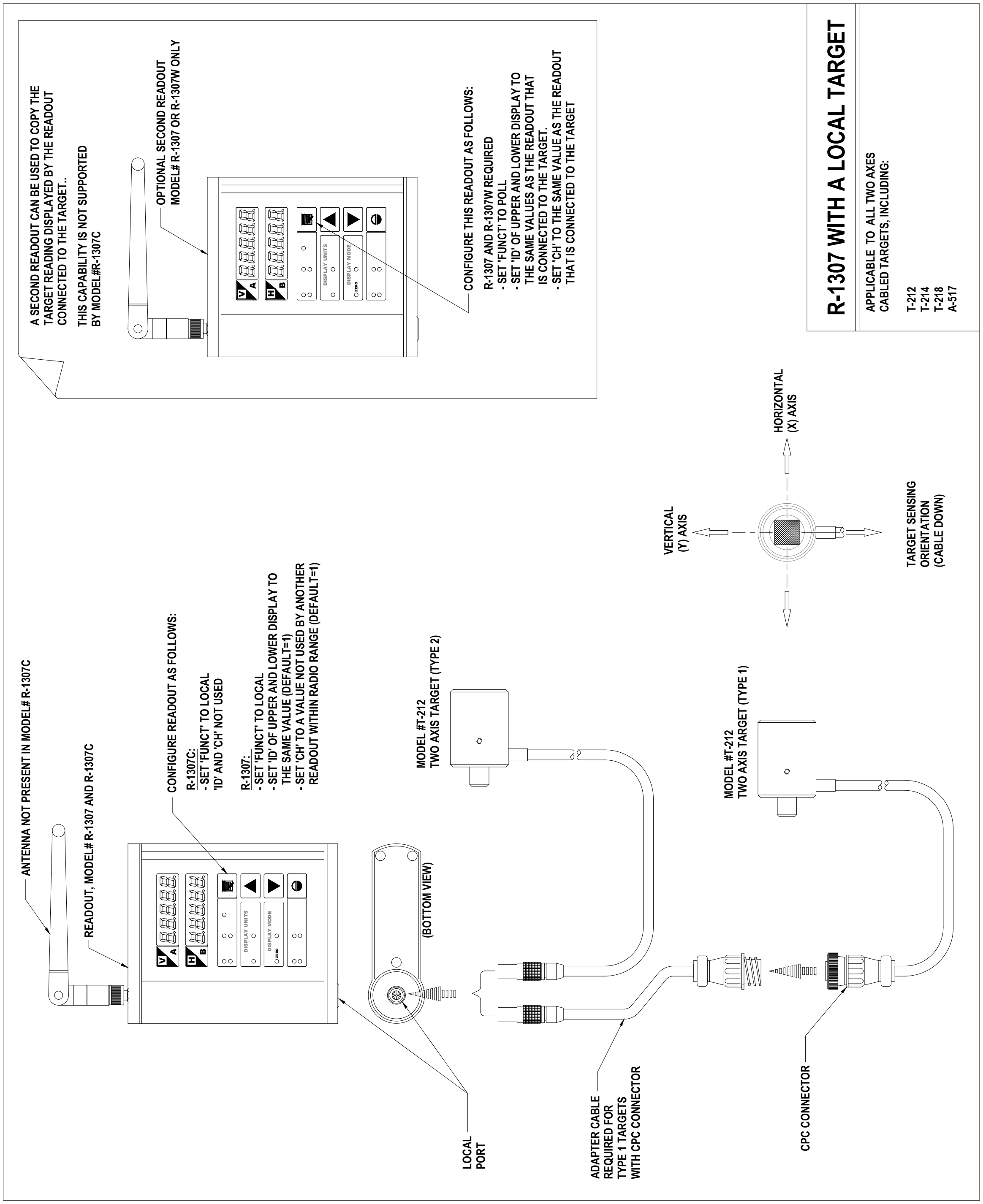
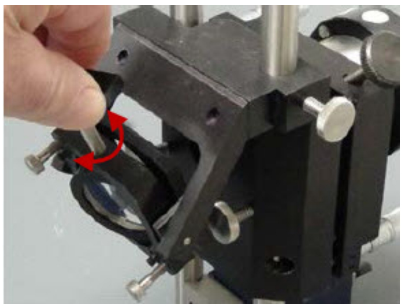


Figure 14 -- *Connecting a Local Target to the R-1307*

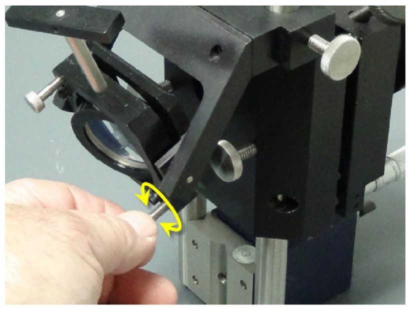
The L-111 Laser Stand and L-102 Laser Beam Translator

The L-706 Laser can be used for applications up to 110 ft. (33 m). The fine-adjustment micrometers can steer the laser beam in the horizontal and vertical axes to .001 in. (0.03 mm) in 110 ft. (33 m). It can either be mounted in customer-supplied fixturing or used with our L-111 Laser Stand and L-102 Laser Beam Translator to be mounted outside the bore. The L-111 and L-102 have coarse angular and fine centering adjustments to align the beam to reference bores, as shown below.

How the L-102 Beam Translator Works

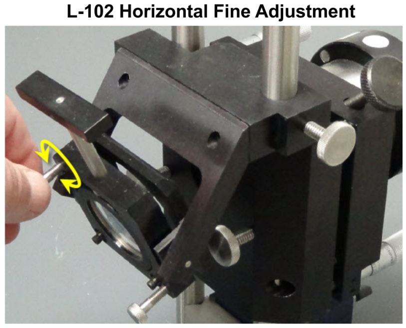


L-102 Horizontal Coarse Adjustment

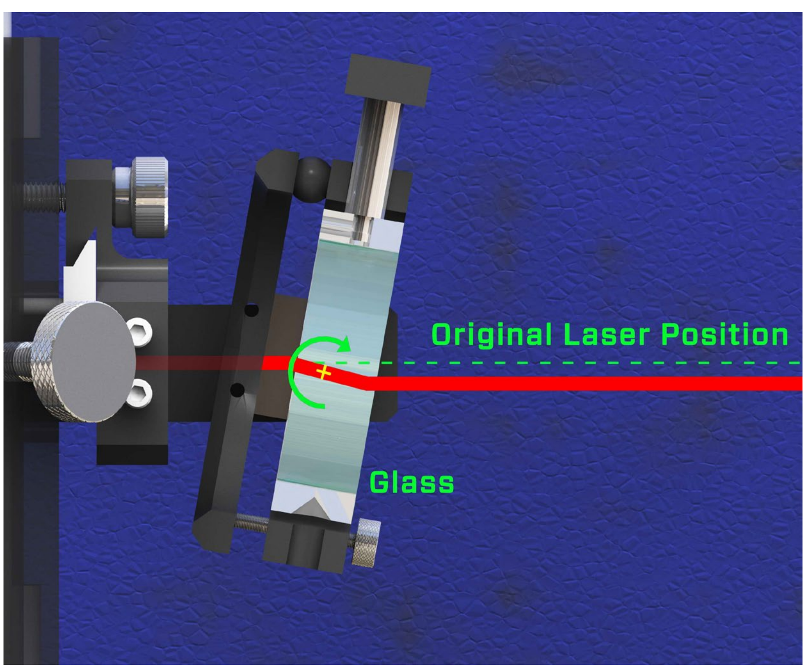


L-102 Horizontal Fine Adjustment

L-102 Vertical Coarse Adjustment



L-102 Vertical Fine Adjustment

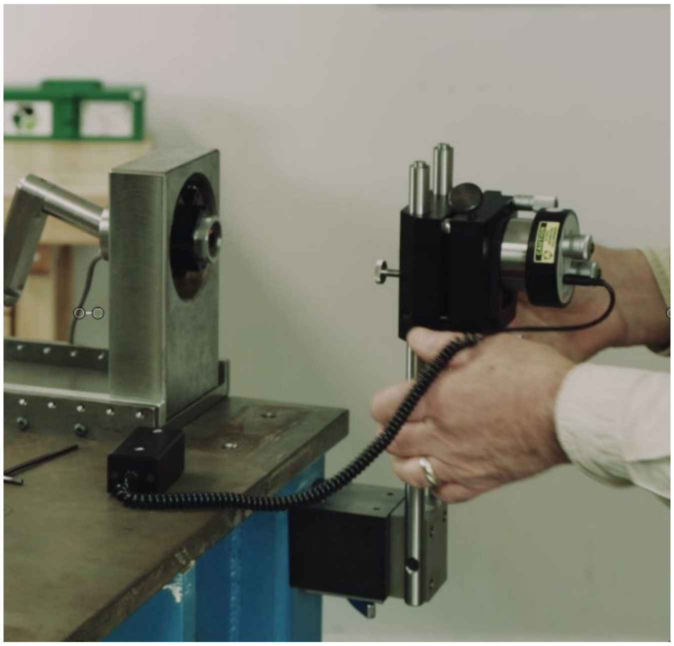


The L-102 Beam Translator moving the beam without angle to center it in the bore.

How to change the L-111 from a Horizontal Surface to a Vertical Surface

The L-111 has two mounting orientations: one for horizontal surfaces (shown left), and one for vertical surfaces (shown right), such as bore or gearbox flanges.

L-111 with L-706 in Horizontal Mount Mode

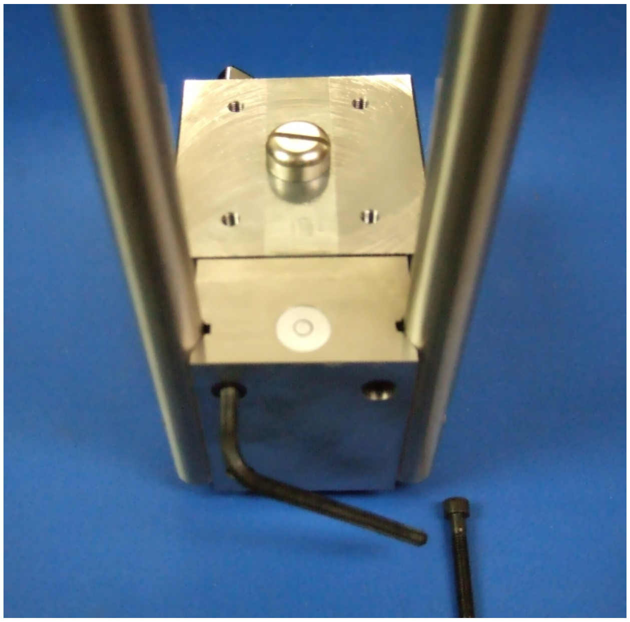


L-111

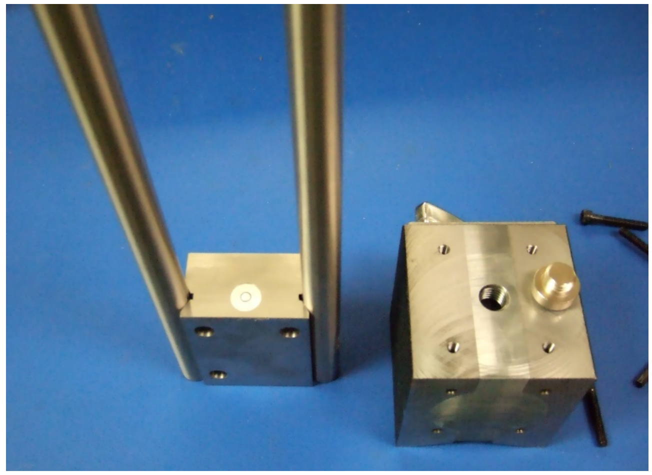
with L-706 in Vertical Mount Mode

The following steps allow a user to change the L-111 from Horizontal Mount Mode to Vertical Mount Mode.

1. Using the provided Allen wrench, remove the three bolts that hold the L-111 stand to magnetic base.

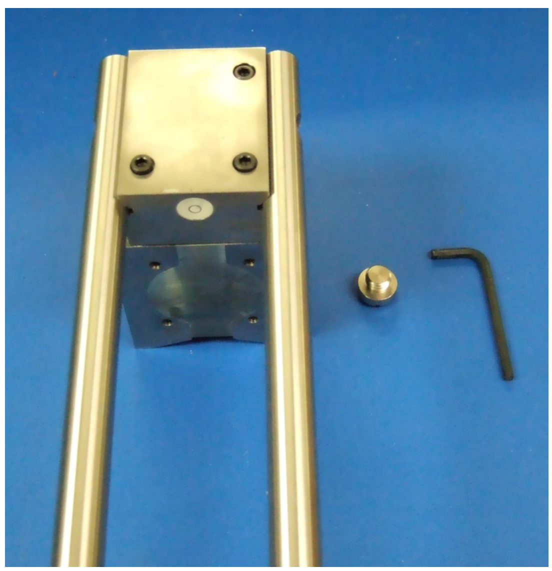


2. Using a screwdriver, remove the large magnetic base dustcover screw. On top of the magnetic base you will see the four attachment screw holes, however, you will only use three screws to attach the bracket to the magnetic base. This is a kinematic mount that stabilizes the laser base for accurate and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



3. Attach the L-111 mounting block to top of the magnetic base, making sure that the level vial is facing opposite the magnetic base switch. Make sure to tighten the bolts very tight to ensure there is no movement in the block when being used.

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

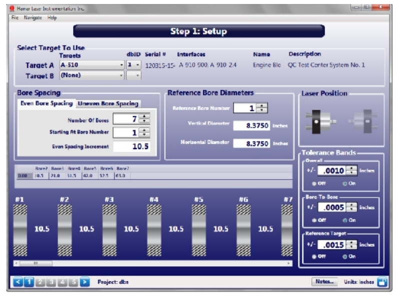


Bore9 Software

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.

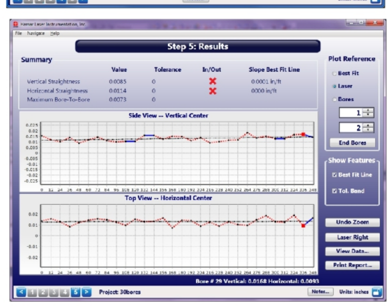


- In **Step 2 - Target Mounting Error**, an easy procedure is followed to remove mounting errors. Mounting errors must be compensated for in order to achieve accurate results in bore and spindle work. Bore9 uses the NORMIN method developed by Hamar Laser to quickly and precisely cancel out these errors 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 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 15).
2. Insert the laser into the L-111 Stand with the level on the top, centered from left to right (see Figure 16).
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.

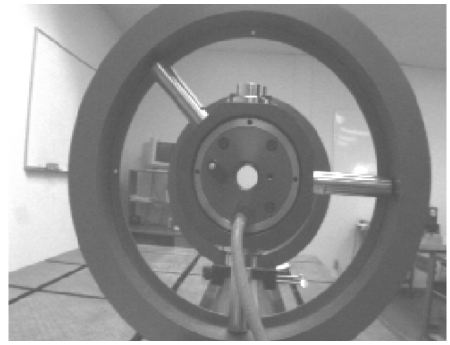


Figure 15 -- *Bore Target in the NORMal position (target cable trailing downward from the bottom of the target).*

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, (see Page 6) 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.

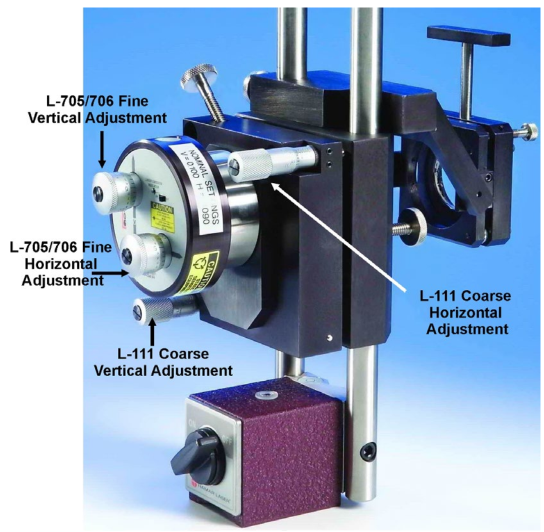


Figure 16 – *L-706 Laser and L-102 Beam Translator on L-111 Laser Stand*

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 15).
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 6) 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 17). Write down the **V** and **H** readings (INverted).

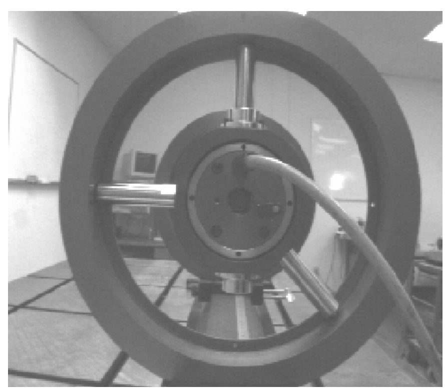


Figure 17 – *Bore Target in the INverted position (target cable trailing downward from the top of the target).*

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.
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 mid-point 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 16) 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 18) 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 Bores*. The laser is now aligned (bucked-in) to the two end bores.

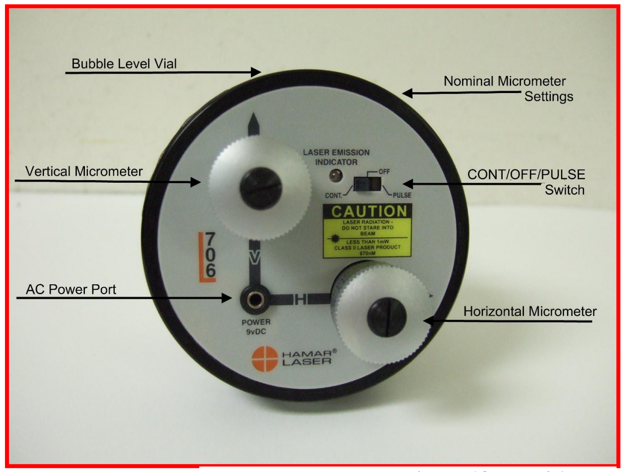


Figure 18 – *L-706 Laser*

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 43).*

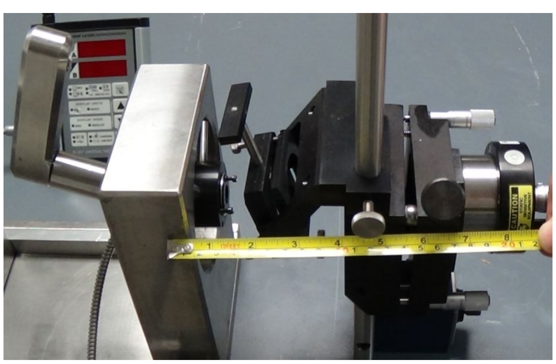


Figure 19-- *D1 Distance Measurement: Center L-111 posts to mid-point of the target in* ***Near Bore***

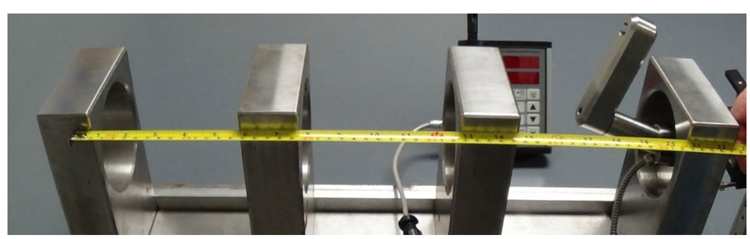


Figure 20 – *D2 Distance Measurement: Mid-point of target in* ***Near Bore*** *to center of target in* ***Far Bore***

Taking a measurement for each inner bore

1. Take a reading on the near target with the target in the normal position (see Figure 15). Write down the **V** and **H** Readings (NORMal).
2. Invert the target and take another reading (see Figure 17). 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 38).

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:

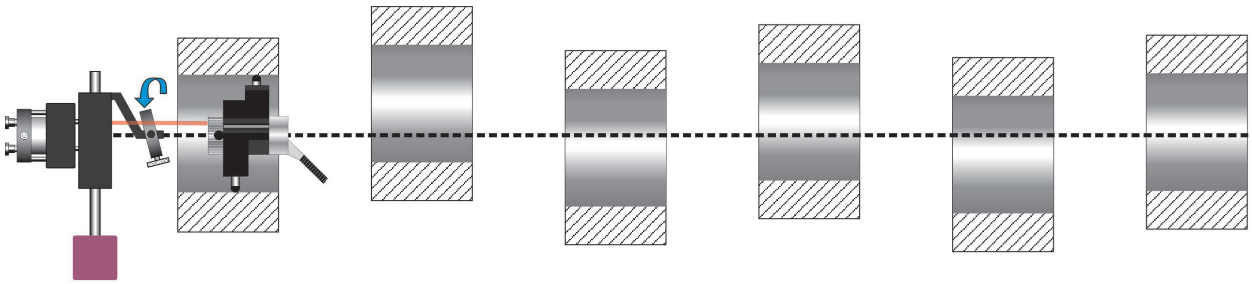
Formula: -1*(D1/D2)*Target Set Point Far Bore (from Step 19)

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**

Bore Alignment Using the A-512 Target/A-514 Bore Adapter

To perform alignments, the laser is mounted in the L-111 Laser Stand and the L-102 Laser Beam Translator is attached. The L-111 has coarse angular adjustment capabilities and the L-102 can translate (move) the laser beam up/down and left/right without changing the angle.



The entire assembly is then mounted near the first reference bore. The A-512/A-514 target/adapter is placed in the first bore and the L-102 Beam Translator is adjusted to center the laser beam to the target. The target is then moved to the *Far* reference bore and the angular adjustments are used to tilt the laser to the center of the target. This process is repeated until the target reads zero at both locations. The laser is now parallel to the end reference bores and the target can be moved to (or a second target can be placed in) the inner bores for alignment checks. Since the laser provides live data, any alignment errors can be adjusted and the user can watch the readings update live in the readout.

Target fixturing can consist of a 3-legged, spider-type fixture with a flange adapter (T-225) or a 4-legged, self-centering adapter (A-514).

Measuring Bore Alignment

The A-512/A-514 target/adapter are then placed in the desired bore for measurement, and once it is properly centered, the readout displays the bore misalignment. To truly align a bore to a centerline, two sets of readings are needed: one in the front and one in the back of the bore. The average of these two sets of reading indicates how far off center the bore is relative to the reference bores. The difference between the readings is how much angle the bore has to the reference bore centerline. To align a bore, both ends of the bore must be adjusted to zero, an easy task given that the readings from the target are live.

High-Tolerance Bore Alignment

For high-tolerance bore alignment applications, the remaining target sensor concentricity error (TSCE) must be calculated using the NORMIN method (see Appendix A on Page 38). TSCE is calculated by taking two readings, one with the target at the 12 o'clock position and a second at 6 o'clock (horizontal and vertical calculations are done separately). The second reading is added to the first and the result is divided by two. This is the TSCE and shows how far off the center of the target is from the center of the bore. This calculation creates an offset that can then be subtracted from all subsequent bore measurements to get the true misalignment number. Our Bore9 software can easily calculate TSCE and even automatically remove it from the displayed reading.

Measuring Bore Diameters

To measure bore diameters by performing calculations manually, see *Appendix B – Calculating Bore Diameters* on Page 40. To measure bore diameters using our Bore9 software, please see the Bore9 manual.

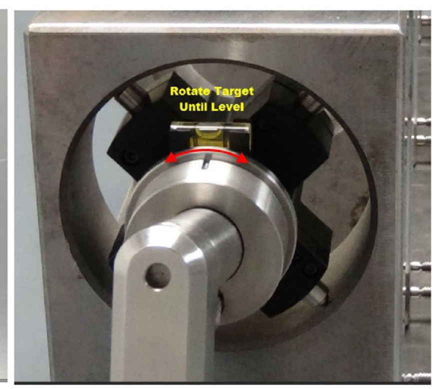
Bore Alignment Using the L-111/L-102 and A-512/A-514

Two Point Buck-In Procedure

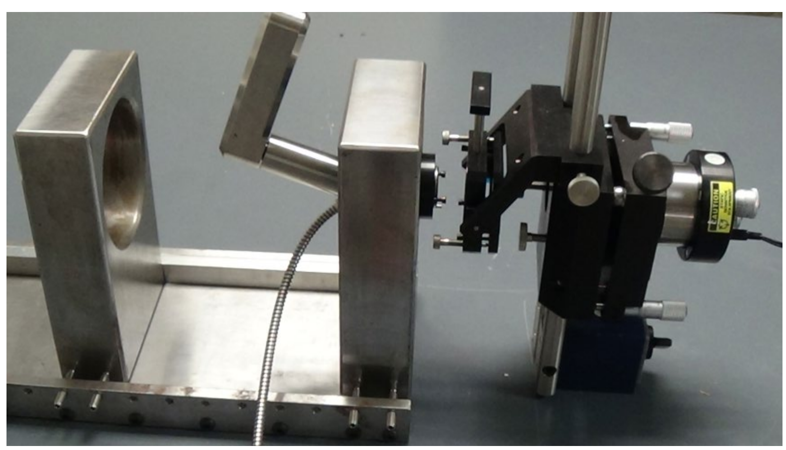
Step 1: Insert the Target in the *Near* Bore
Measure the nominal bore ID. Use the A-514G Leg-Setting Gage to set the legs of the A-514 Bore Adapter to the nominal bore ID (see Page 11 for a detailed procedure on how to set the legs). Insert the target mounted in the self-centering adapter into the *Near 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
Insert the laser into the L-111 Stand with the level on the top, centered from left to right.



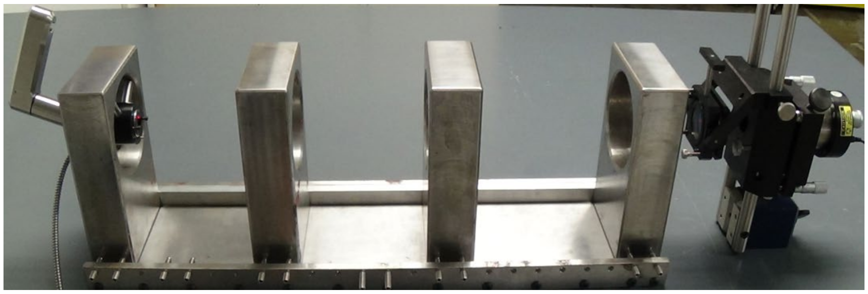
Step 3: Position the L-111 Assembly
Position the L-111 assembly as close to the near reference bore as possible and power on the laser.



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.*

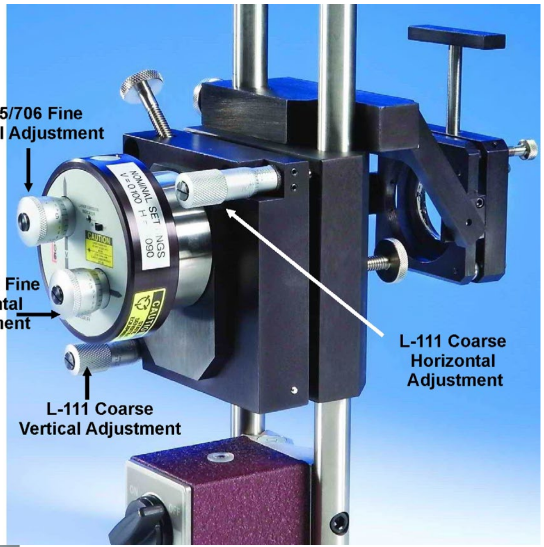
Unlock the magnet holding the L-111 assembly and slide the whole assembly left or right until the laser beam is *visually* near the center of the target. Turn the magnet back on.

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.

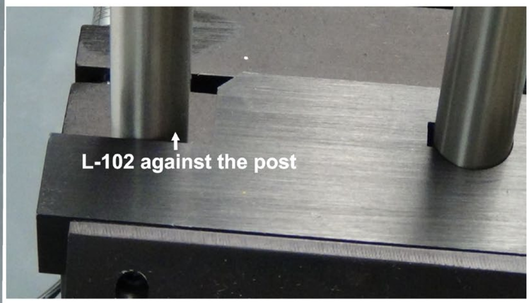


Step 6: Laser Rough-in -- Steer the Laser to the Center of the Target in the *Far Bore*
Using the long micrometers on the L-111 stand, steer the laser beam vertically and horizontally until it is *visually* near the center of the target (you do not need the R-1307 for this).

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

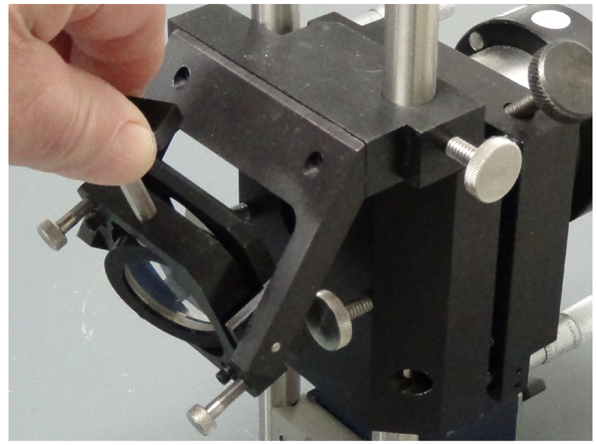


Step 7: Place the L-102 over the post of the stand
Ensure the L-102 is seated against the opposite post of the stand and tighten the thumb screw.



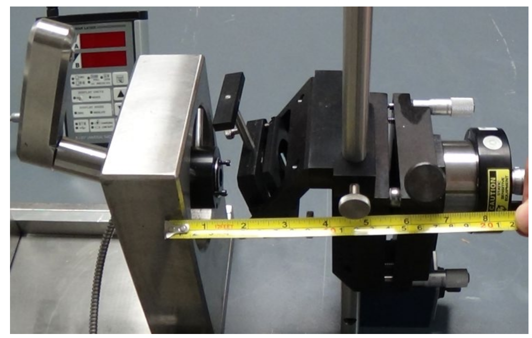
Step 8: Move the Target Back to the *Near Bore*

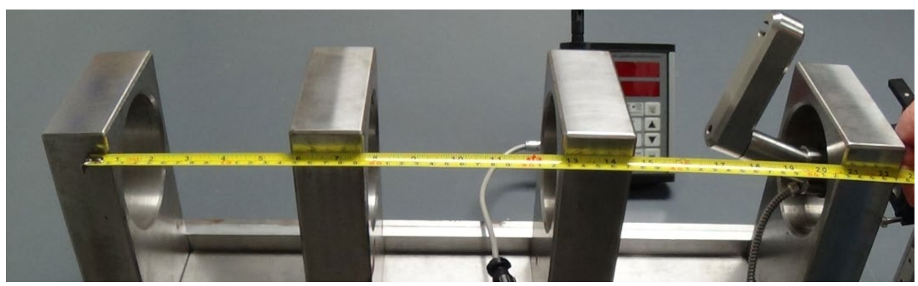
Remove the target from the *Far* reference bore and reinsert it into the *Near Bore*. Be sure to place the target in the *exact* location that it was in previously, with the cable at 6 o'clock. Plug the target into the readout and power on the readout. Using the coarse adjustment of the L-102 beam translator, adjust the laser beam until the readout displays less than .0015 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 43).



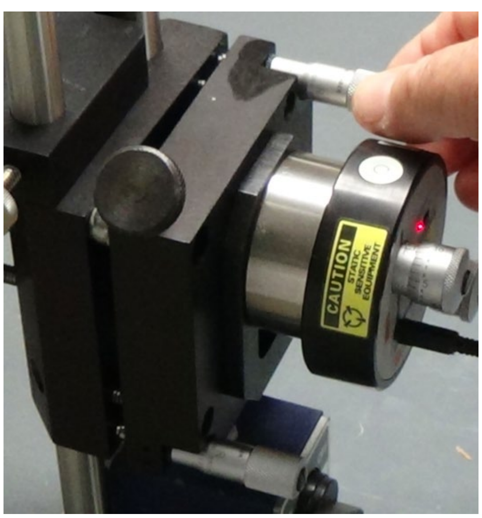


Step 9: Translate the Laser to .0000 in. in the *Near Bore*
Using the fine adjustments on the L-102 beam translator, adjust the laser beam until the readout displays .0000 in. (0.00 mm) both vertically and horizontally (see Page 19).

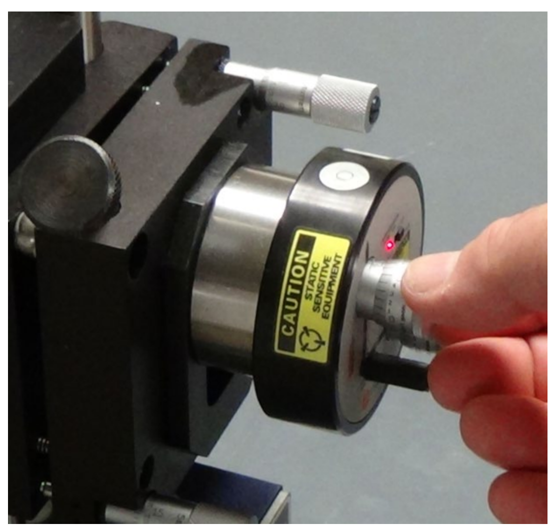
Coarse Adjust the L-102 **Fine Adjust the L-102**

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 micrometers on the L-111 stand, steer the laser beam until the readout displays less than .003 in. (0.05 mm).

Use the micrometers on the back of the laser (short 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 43.*



Coarse adjust the laser first using the long micrometer on the L-111 Stand. In this instance, the horizontal adjustment is being made.



Fine adjust using the short micrometer on the laser. In this instance, the vertical adjustment is being made.

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-111/ L-102/Bore9

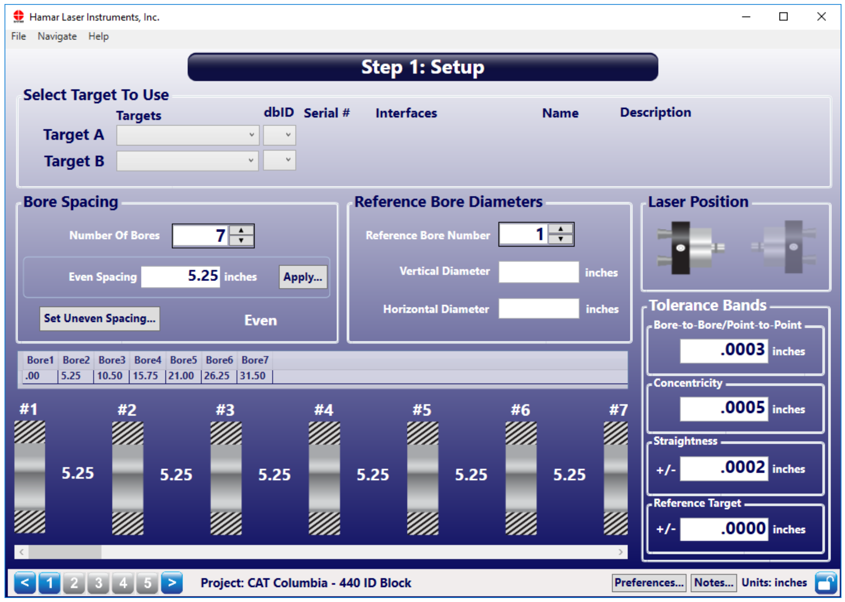
Note: *A visual buck-in (determining visually that the laser beam is near the center of the target without using the readout or the beam translator) should be done* ***before*** *attempting to buck-in using the readout and beam translator. The beam translator is limited to the amount it can shift the 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 43).

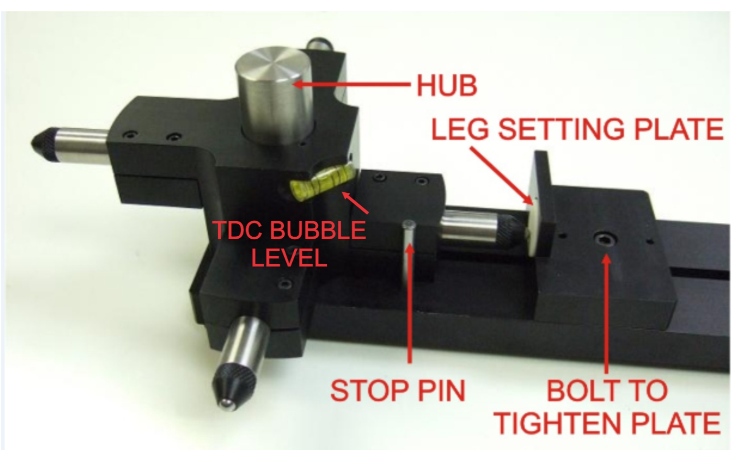
Step 1: Setup

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.

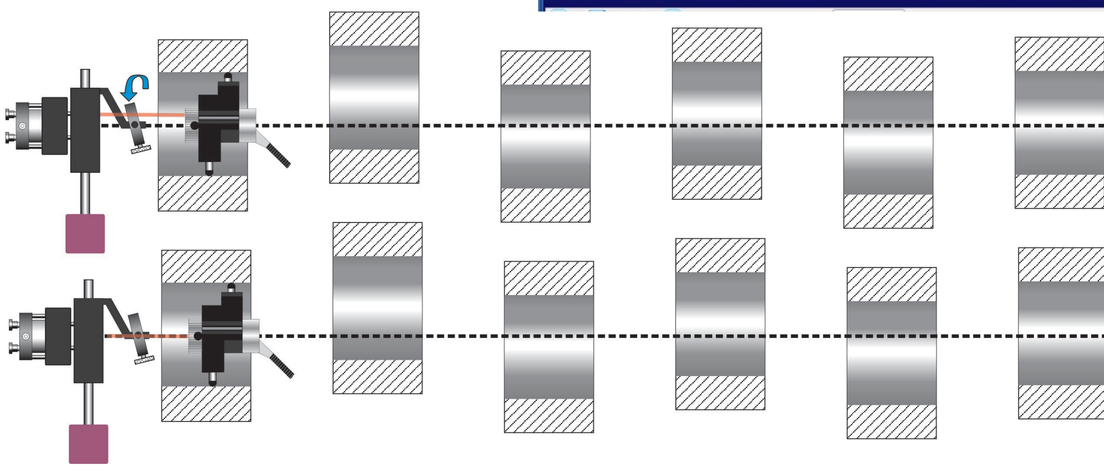


c. Measure the nominal bore ID. Use the A-514G Leg-Setting Gage to set the legs of the A-514 Bore Adapter to the nominal bore ID (see Page 11).

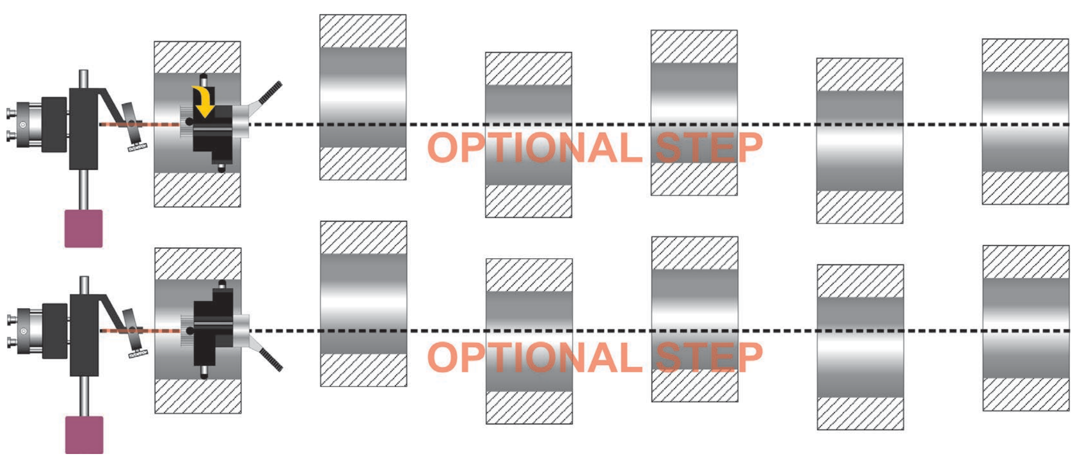


Step 2: Target Mounting Error

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).

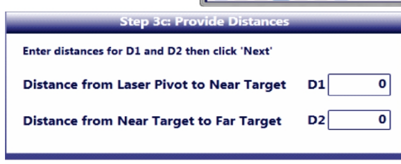


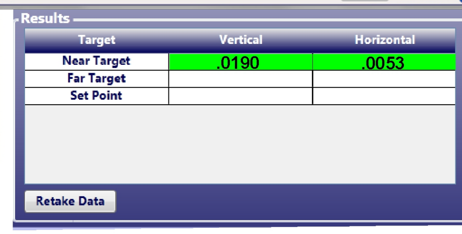
b. Press **Record** to record data for the target in the NORMal position. Rotate the target 180 degrees (INverted position) and reinsert into the *Near Bore*. Press **Record** to record data for the target in the INverted position. Rotate target 180 degrees again back to the NORMal position and reinsert 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).*

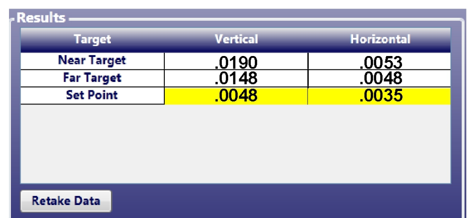


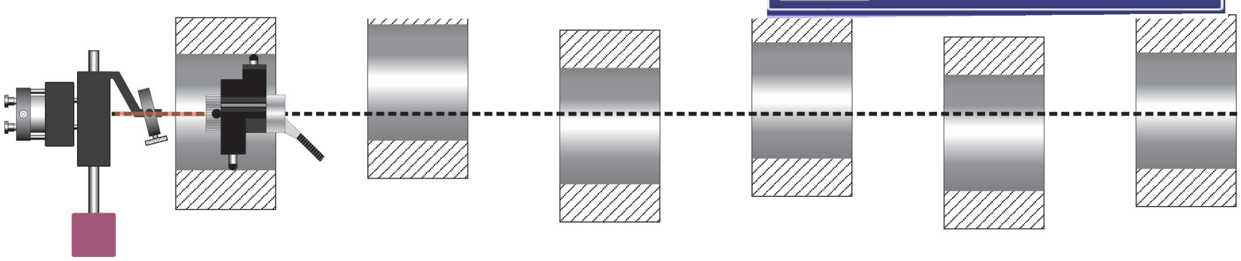
Step 3: Laser Buck-in

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). 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*.

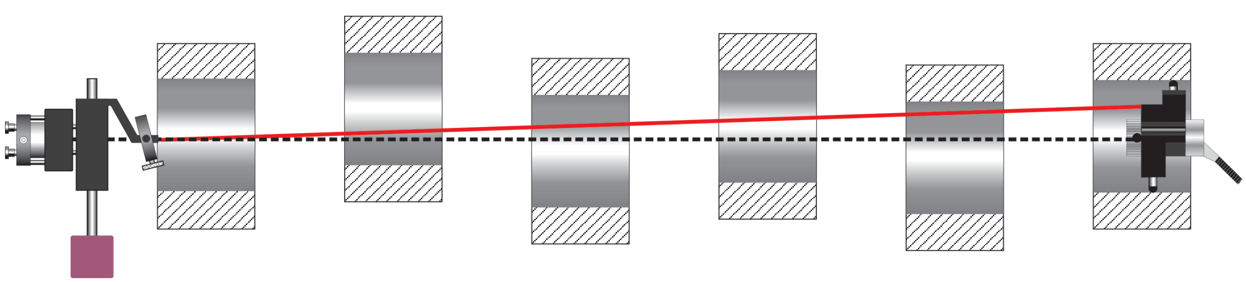




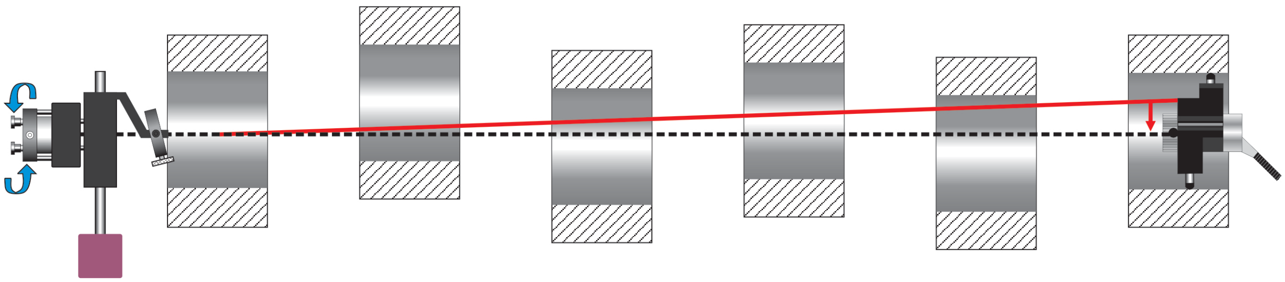




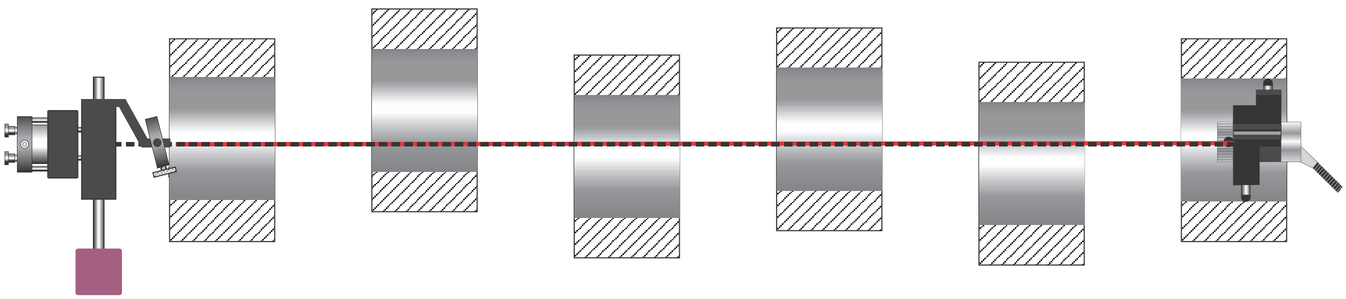
b. Move the target to the *Far Bore* and press **Record**. A calculation of the laser Set Point will be made to aid the laser setup and offsets will be applied to on-screen live data.



c. 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.

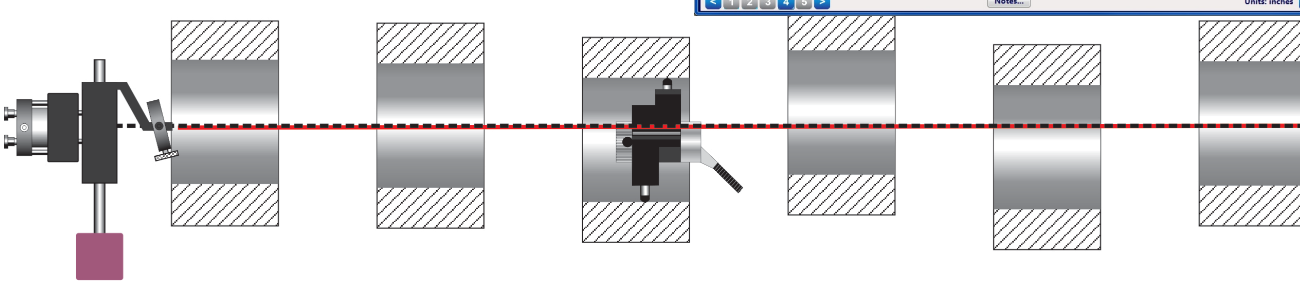


d. Repeat the process to confirm zero at both end bores. The laser is now "bucked in" (concentric) to the centerline of the near and far reference bores.



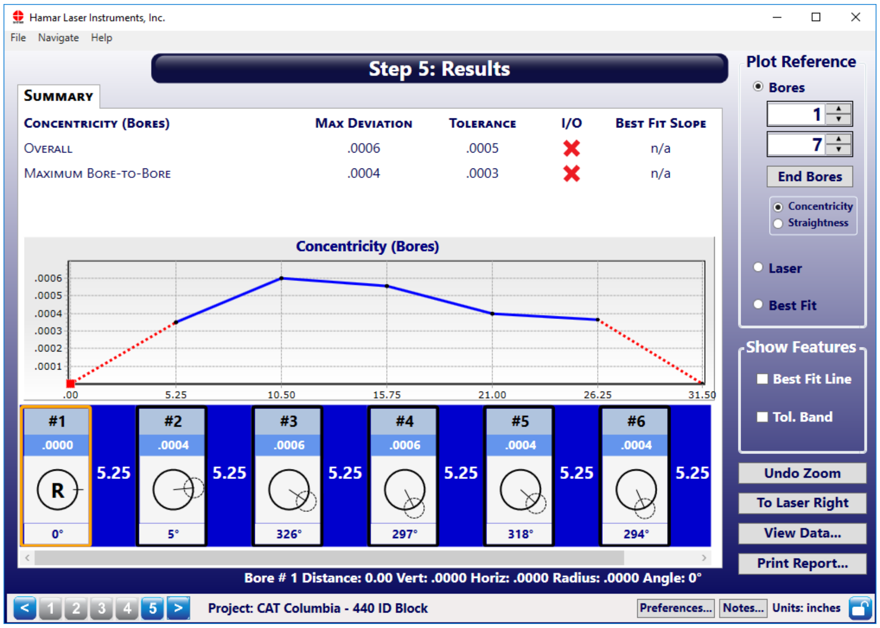
Step 4: Record Data

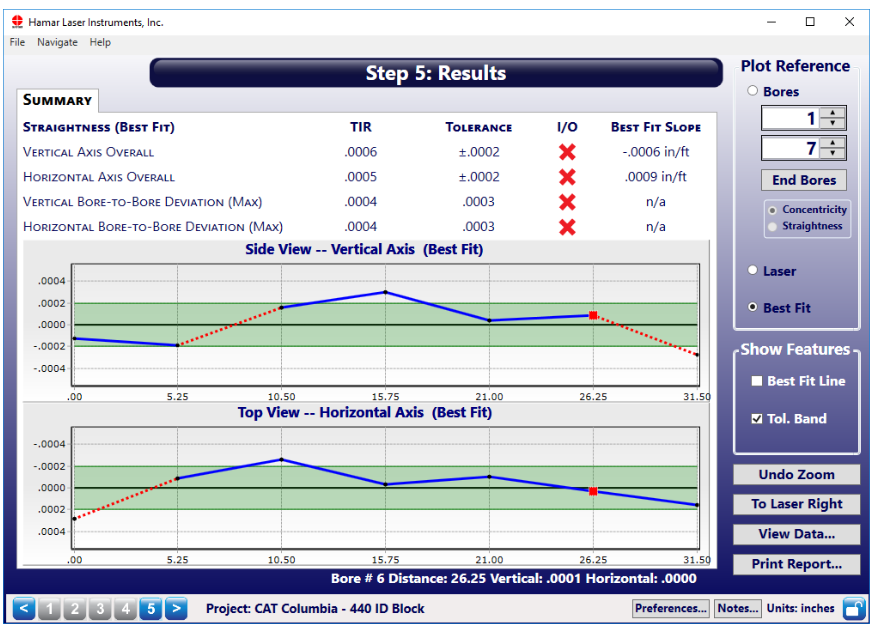
a. Move the target to the first bore you want to measure for alignment and press **Record**. Continue moving the target to each bore until all data is taken.



Step 5: Results

a. Step 5: Results displays 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.





Bore9 Sample Report

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:

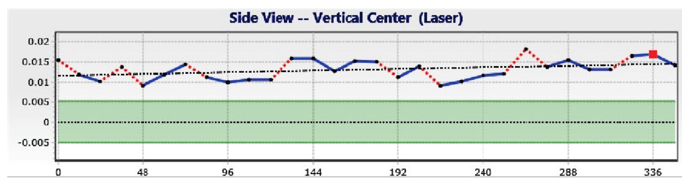
Alignment Results

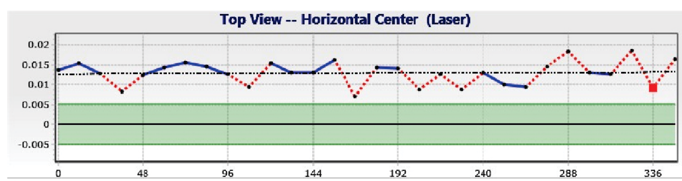
Alignment Check	Value	Tolerance (+/-)	BF Slope	Best Fit I/O	Plot I/O
Vertical Straightness (TIR)	.0085	.0051	.0001	✓	✗
Horizontal Straightness (TIR)	.0114	.0051	.0000	✗	✗
Vertical Bore To Bore (Max)	.0061	.0031		✗	N/A
Horizontal Bore To Bore (Max)	.0093	.0031		✗	N/A

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.

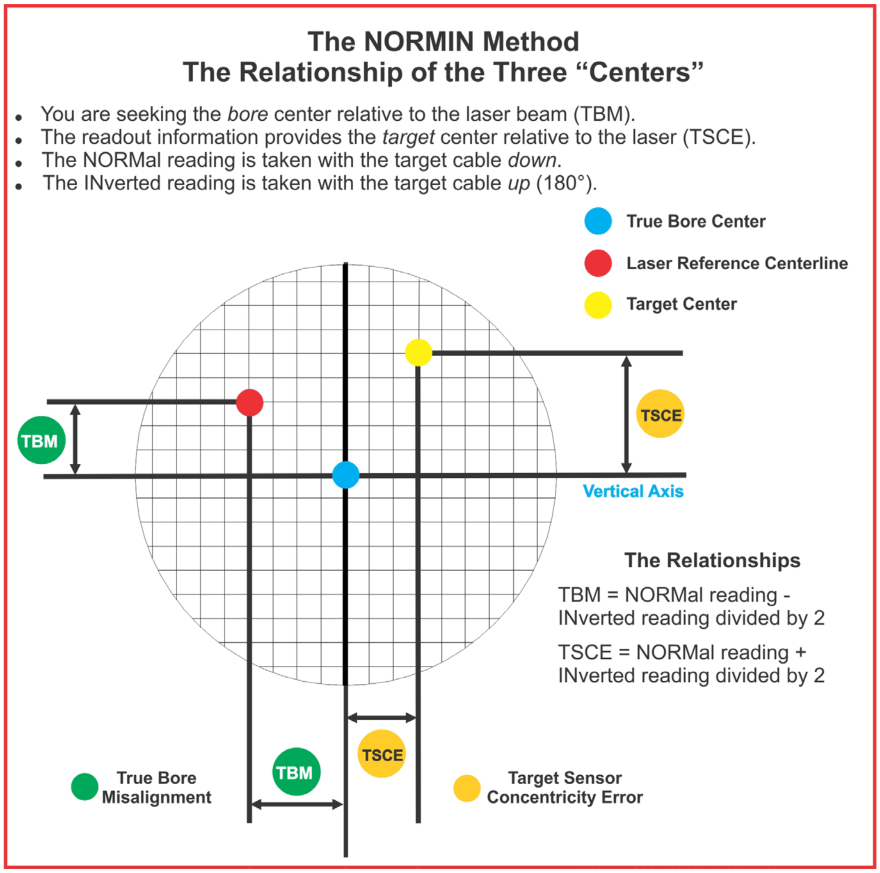


Figure 21 -- *Three centers of bore alignment*

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 21.

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 22 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.).

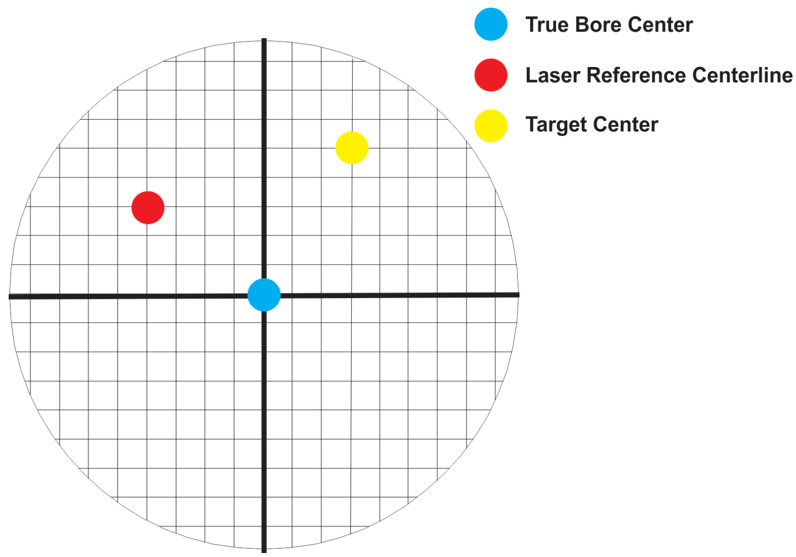


Figure 22 – *Target in the NORMal position*

Figure 23 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 23, 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.

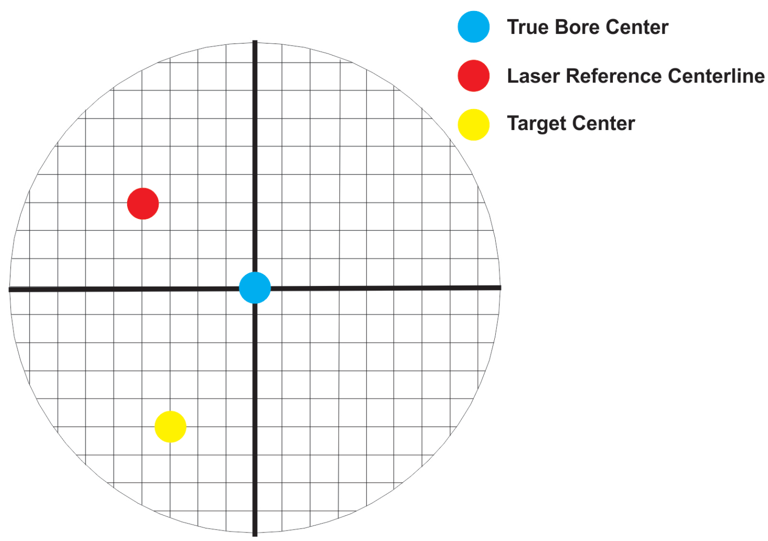


Figure 23 – *Target in the INverted position*

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:

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

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:

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

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				

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

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

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 25 on Page 42).

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 24 -- *Chart for Readout Data*

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

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

$$\text{Difference in Diameter} = \text{Reference Diameter} + ((\text{MDT} - \text{RDT}) \times 2)$$

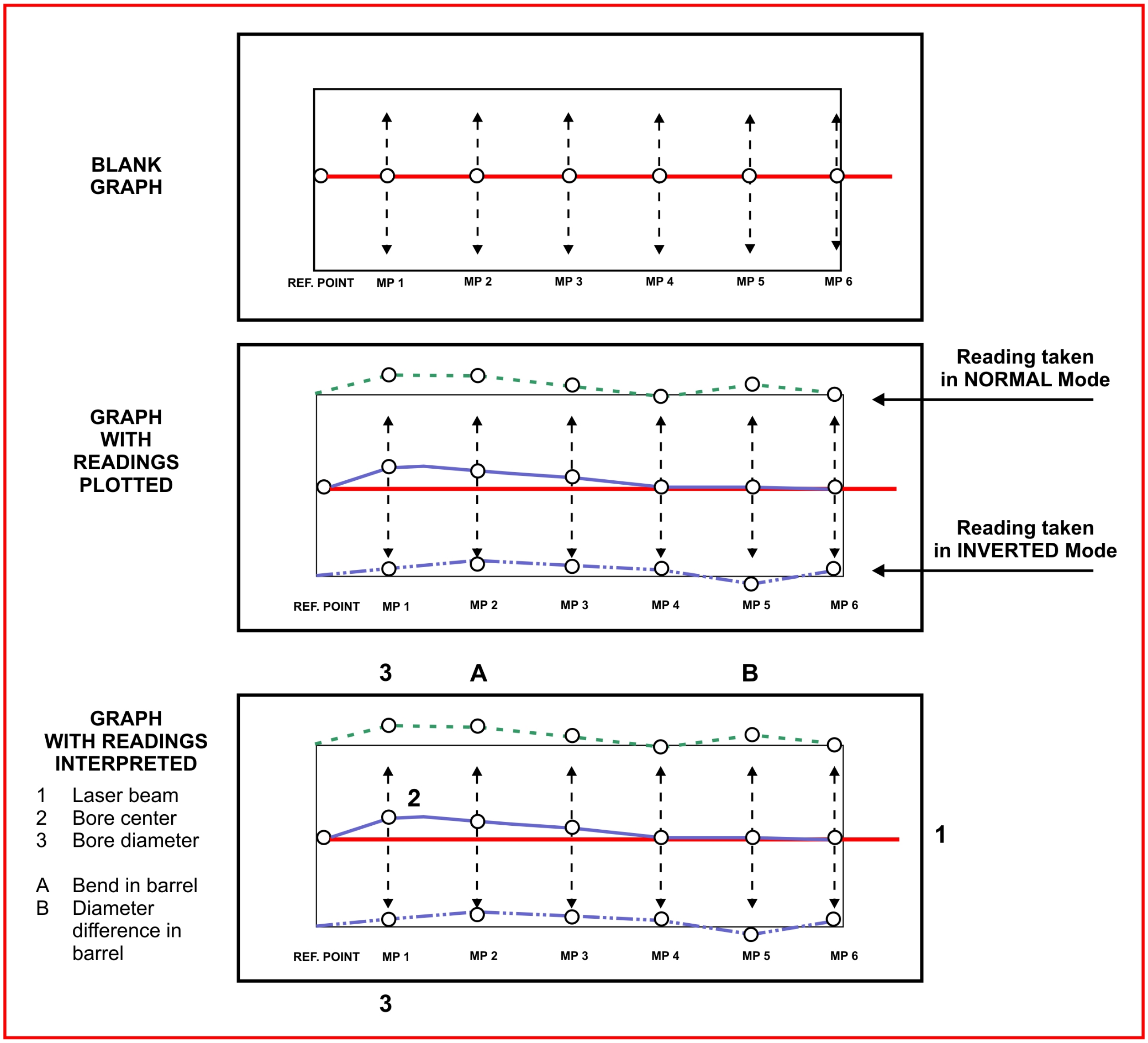


Figure 25 – *Sample plot of readout data*

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 26 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.

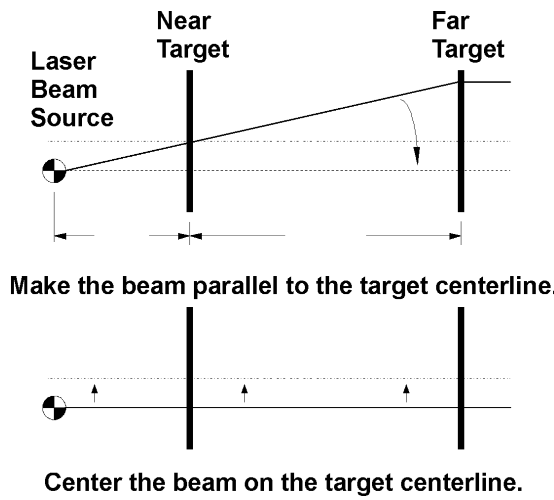


Figure 26 – *Remote Buck-in*

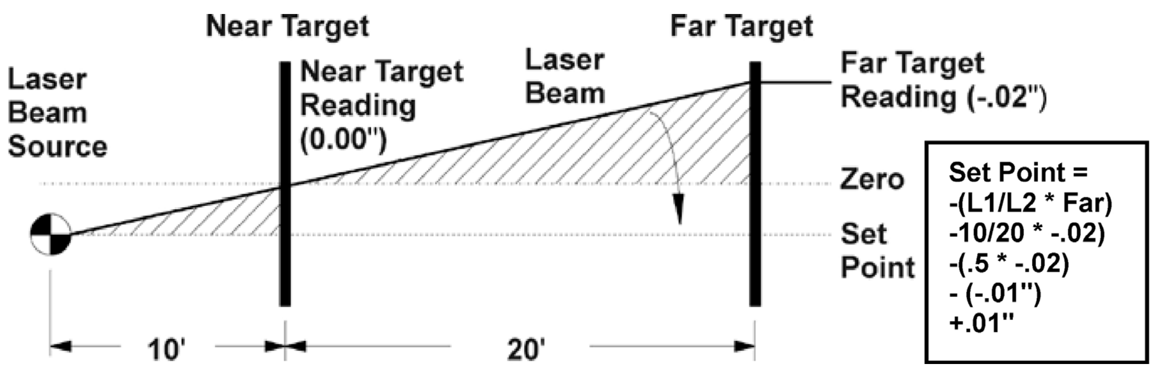


Figure 27 - *Calculating the Set Point*

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 27).

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 27 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 28 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).*

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).

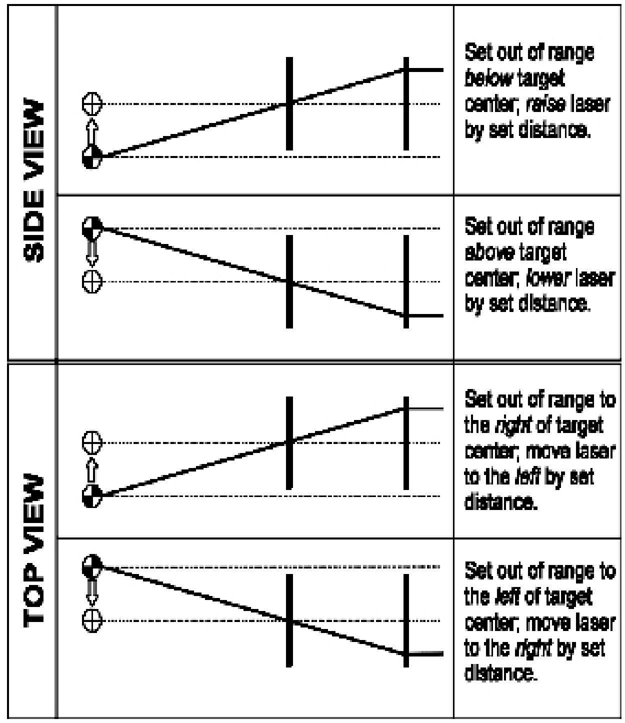
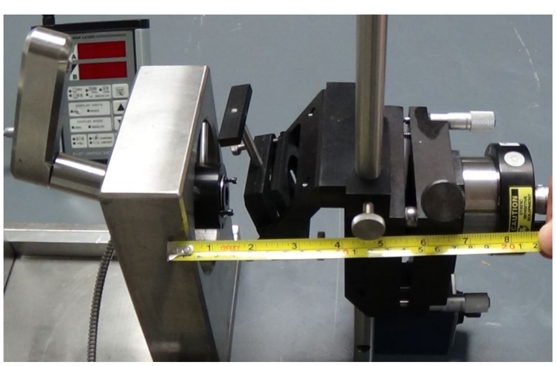
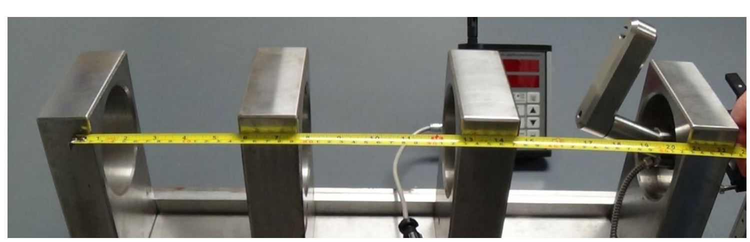


Figure 28 - *Moving the laser when the Set Point is out of range of the target cell*

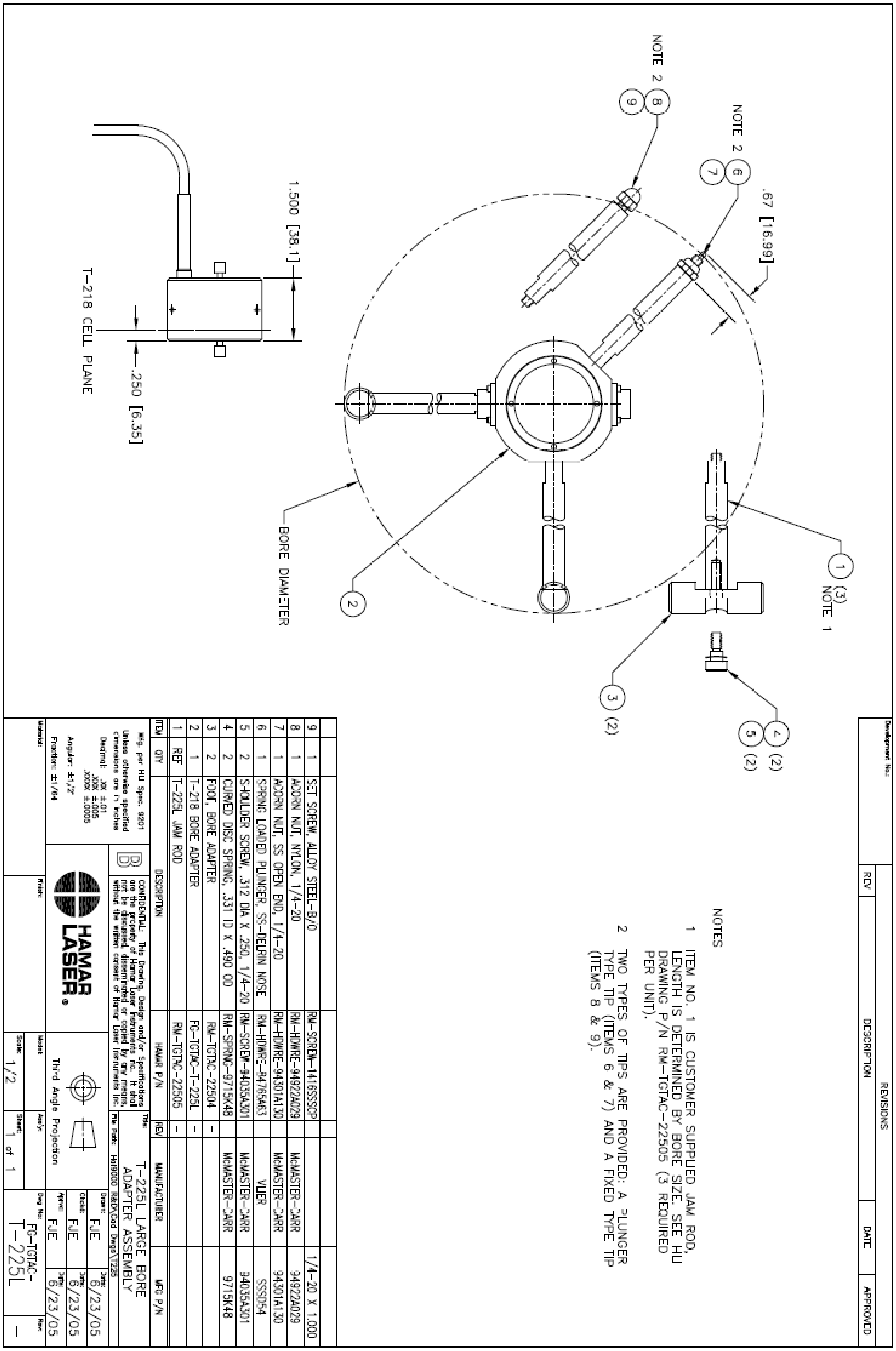
The determining factor for which method to use can be summed up as follows:

- 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.

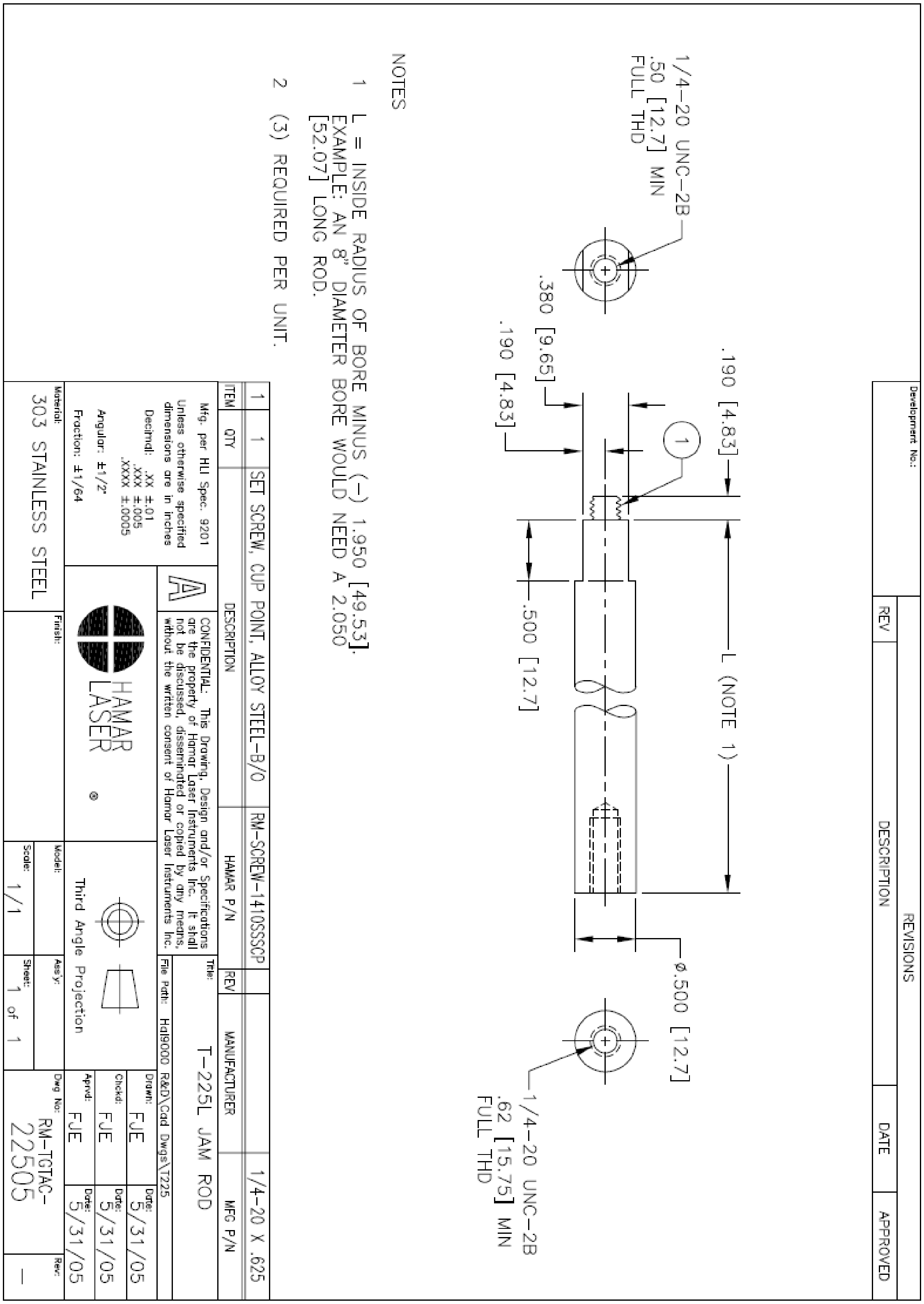




Appendix D – T-218/T-225L Dimensions (Model 3)



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 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.