Operations Manual

L-708/L-708LD
Laser Bore Alignment

February 2019

HAMAR LASER

HAMAR LASER INSTRUMENTS, INC.
www.hamarlaser.com

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

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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

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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 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 20.

Introducing the L-708 Laser Bore Alignment System

Hamar Laser's L-708 Laser Bore Alignment System is the most accurate, versatile and portable bore alignment laser system available. The system can be used for a variety of bore alignment and measurement applications, including engine block bearings, compressor bores, shaft bearing bores, and stern tubes. Misaligned bearing bores cause premature failure and require frequent replacement, more downtime and higher maintenance costs. Accurately aligned bores last longer and prevent bigger problems *before* they occur.

L-708 Key Features

- Adaptable to most bore applications
- Fast, easy setup using simple, self-centering adapters
- Set up and begin capturing alignment data in less than 20 minutes
- Measure straightness for bore diameters from 3.5 in. (86 mm) to 40 in. (1 m)
- Adjustable legs fit any bore diameter
- Leg Setting Gage centers adapters to .0005 in. (0.0075 mm)
- Live, "real time" data display with large color graphics
- Choice of standard LED readout or add a second readout to transmit readings wirelessly up to 200 ft. (61 m)
- Operational range up to 100 ft. (30.5 m) for the L-708 and 200 ft. (61 m) for the L-708LD
- Durable, rugged design

Hamar Laser's patented, self-centering target adapter technology simplifies the setup process and reduces setup time to minutes rather than hours. Setting up the system takes only 15 to 20 minutes and alignments are performed up to three times faster than those done with optical bore scopes or tight wires. Alignment data is real time, so misaligned bores can be brought into tolerance very quickly.

Briefly, the system setup process is as follows:

- The A-514 Bore Adapters are adjusted to the desired bore radius using the Leg Setting Gage.
- The L-708 Laser and A-512 Target are inserted into their Bore Adapters.
- The entire laser and target assemblies are inserted into the two reference bores, where they self-center.
- The laser's angular adjustment knobs are used to set/tilt the laser to zero on the target, establishing the reference bore centerline.
- With the laser now parallel to the end bores, the target can be moved (or a second target may be added) to inner bores for alignment checks.
- Since alignment data in the target updates in the readout automatically, any errors can be adjusted using the target as a live indicator.

The L-708 Laser Bore Alignment System Components

Model L-708 Laser

The L-708 Laser provides a straight reference line to which any bore can be aligned and measured. The laser mounts in an adapter, and the laser and adapter are then mounted in either two reference bores or in each end of a continuous bore. The laser projects a beam through the adapter and down through the inside of a bore toward the A-512 Target, which is mounted in the opposite reference bore. The laser beam is steered to zero on the A-512 Target, representing the centerline of the two reference bores.

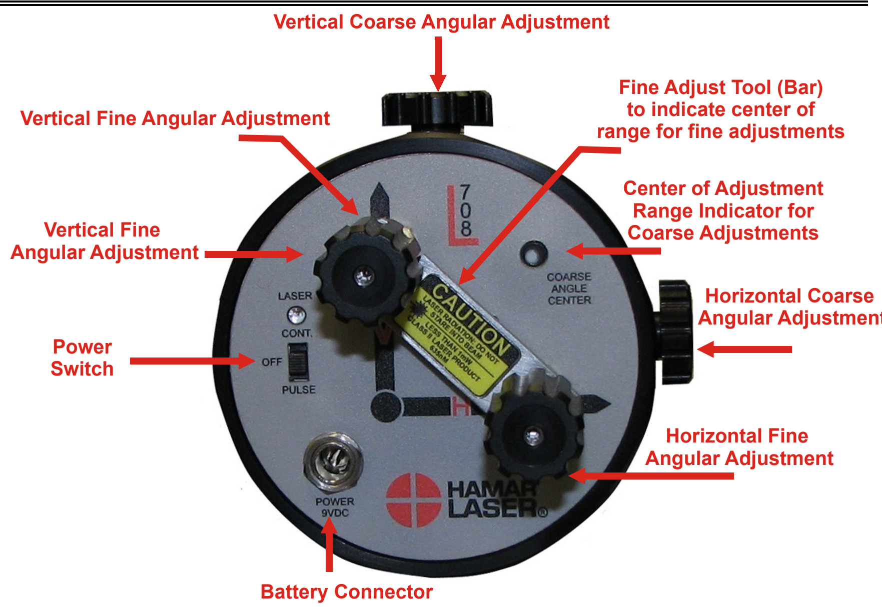


Figure 1 – *The L-708 Laser*

The L-708 Laser has been designed with a 1.2495 in. (31.74 mm) mounting surface. The laser beam is concentric to the OD to within .0003 in. (0.008 mm) and is held in place in an adapter by powerful magnets. With a range of 100 feet (30 M) and under good environmental conditions, it is accurate to .005 in. (0.13 mm) over the entire range. The L-708LD Long Distance Bore Laser has a range of 200 feet (60 M) and under good conditions should hold .010" (0.25 mm) over the full distance. The L-708LD requires the use of the T-1218 2-Axis Target, T-1220 or T-1240 targets (20x20 mm PSDs) since the laser beam diameter is larger (10 mm). By following the NORMIN procedure described in Appendix A, accuracies of .0002 in. (.005 mm) in 10 feet (3 m) can be achieved.

The L-708 provides a straight reference line to which any bore can be aligned and measured. The laser mounts in an adapter, and the laser and adapter are then mounted in either the bore or the counter bore of the gearbox spindle. The laser projects a beam through the adapter and down through the inside of a bore toward the A-512 Target, which is mounted in the opposite end of the bore. The laser beam is then adjusted (qualified) to project the actual axis of rotation of the gearbox.

The following describes the operational features of the L-708 Laser, shown in Figure 1.

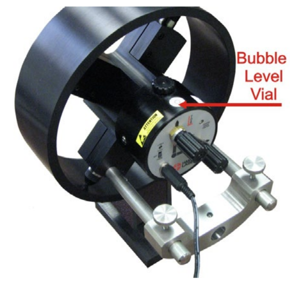


Figure 2 – *Top of L-708 Laser showing bubble level vial*

- **The power switch** has a lighted LED to indicate that power is ON.
- **The battery pack connector** accepts a slip-fit probe with a flexible cord.
- **The bubble level vial** on the laser mounting flange is used for rotational accuracy. When the bubble in the level vial is centered horizontally, all adjustments controlling laser beam angle will shift the laser beam vertically or horizontally with reference to the bore/target axis. If the bubble is *not* centered, any adjustment to one laser axis will change the laser beam position in both axes. The levels also provide fixture mounting repeatability.
- **Precision Angular Adjustment Knobs** provide angular pointing control for the laser beam so it can be tilted with a resolution of .0007 in. in 100 ft. (0.018mm in 30.5 m). The L-708LD laser has an angular adjustment resolution of .0014 in. in 200 feet (0.036 mm in 61 m).
- **The Center of Adjustment Range Indicator for Coarse Adjustments** is a small window containing a white dot. The white dot follows the coarse angular adjustment of both axes. If the white dot displays in the center of the window, both the Horizontal and Vertical angular adjustments are centered.
- **The Fine Adjust Tool Bar** swivels to indicate the middle of the adjustment range of the fine adjustment knobs. Rotate the bar (located under the Vertical and Horizontal Fine Adjust knobs) and tighten the knobs until they nearly touch the tool bar. Rotate the bar away from the knobs and the knobs are now in the middle of the adjustment range.

Figure 3 – *Fine Adjust Tool Indicator in the OUT position*

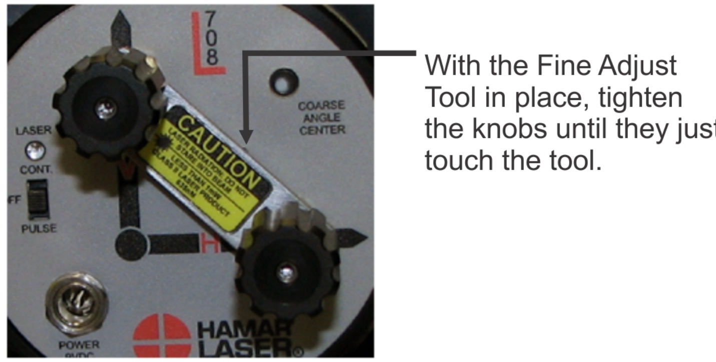
Starting an Alignment with the L-708

To start the alignment, it is important to make sure the L-708's angular adjustments are in the center of their adjustment range. There are two indicators to aid in setting the adjustments in the center of their range:

1. **Coarse Angular Adjustment Indicator** – a white dot in a round window that indicates how far off center the coarse angular adjustments are. To start an alignment, ensure the white dot is centered in the window using the *coarse* angular adjustments.

Center the white dot in the round window. This picture shows the vertical axis still needs to be adjusted to bring it to the center.

2. **Fine Angular Adjustment Indicator** – a tool has been provided to fit between the Fine Adjustment Knobs and the brass nut. This tool acts as a gage to show you how far to tighten the knobs to the center of their adjustment range. Slide the tool between the black Fine Adjustment Knob and the brass nut and tighten the knobs until they touch the tool. Then loosen the knobs just enough so you can remove the tool. The Fine Adjustment Knobs are now in the center of their range.



Adjusting the L-708 Laser

In a typical bore measuring application, the L-708 Laser is mounted concentric to one end of the bore by means of a bore adapter. The L-708 laser beam is concentric to its 1.2495 in. (31.74 mm) OD mounting surface to .0003 in. (0.008 mm) and the face of the laser has powerful magnets to hold the laser in the adapter. Because fixtures are seldom perfect, the laser beam requires angular adjustments 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 angular adjustment knobs to set/tilt the laser to zero on the target, establishing a reference bore centerline.

Pulse/Continuous Modes for the L-708 Laser

The L-708 Laser is 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-1307C, R-1307-900/2.4 and R-1307-2.4ZB support Pulse Mode when used with their respective interfaces. See the R-1307 Operations Manual for further information.

Attaching the Battery Pack

The L-708 Laser battery pack is a stand-alone unit that attaches magnetically. 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 is inserted in the control panel of the L-708 Laser.

Figure 4 – *Attaching the L-708 Battery Pack*

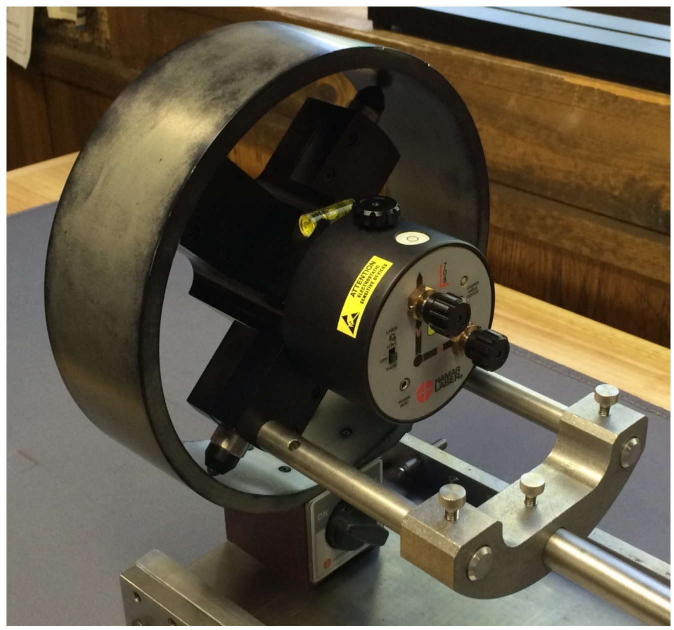
1. **Turn off the main power switch.**
   The main power switch *must* be off before attaching the battery pack.
2. **Insert the probe into the battery power input jack.**
   The jack is located on the end panel of the battery pack. Insert the probe gently until it snaps into place.
3. **Insert the probe 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 probe gently until it snaps into place.

Replacing the Batteries

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

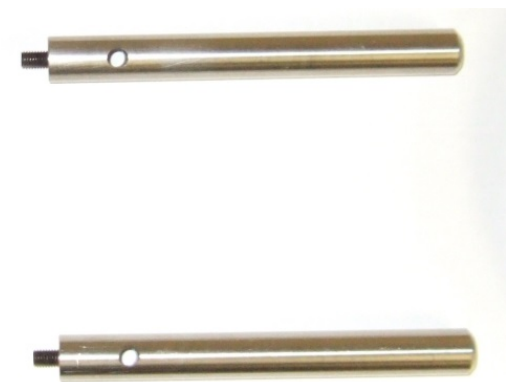
1. **Unplug the battery pack from the laser.**
   Pull the probe out of the laser control panel and gently set aside.
2. **Unscrew the cover of the pack.**
   Locate and loosen the two captive flathead screws, and remove the cover.
3. **Replace the two batteries.**
   Remove the old batteries and replace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

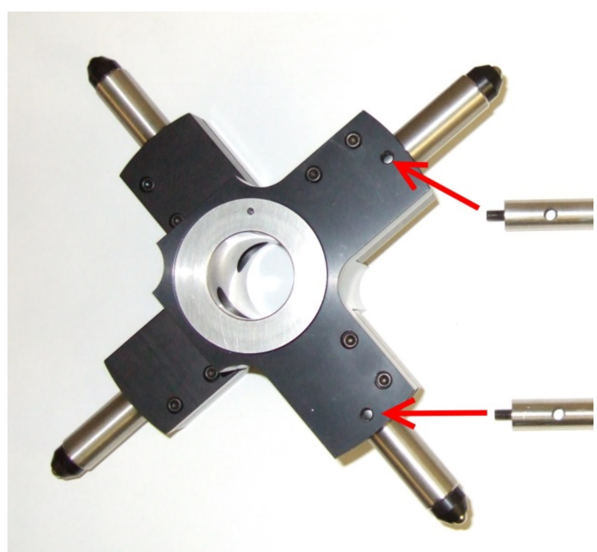
Assembling the A-514CW for the L-708 Laser



The A-514CW (counter weight) is used in conjunction with the L-708 Laser and the A-514B and A-514C bore adapters to hold the equipment in place.

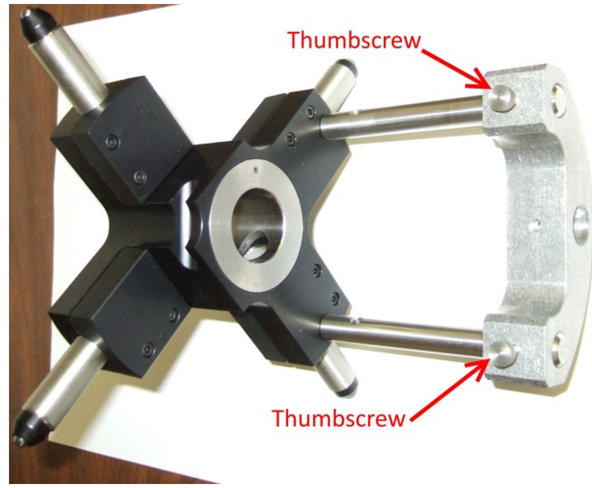
1. Assemble the bore adapter for the L-708 Laser and locate the two poles shown in the image below.



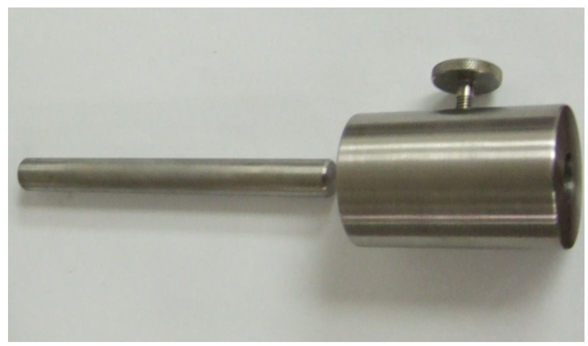


2. Screw each pole into the A-514B or A-514C Bore Adapter.

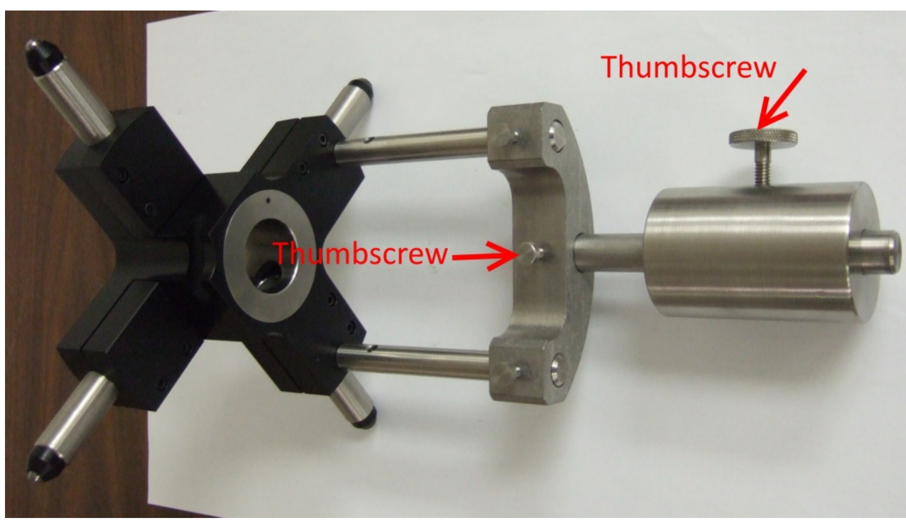
3. Attach the counter weight at the end of each pole and use the thumbscrew to tighten the counter weight to the poles.



4. An extra counter weight and pole are included with the A-514C. Insert the pole in the main counterweight and use the thumbscrew to tighten.



5. Slide the extra counterweight on to the extra pole and tighten the larger thumbscrew on the counterweight to tighten.



Model A-512 2-Axis Self-Centering Target

Hamar Laser has developed the world's first self-centering target (A-512) that uses no moving parts. It takes just seconds to position the target in the bore for an accurate measurement down to .0005 in. (0.0127 mm). The target is designed so that the PSD, (*position sensing detector*) a piece of silicon that detects the center of energy of the laser beam, is centered axially between the four feet of the adapter, two of which are offset axially from the other two. This puts the PSD on the pivot point of the adapter and allows the angle of incidence to the laser beam to vary by up to 45 degrees. The A-512 takes advantage of this property by making the adapter slightly larger than the bore. To insert the target into the bore, attach the insertion handle (see Mounting the Laser/Adapter and Inserting the Target on Page 19).

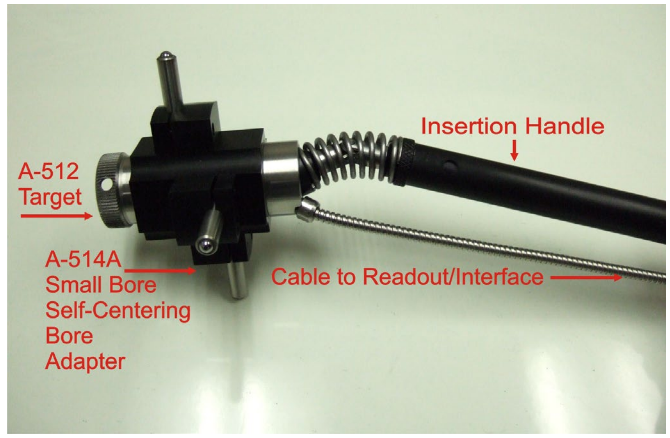


Figure 5 – *A-512Target with A-514A Small Bore Self-Centering Bore Adapter*

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.

The A-512 target and adapter (in self-centering mode) are inserted into the reference bore. A measurement is taken with the target in both the NORMal and INverted positions (see Appendix A – The NORMIN Method beginning on Page 23). The two readings are averaged and the result is the starting measurement for the laser. At each subsequent measuring point, two sets of readings (NORMal and Inverted) are taken and averaged. Subtract the result from the reference measurement to obtain the diameter change.

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 $\pm$.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.

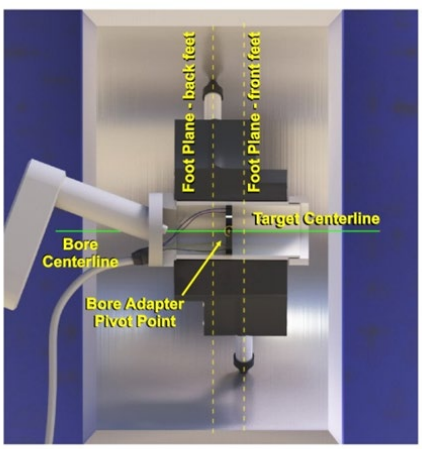
The A-514 A, B and C Self-Centering Laser and Bore Adapters

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 3.5 in. (90 mm) to 40 in. (1m) and the A-514B and A-514C come with counterweights to prevent the assembled system from tipping. Three sizes are available, as follows:

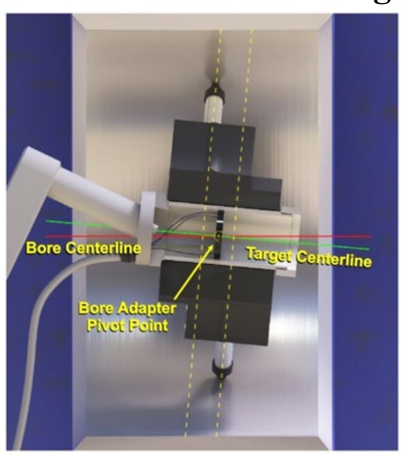
- **A-514A** for bores from 3.75 in. (95 mm) to 6.75 in. (172 mm)
- **A-514B** for bores from 6.5 in. (165 mm) to 17.5 in. (445 mm)
- **A-514C** for bores from 17.0 in. (432 mm) to 40.0 in. (1 m)

Note: *For bores over 1 m, 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.*

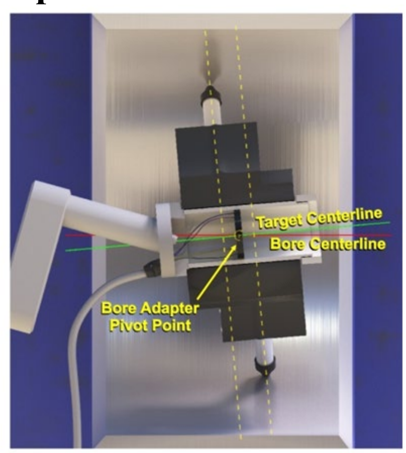
How the A-512 and A-514 Self-Centering Adapters Work



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



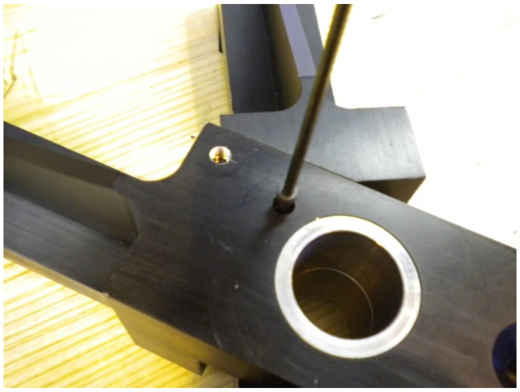
Bore ID > Nominal ID
Target Tilts Forward
PSD Is Still Centered



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

Assembling the Bore Adapters

The A-514A, B and C Bore Adapters are all assembled the same way. Each adapter consists of two legs that cross each other, forming an “X” shape. Using a bolt and Allen wrench provided, screw the bolt down and tighten.



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-514GS (left) and A-514GL (right) Leg Fixtures*

Assembling the A-514GS and A-514GL

1. Using the bolt and Allen wrench provided, tighten the hub to the plate.

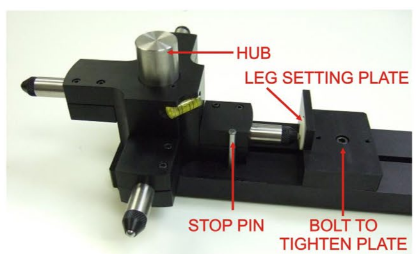
2. Once the hub is tightened, turn the plate right side up and slide the spacer over the hub.

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. So 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.*



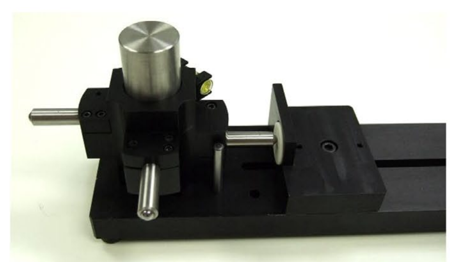


Figure 7 – *Setting the legs for the A-514GS*

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" 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 12.

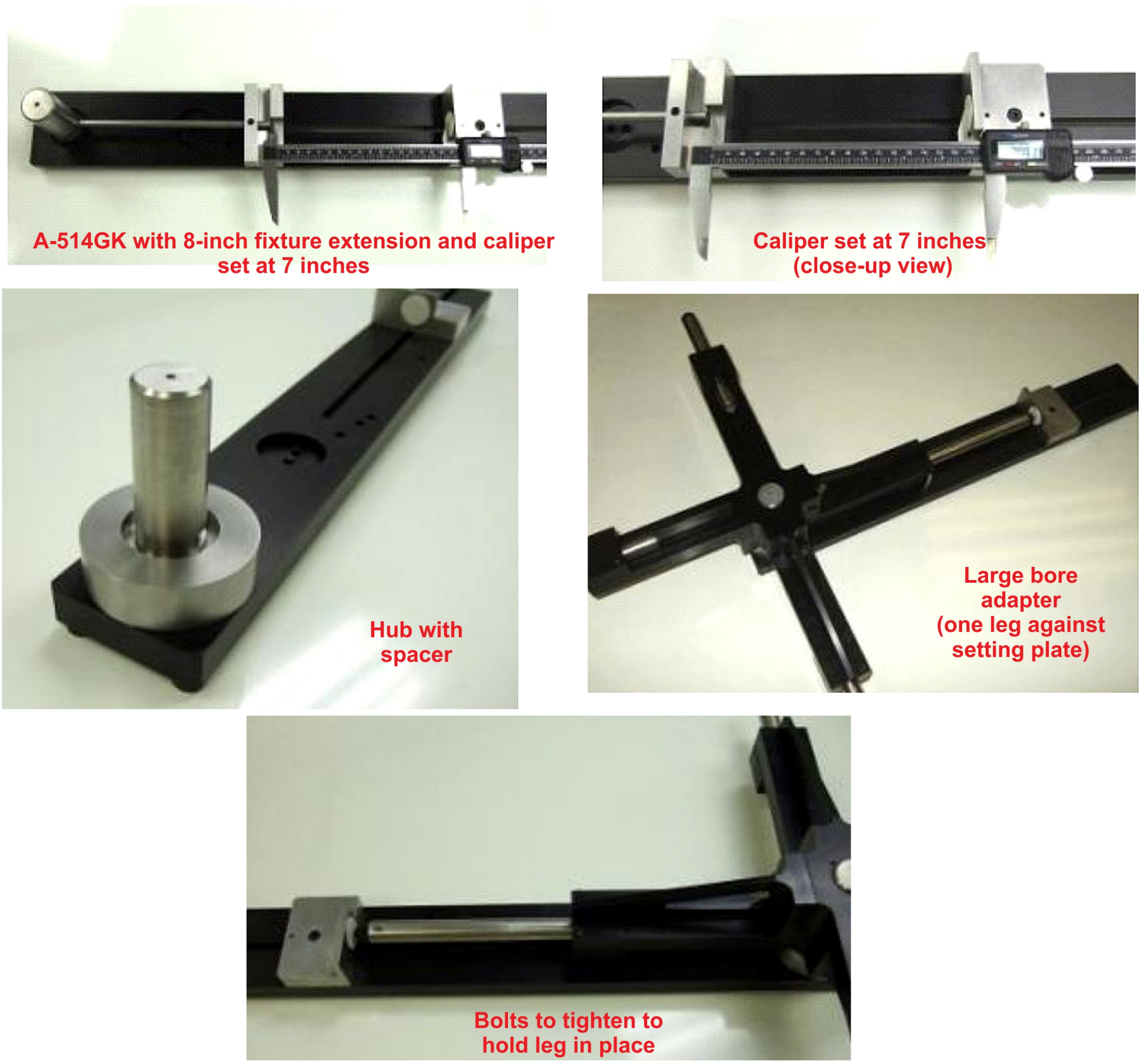


Figure 8 – *Setting the legs for the A-514GL*

The Model R-1307 Readouts

Readouts are used for viewing and interpreting the target data. The R-1307 is a simple LCD readout that displays raw target data. The user performs all calculations and plots the data manually. If the package is to be used only for alignments, the readout is the simplest and most cost-effective choice. The Model R-1307C, Models R-1307-900/2.4 and R-1307-2.4ZB (with ZigBee® radio technology) are compatible with the L-708/L-708LD Bore Alignment System.

Figure 9 – *R-1307 Readout*

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-1307-900/2.4 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 10 – *R-1307KS Readout Stand*

Figure 11 -- *A-910-2.4ZB Computer Interface*

Model R-358 Computer Interface

If the alignment package is to be used for measuring bore diameter, the R-358 Computer Interface may be used. The R-358 couples with a portable computer to act as a readout and allows the use of alignment software to perform calculations, display live laser beam-to-target position information, and plot results that can be saved and printed.

The R-358 computer interface provides exceptionally high accuracy (.00004 in. resolution) for downloading target data to Hamar Laser's alignment software. The interface attaches to the computer with an RS-232 cable and it is powered by a lithium ion battery for long life and usage. An AC adapter/charger is provided, and the unit features LED charging and power indicators.

Figure 12- *R-358 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

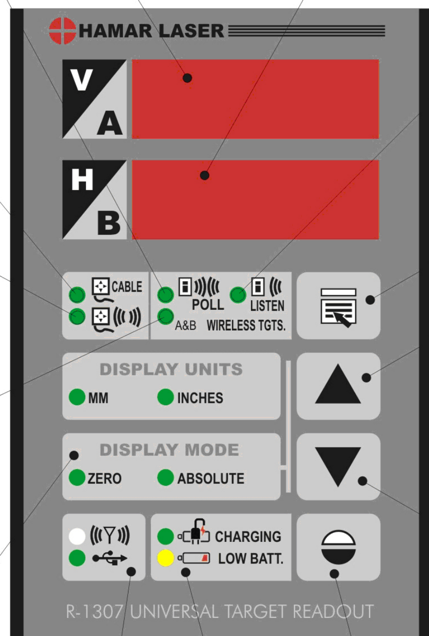
LOCAL TARGET INDICATOR
ON : READOUT IS SET TO DISPLAY DATA FROM A TARGET CONNECTED TO THE LOCAL PORT

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

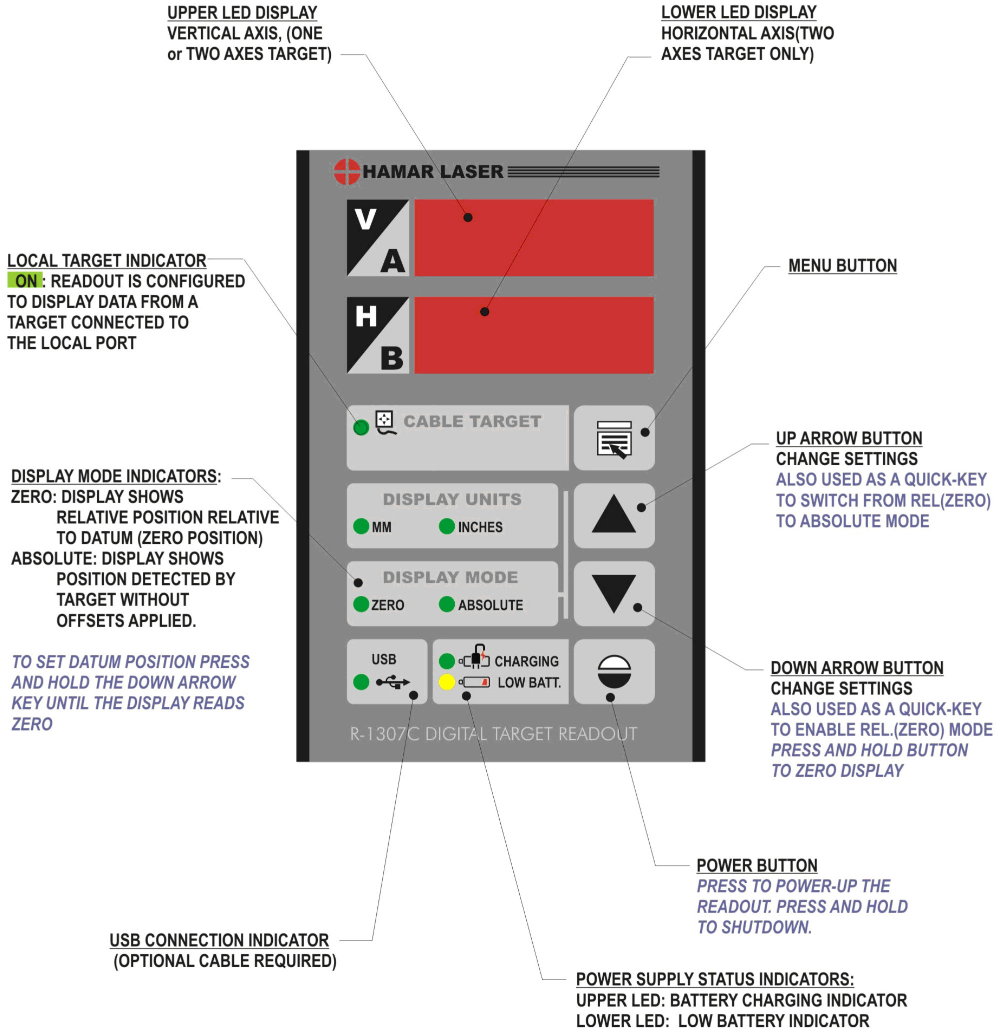
DOWN ARROW BUTTON
CHANGE SETTINGS
ALSO USED AS A QUICK-KEY TO ENABLE REL.(ZERO) MODE
PRESS AND HOLD BUTTON TO ZERO DISPLAY

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

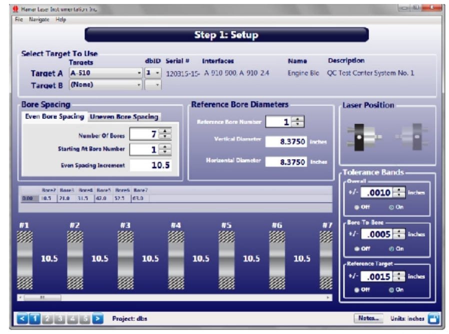
Model R-1307C Readout -- Control Panel



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 bores, 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.

Setting up the Equipment

This method allows centering to .0005 in. (0.0127 mm).

Figure 13 – *Laser mounted in bore adapter*

1. **Adjust the A-514 Self-Centering Bore adapters for both the laser and target.**
   Using the L-514GS or A-514GL Leg-Setting Gage, set the adapter legs to the desired bore radius. See *Setting the Legs for the A-514GS* on Page 12 and *Setting the Legs for the A-514GL* on Page 12 for more information on this procedure.
2. **Insert the L-708 Laser and A-512 Target into their adapters.**
   When using the small adapter, hold the laser from the back end and tip it slightly upward, inserting the adapter and laser at an angle. The weight of the laser will pull it down after releasing. The medium and large bore adapters are provided with counterweights to hold the laser in place so the unit doesn't tip.

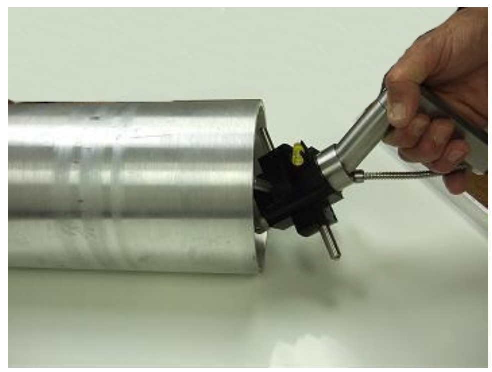


Figure 14 – *Inserting the Target*

3. **Insert the laser and target assemblies into the two reference bores.**
   Attach the weighted insertion rod to the target/adapter and tip the unit forward to insert into the bore. The weight of the handle forces the target to tip backward and seat the target legs into the bore, centering the adapter/target. Ensure that the target cable is at the 6 o'clock position and release the handle as soon as the target is in place in the bore end. The target centers itself securely.
   Repeat for the laser/adapter assembly.
   Note: *To remove the target, lift the handle up and slide the target/adapter out of the bore.*
4. **Use the laser's angular adjustments to set/tilt the laser to zero on the target, establishing the reference bore centerline.**

Connecting and Setting Up the Readouts/Computer Interfaces

Before connecting and configuring a readout, ensure that the laser is mounted and the target installed.

Configuring the R-1307 or R-1307C for a Local 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 15.**
   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).

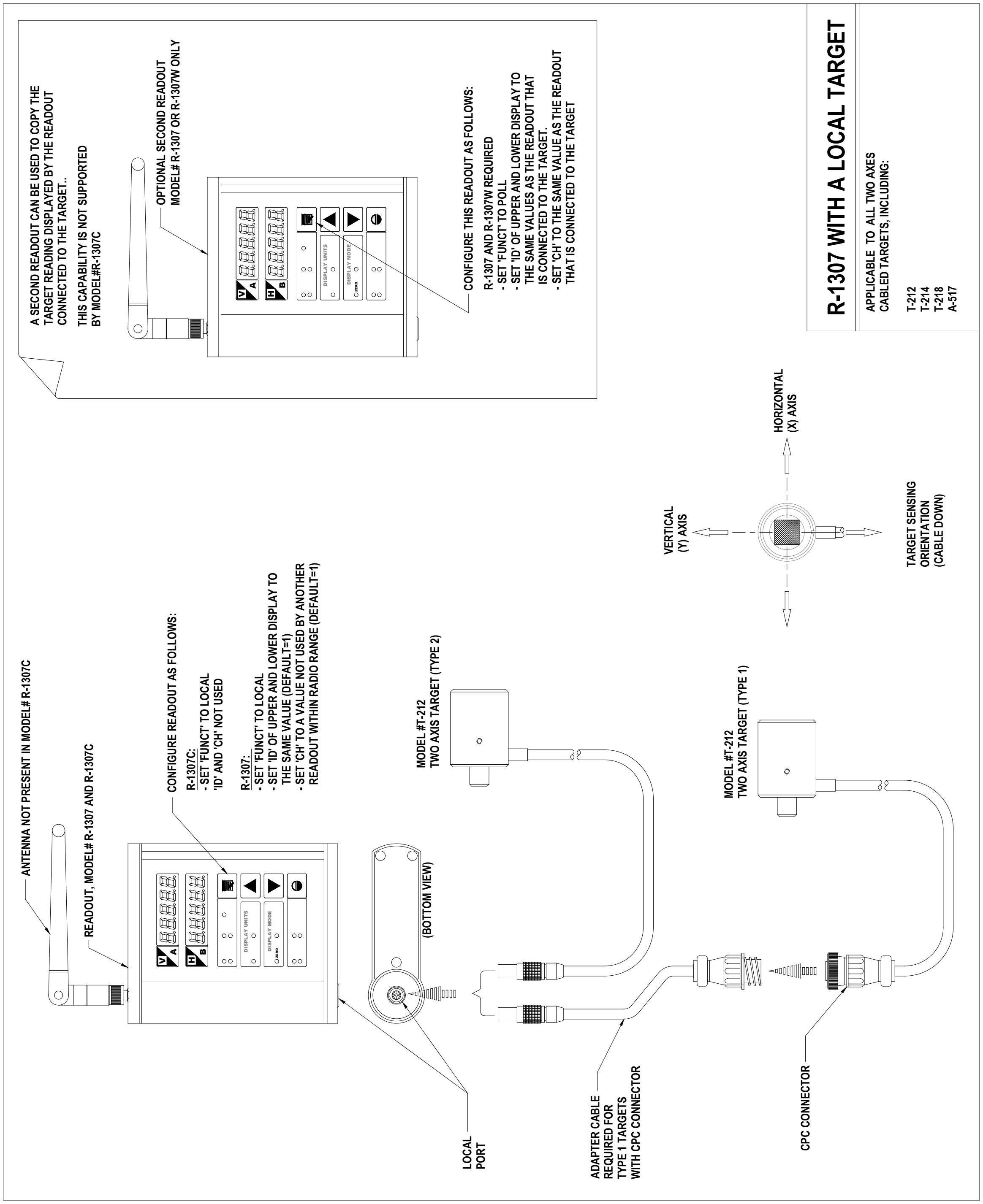


Figure 15 -- *Connecting a Local Target to the R-1307*

Setting the Target Network ID and System ID

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.

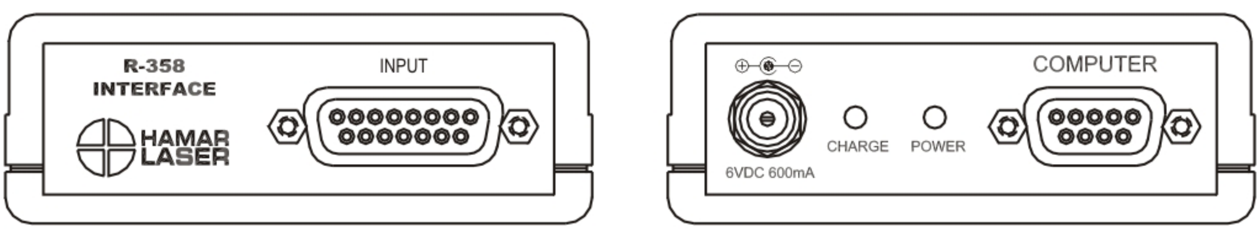
3. **Set the Local Target Network ID**
   Press the MENU button until the *upper* display shows id_: nn with the current Target ID (nn) blinking. Use the UP and DOWN arrow keys to set the Target ID (the default is 01).
   Press the MENU button again until the lower display shows id_: nn with the current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

4. **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).

Connecting to the R-358 Computer Interface

Before using the R-358 Computer Interface, ensure that the battery is fully charged or that the AC charger/adapter is plugged in. Make all connections with computer power *off*.

1. **Connect the target(s) to the INPUT connector on the front of the R-358 Interface.**
   The interface can support one 4-axis target. It can also support two 2-axis targets with the use of an optional splitter cable.



Front Back

2. **Connect the R-358 Interface to the computer.**
   Connect the interface to the computer serial port using the standard RS-232 cable provided. The connector for the cable is located on the back of the unit and is labeled COMPUTER.

3. **Power on the computer.**

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.

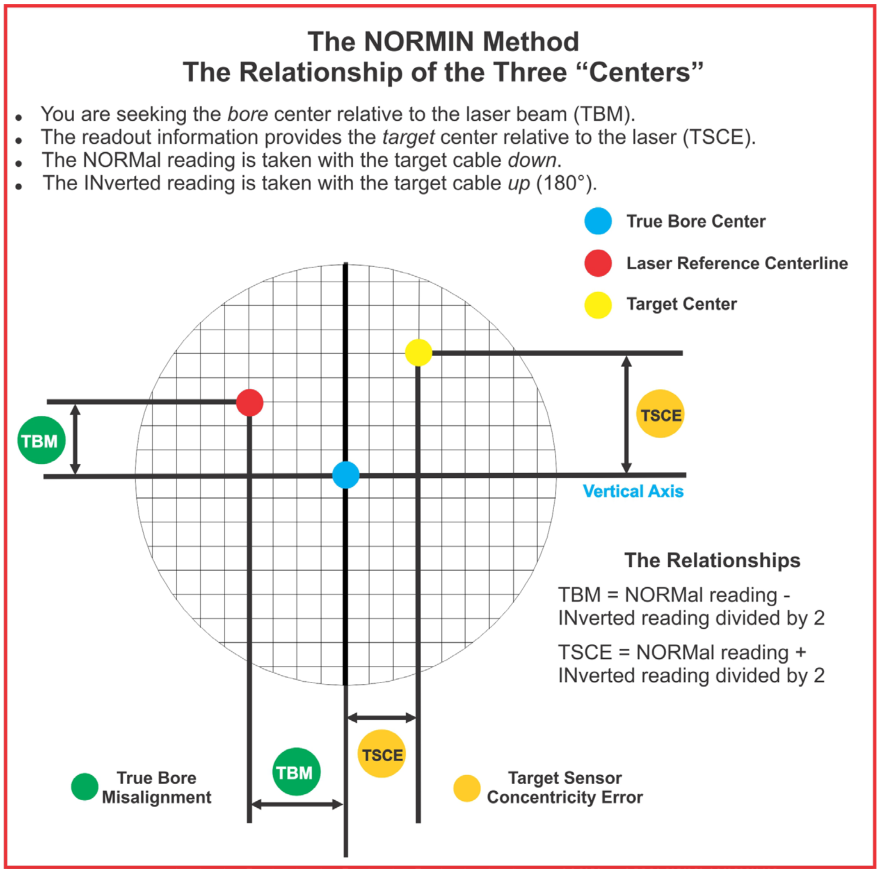


Figure 16 -- *Three centers of bore alignment*

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 18.

Two relationships can be calculated from these three centers and two sets of NORMIN readings: Target Sensor Concentricity Error (TSCE) and True Bore Misalignment (TBM). 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 17 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.).

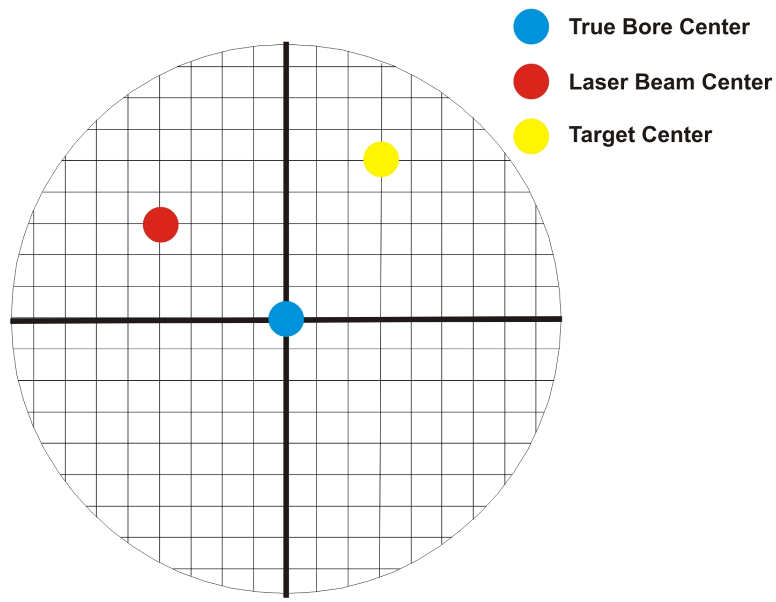


Figure 17 – *Target in the NORMal position*

Figure 18 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 18, the vertical readings are positive and the horizontal readings are negative. When the vertical TCE is calculated, (NORMal+INverted divided by 2) the Target Center is .004 in. higher and .003 in. to the right of the True Bore Center in the NORMal position.

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

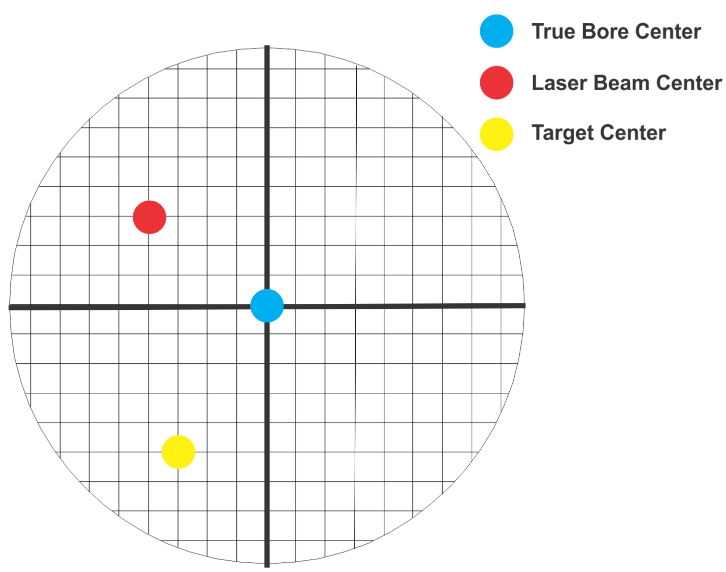


Figure 18 – *Target in the INverted position*

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 20 on Page 27).

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 19 -- *Chart for Readout Data*

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

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

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

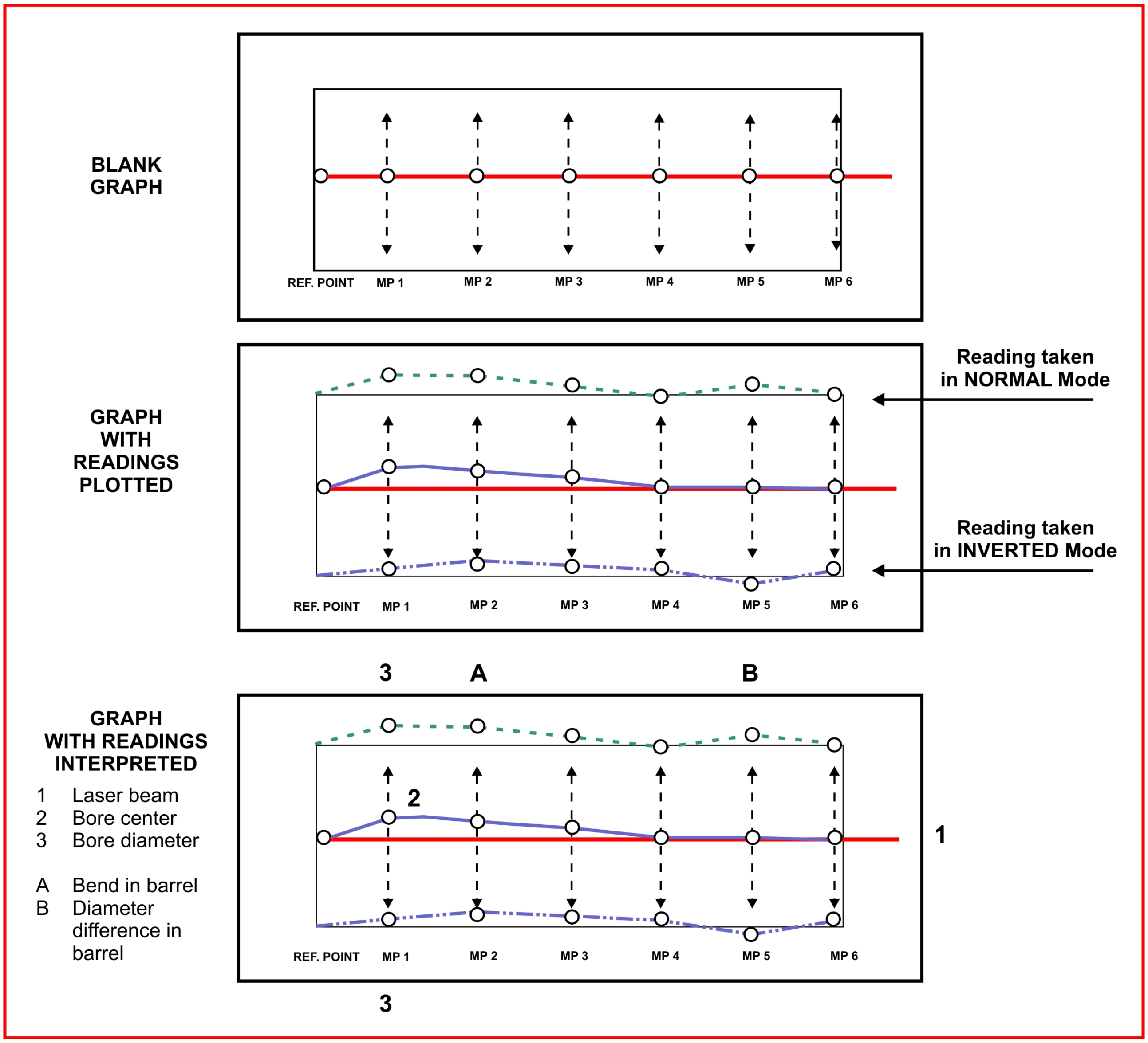


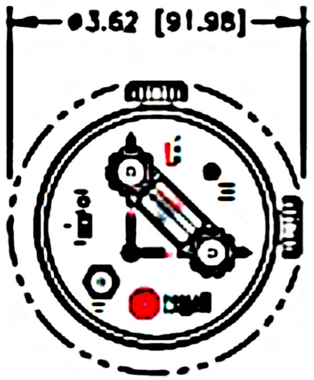
Figure 20 – *Sample plot of readout data*

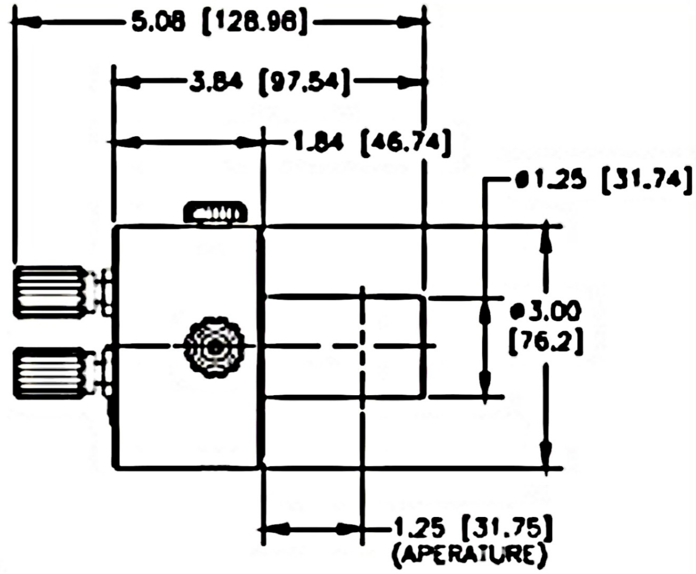
Appendix C – Technical Specifications

L-708/L-708LD Laser	
Size	See drawing on Page 29
Weight	1.6 lb. (0.7 kg)
Power	9V external battery pack/AC adapter
Center	Laser concentric to within .0003 in. (0.008 mm) No adjustment
Angular Adjustment Resolution	Controlled by two high-pitch adjustment knobs Coarse: .0006 in/ft (0.05 mm/m) Fine: .000007 in/ft (0.0006 mm/m)
AngularAdjustment Range	Coarse: ± 1.0° (± .21 in/ft or 17.5 mm/m) Fine: ± 0.03° (± .007 in/ft or 0.6 mm/m)
Operating Distance	L-708: Up to 100 ft. (30.5 m) L-708LD: Up to 200 ft. (61 m)
Laser Beam Distance	L-708: < 0.25 in. (6.4 mm) diameter L-708LD: < 0.38 in. (9.6 mm) diameter
Beam Straightness	.00001 in/ft (.0008 mm/m)
Beam Stability	.0001 in/hr./°F (0.004 mm/hr./°C) .0001 in/ft/hr./°F (0.01 mm/M/hr./°C)
Laser Type	Diode Laser < 0.9 mW Cw, BRH Class II
Laser Wavelength	670 nanometers
Materials	Aluminum Flange. All mounting surfaces: 303 SS

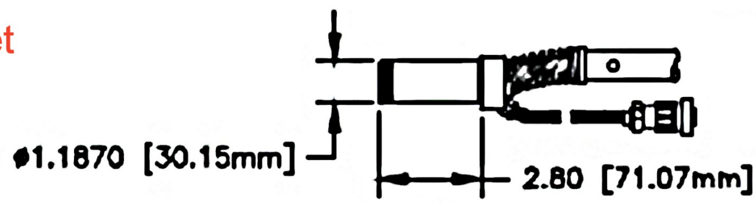
Target and Bore Adapters	
A-512 Target	Mounting Surface OD: 1.870 in. (30.15 mm) Target sensor concentric to OD to within .0003 in. (0.008 mm) Mounting surface 303 SS
A-514A Small Bore Target Adapter	For bore diameters from 3.5 in. (88.9 mm) to 6.5 in. (165.1 mm)
A-514 B Medium Bore Target Adapter	For bore diameters from 6 in. (152.4 mm) to 18 in. (457.2 mm)
A-514C Large Bore Target Adapter	For bore diameters from 17 in. (431.8 mm) to 40 ft. (1 m)
A-514G Bore Gage	Sets A-514 Adapter legs to correct bore diameter to .0002 in. (.005 mm). Use A-514GS for A-514A and B Adapters and A-514GL for A-514A, B and C Adapters.

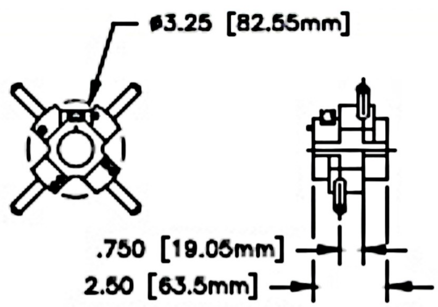
L-708 Laser



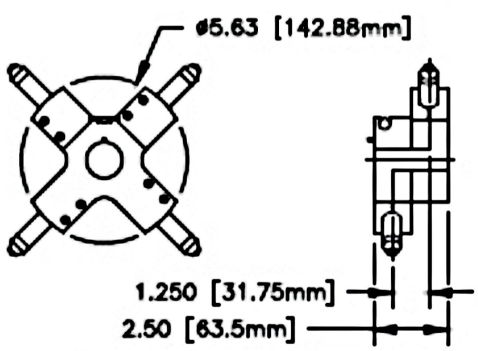


A-512 Target

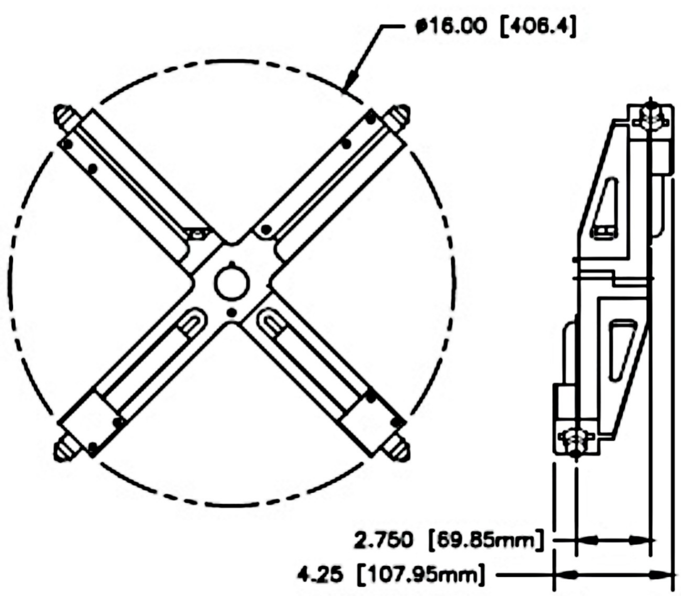




A-514A Target Adapter



A-514B Target Adapter



A-514C Target Adapter

Appendix D – 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.