

Extruder Alignment using the L-705 Bore Laser System

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Table of Contents

| | |
|--|----|
| Critical Note on Calibration | 1 |
| The L-705 Bore Laser System for Single Barrel Extruders..... | 2 |
| Lasers | 2 |
| Model L-705 Laser | 2 |
| Model L-706 Long Distance Laser | 4 |
| Pulse/Continuous Modes (L-705 and L-706 Lasers)..... | 5 |
| Readouts | 5 |
| Model R-1307-2.4ZB | 5 |
| Computer Interfaces..... | 8 |
| The A-910-2.4ZB Wireless Computer Interface and Utility Software | 8 |
| Model R-358 Computer Interface | 8 |
| Targets and Adapters | 10 |
| Model A-510 2-Axis Self-Centering Target | 10 |
| Model A-510LTA and Model A-510STA Bore Adapter Hubs for the A-510 Target | 11 |
| The A-510 Uses PSD to Detect the Laser | 11 |
| Assembling the Bore Adapter Hubs..... | 12 |
| Model T-221 Bore Target | 13 |
| Bore9 Software | 18 |
| Using Bore9, Step 3 – Buckin (Laser Setup) | 19 |
| L-705 Extruder Alignment System (Overview of Basic Setup) | 21 |
| Aligning Extruders | 25 |
| Setting up the Equipment – A-705 Gearbox Spindle Laser Fixtures | 26 |
| Assembling the A-705 Chuck Fixture and Installing the L-705 Bore Laser | 26 |
| Inserting the A-510/A-510STA Target and Self-Centering Adapter | 31 |
| Qualifying the L-705 Laser | 32 |
| Coarse Qualifying the L-705 Laser Using the Visual Method..... | 32 |
| Coarse Qualifying the L-705 Laser Using the Target Method..... | 33 |
| Fine Qualification and Performing Alignments | 35 |
| Measuring Barrel Wear..... | 37 |
| Reconfiguring the A-510 Target | 37 |
| Taking Measurements | 38 |
| Calculating Bore Diameters..... | 39 |
| Bore Size Measurement..... | 39 |
| Plotting Measured Data | 40 |
| Appendix A – The NORMIN Method (Bore and Spindle)..... | 42 |
| Appendix B – L-705 Laser Safety Information | 44 |
| Appendix C – The R-1307 Menu | 45 |

| | |
|---|----|
| Appendix D – The A-910 Radio Transceiver/Hub | 46 |
| Front Panel Features | 46 |
| Rear Panel Features | 46 |
| Using the R-1307 with a Cabled (Local) Target and the A-910 Radio Transceiver | 47 |
| Setting the Target Network ID and System ID for the R-1307 Readout | 47 |
| Miscellaneous Display Messages | 47 |
| The Zigbee® Radio Utility for the A-910-24.ZB | 48 |
| Pre-installing the Common USB Port Driver (A-910-2.4ZB) | 48 |
| Installing the A-910 Utility Software | 48 |
| Configuring the Hardware and Utility Settings | 49 |
| Manually Selecting the COM Port | 50 |
| Setting the Target System ID and Target Network ID | 51 |
| Setting the System ID | 51 |
| Appendix E – Agency Certifications | 52 |
| Appendix F – Discontinued Components | 54 |
| Model R-307V 2-Axis Large Number LED Readout | 54 |
| Model R-307 2-Axis LCD Readout | 54 |
| Setting Up the R-307 2-Axis LCD Readout | 55 |
| Calibrating the R-307 2-Axis LCD Readout | 56 |
| Appendix G – Care and Cleaning of Target Optics | 62 |
| Appendix H – Laser Buckin for Gearbox AOR (Manual Method) | 63 |
| Laser Buckin AOR Procedure | 63 |

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 are 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: $\pm 6 \pm .02$ F. 10. 10 or $\pm 6 \pm .02$ P. 10. 10 for R-1307 #2



Pulse/CONTInuous Mode Switch set to CONTInuous.

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 Readouts for a Cabled (Local) Target* on Page 7.

The L-705 Bore Laser System for Single Barrel Extruders

This manual describes the equipment and procedures for aligning single barrel extruders using Hamar Laser's L-705 Bore Laser System. The system includes targets, fixtures, readouts and software that may be purchased for special alignment needs.

Lasers

Model L-705 Laser

The L-705 Laser has been designed with a .750 in. (19.05 mm) mounting stud and flat face with magnets to hold it flush to fixturing. Since the laser beam is concentric to the OD to within .0005 in. (0.01 mm), a simple flat face and .750 in. (19.05 mm) hole on center is all that is needed to hold the laser (the extruder package includes a self-centering chuck fixture). In fact, the laser replaces the first reference target that a typical borescope would need.

L-705 Features and Setup

The L-705 has a range of 50 ft. (15 m), and under good environmental conditions, it is accurate to .001 in. (0.025 mm) over the whole range. By carefully following the NORMIN procedure described in Appendix A, accuracies of .0002 in. (0.005 mm) in 10 feet (3 m) can also be achieved.

The L-705 provides a straight reference line to which any bore or extruder barrel can be aligned and measured. The laser mounts in an adapter. The laser and adapter, in turn, are mounted in either in 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 or barrel toward any of Hamar's bore targets, which are mounted in the opposite end of the bore or the free end of the extruder barrel. The laser beam is then adjusted (qualified) to project the actual axis of rotation of the gearbox.

Note: *Adapters sold prior to November 1995 were custom fit for each specific application. Extruder packages purchased after that date come with the A-510C Universal Gearbox Adapter (see Page 26).*

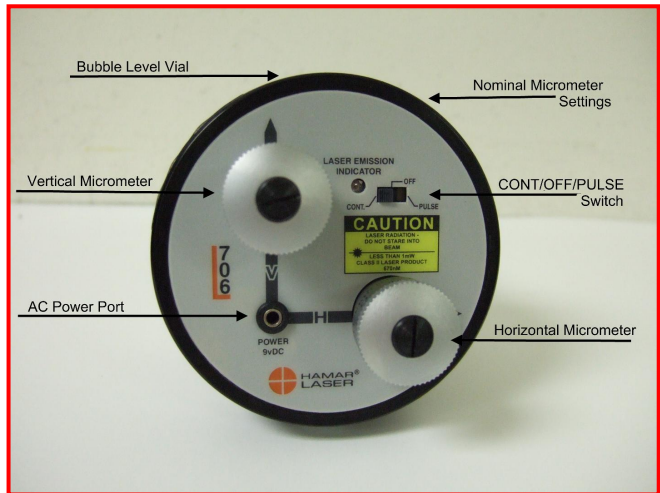


Figure 1 – The L-705 Laser

The following describes the operational features of the L-705 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 5 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 L-705 Laser

The L-705 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 $\pm .0005$ in. (0.0127 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 $\pm .0003$ in/ft.

In a typical bore measuring application, the L-705 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 (see *Coarse Qualifying the Laser* beginning on Page 32).

The circular level vial on the laser mounting flange is used to reference the orientation of the vertical and horizontal axes of the L-705 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.

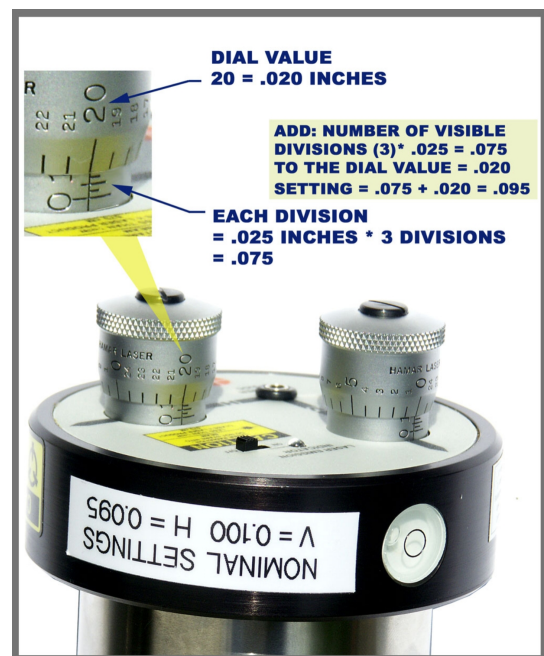


Figure 2 – L-705 Laser Micrometer Adjustments

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.

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 from 50 ft. (15 m) to 110 ft. (33 m). The finer angular adjustments means there is less adjustment range, which make the L-706 difficult to use in shorter distances. In some cases at distances less than 50 ft. (15 m) the laser will run out of angular adjustment before the laser hits the target.

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.

Readouts

Readouts are used for viewing and interpreting target data.

If the package is to be used for measuring barrel diameter, the R-1307-2.4ZB featuring ZigBee® radio technology or the R-358 Computer Interface may be used along with alignment software to perform calculations, display live laser beam-to-target position information, and plot results that can be saved and printed.

Model R-1307-2.4ZB

- Supports both wireless targets (A-1519-2.4ZB) or cabled (local) targets
- Can be configured to support both pulsed-beam and continuous laser modes
- Radio frequency 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



Figure 4 – R-1307 Readout

R-1307 Control Panel

Figure 5 shows the features of the R-1307 Control Panel.

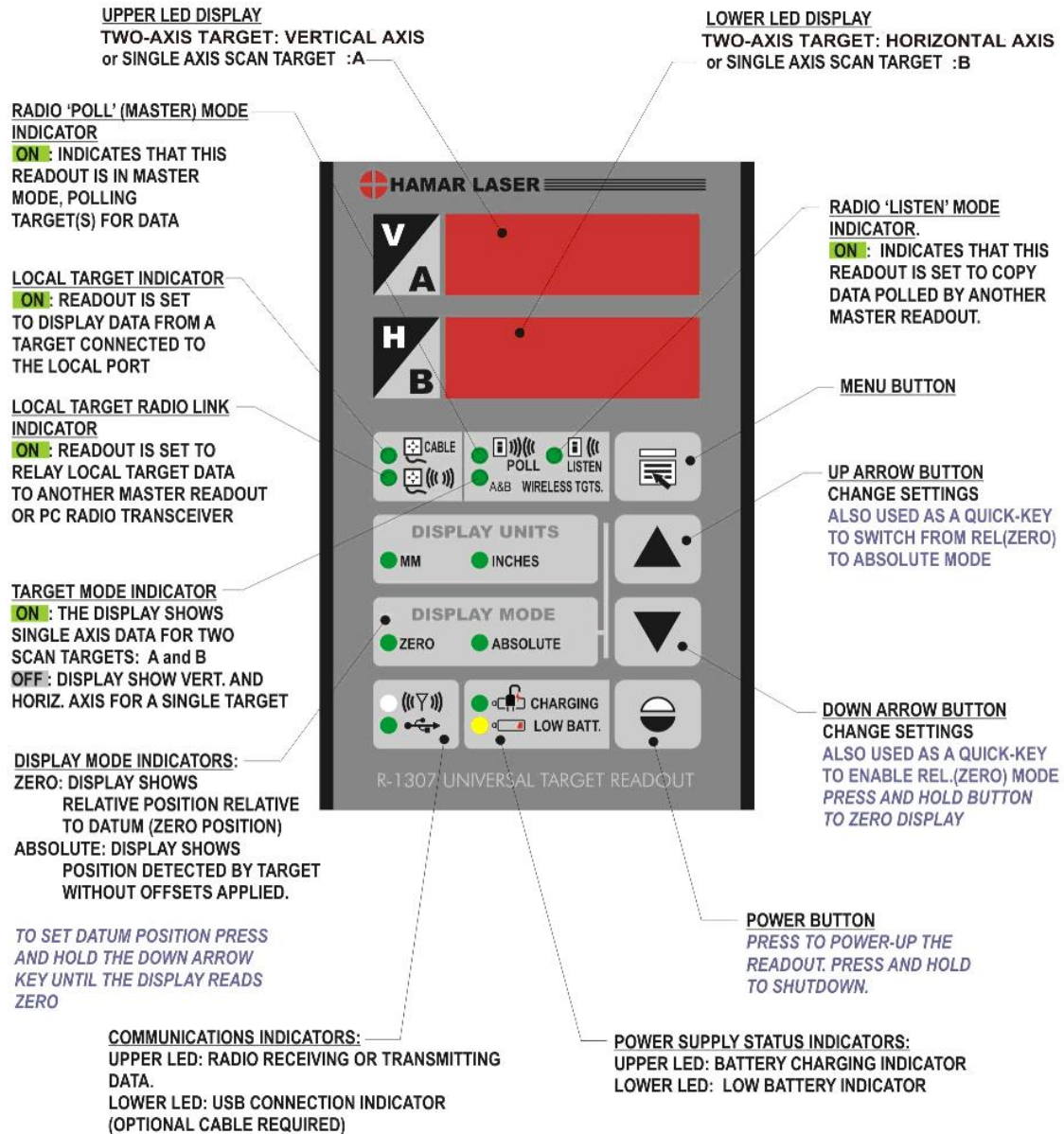


Figure 5 -- R-1307 Readout Control Panel Features

Configuring the R-1307 for a Cabled (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.**
2. **Press and hold the MENU button for approximately 2 seconds to enter configuration mode.**
3. **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.
4. **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. Adjust this value as required to suit the application. The default for this application should be changed to at least 8. For long distance shots, use 16 or 32.
5. **Set the Readout Function to Cabled (Local) Target**
Press the MENU button until the upper display shows $FUNCTION$. Use the UP and DOWN arrow keys to select $FUNCTION LOCAL$.
6. **Select the PSD descriptor applicable to your target**
Press the MENU button until the upper display shows $TGT=nn$, where nn designates the target number. Each R-1307 has three target descriptors:
 - TGT=0 (for HLI use only. Do not use)
 - TGT = nn, P.10.10 (pulsed beam mode)
 - TGT = nn, F.10.10 (fixed beam mode)

nn= R-1037 Readout number and matching target number

Press the UP or DOWN arrow to select the correct target number and to change the second window. For example, $TGT=02 F. 10. 10$ or $TGT=02 P. 10. 10$ for R-1307 #2

WARNING: The R-1307 can store up to 9 target calibration factors. Therefore, two or more targets can be used with one R-1307 Readout by specifying the target number in the R-1307 menu. The R-1307 then uses the calibration factors for the target number selected. If, however, a target number is entered in the R-1307 menu that does not correspond to the actual target in use, calibration factors will be incorrect.

7. **To exit configuration mode, press and hold the MENU button for approximately three seconds until the display returns to normal mode.**
The R-1307 will also return to normal mode automatically after approximately four seconds of inactivity.

Computer Interfaces

The A-910-2.4ZB Wireless Computer Interface and Utility Software

The A-910-2.4 ZB operates with the R-1307-2.4ZB models and plugs directly into any unused computer USB port to communicate directly with the targets. Utility software is provided for driver installation, setup and configuration. See Appendix D beginning on Page 46 for more information.



Figure 6 – A-910-2.4ZB Wireless Computer Interface

Model R-358 Computer Interface

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 7 – R-358 Computer Interface

Connecting to the R-358 Computer Interface

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

1. **Connect the 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.

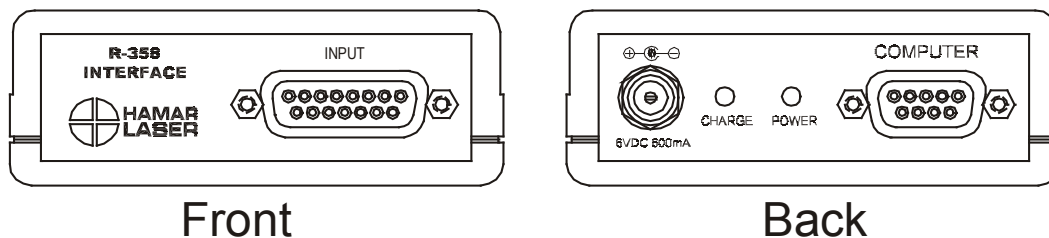


Figure 8 – R-358 Interface Connections

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. **Turn on the computer.**

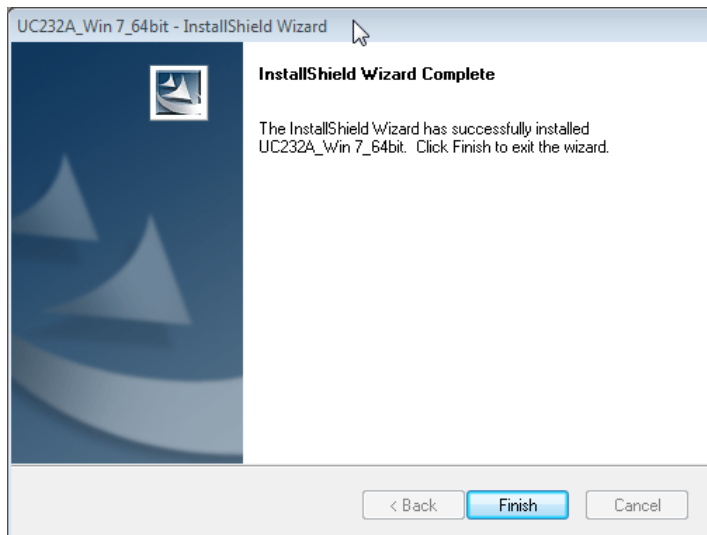
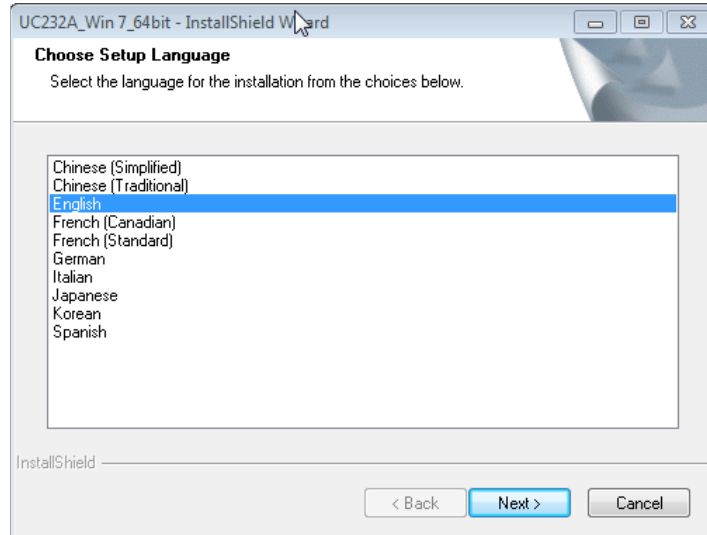
Installing the (RS-232) USB to Serial Driver

This driver is required for the R-358 Computer Interface to communicate with targets via the RS-RS-232/USB converter cable and the computer USB port. The driver creates a virtual COM Port that is recognized by the applications as a standard serial port.

Note: You must pre-install this driver prior to connecting the device(s) to the computer through the USB port.

Installing the Driver

1. Insert the Flash drive in an available USB port.
2. Select **My Computer**, locate the **REMOVABLE DISK** icon and click to open it.
3. Select the USB Drivers folder.
4. Open the **GUC232A_Win8** folder and double click **GUC232A_Windows_8_Setup.exe** to initiate the installation process. The **Install Driver** dialog box displays.
5. Select the language for the installation and click **Next** to continue.
6. Once the installation is complete, the **Installation Successful** message displays. Click **Finish** to exit.



Targets and Adapters

Model A-510 2-Axis Self-Centering Target

Hamar Laser has developed the world's first self-centering target (A-510) that uses no moving parts. It takes just seconds to position the target in the barrel for an accurate measurement down to .0005 in. (0.01 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 4 ft. of the adapter, two of which are offset axially from the other two. This, in effect, 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°. The A-510 takes advantage of this property by making the adapter slightly larger than the bore. To insert the target into the barrel, attach the spring-loaded pole to the target and pull the target cord (see *Inserting the Target* on Page 31). This tips the target forward, allowing it to easily slide into the bore. When the cord is released, the target and adapter "jam" into the bore, finding the center automatically. The weight of the pole keeps the target centered in the bore.

A-510 Target/Adapter Components

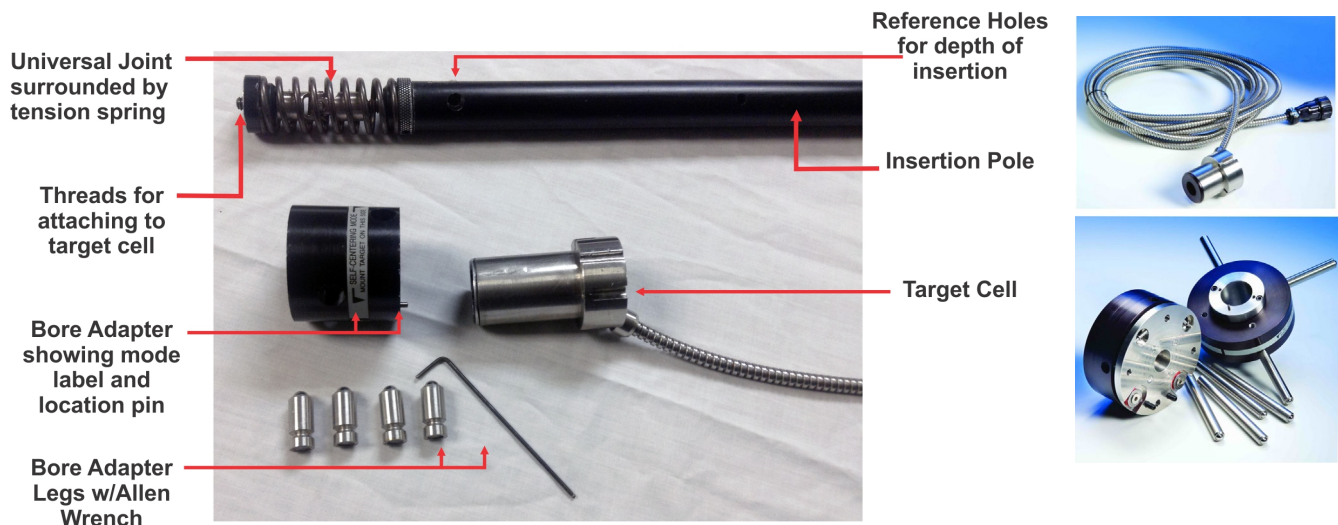


Figure 9 – A-510 Target/Adapter Components (left) and A-510 Target with Adapters (right)

The A-510 Target unit is composed of a target cell, a bore adapter, and an insertion pole (see Figure 9). The target is inserted in the barrel to sense the position of the laser beam. Laser beam position data is displayed on a readout or a portable computer.

Model A-510LTA and Model A-510STA Bore Adapter Hubs for the A-510 Target

The Model A-510LTA is a self-centering, large-bore target adapter hub for bores measuring 4.25 in. to 20 in. (110 mm to 500 mm). The Model A-510STA is a self-centering small bore target adapter hub for bores measuring 2 in. to 5 in. (50 mm to 127 mm).

The adapters can be placed on the A-510 Target in two ways:

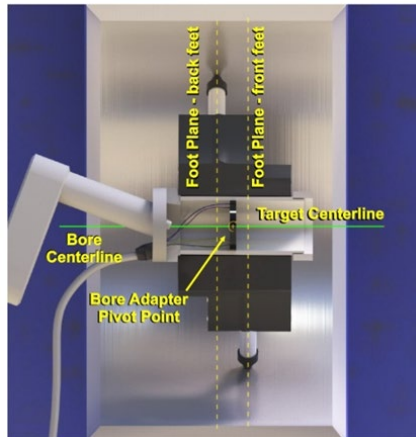
- **Self-Centering Mode** – When inserting the target/adapter into the barrel, the target will center itself into the bore.
- **Measuring Mode** – By using our NORMIN procedure and measuring a reference diameter, this mode will measure diameter changes in the bore.

To measure barrel wear/diameter changes, a measurement is taken of a reference bore with an inside micrometer, usually at the free end of the barrel. The A-510 Target and adapter in Measuring Mode are inserted into the reference bore. A measurement is taken with the target in the NORMal position and in the INverted position. 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 determine the diameter change.

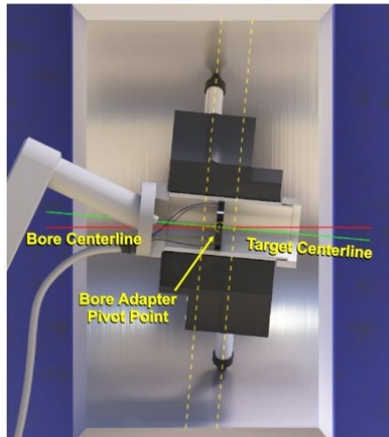
The A-510 Uses PSD to Detect the Laser

The target cell is a position-sensitive detector (PSD) surrounded by a stainless steel housing. When light contacts the sensor, it finds the center of energy down to a resolution of 0.5 microns (A-910-2.4ZB). The effective cell sensitivity range is $\pm .100$ in. (2.5 mm) and changes in the x and y axis position of the target can be displayed on the R-1307 Readout with a resolution of .0001 in. (0.003 mm).

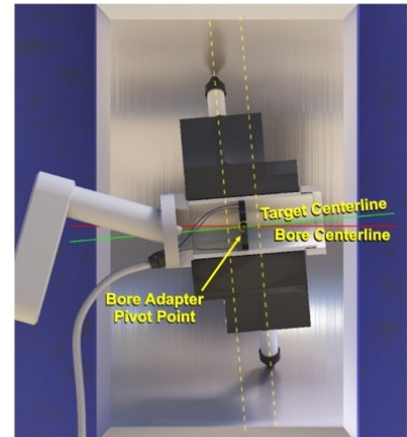
How the A-510 and A-510STA Self-Centering Adapters Work



**A-510/A-510STA
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 Adapter Hubs

1. Insert the A-510 Target into the bore adapter. Align the groove in the target to fit the pin in the bore adapter hub. Secure the laser to the bore adapter with the two screws and tighten using a 3/32 in. Allen wrench (see *Configuring and Assembling the A-510 Target for Barrel Alignment/Barrel Measurement on Page 17*).
2. Insert leg into A-510STA or A-510LTA and tighten the setscrew with an Allen wrench (provided) to push the leg against the OD of the A-510 Target.
3. Repeat Step 2 for the remaining legs.

Note: Ensure that the legs are removed from the adapter hub before inserting or removing the A-510 Laser.



Figure 10 – A-510STA Bore Adapter Legs and Hub



Figure 11 – Insert leg and tighten set screw in the A-510STA to push the leg against the OD of the A-510 Target



Figure 12 – Target/Adapter assembly completed

Model T-221 Bore Target

The Model T-221 Bore Target is a self-centering, small-bore target adapter hub for bores measuring 1.18 in. to 2.36 in. (30 mm-60 mm). Each bore diameter requires a set of M-221CLS Self-Centering Adapter Discs. The M-221CLS are replaceable in the diameter range noted above.

Note: *The T-221 can only be used in Self-Centering Mode.*

50 MM TARGET ASSEMBLY:

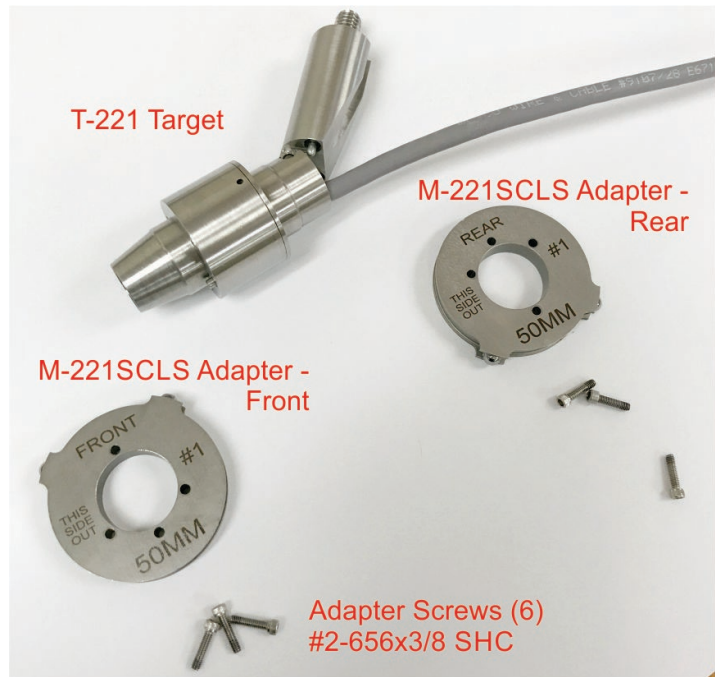
Top: T-221 Target,

Center left: 50 mm adapter

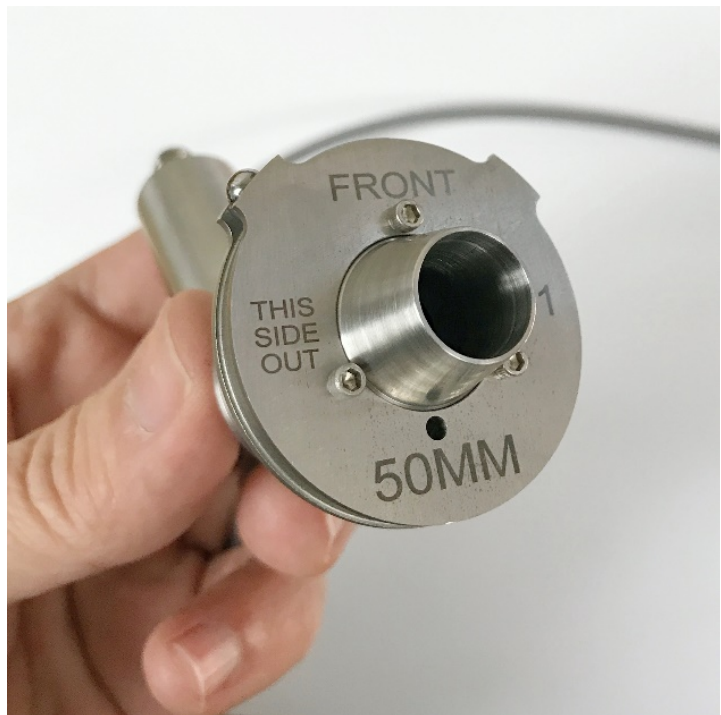
Center right: 50 mm adapter

Bottom: (6x) adapter screws, #2-56 x $\frac{3}{8}$

SHCS



Front 50 mm bore adapter installed.

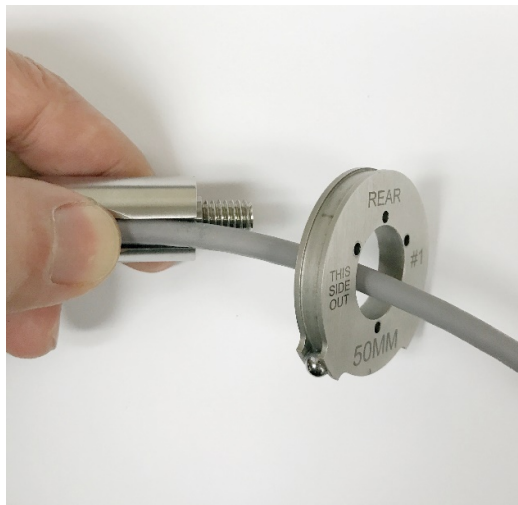


To install rear 50 mm adapter:

1. Slip cable through adapter.



2. Tuck cable into slot.



3. Slide adapter through to target.



4. Rear 50 mm adapter installed.



5. Complete target assembly with 50 mm adapters.



6. Attach pole and install level block to align it with the target.



7. Measuring orientation in a bore.



Configuring/Assembling the A-510 Target for Barrel Alignment/Barrel Measurement

The A-510 Target can be configured to work in either *Self-Centering Mode* or reversed to attach to the target in *Bore Measurement Mode* by inserting the target module into either one side or the other of the bore adapter.

Configuring for Barrel Alignment

Hold the adapter in the left hand (with the arrows on the *Self-Centering Mode* label pointing to the right). Insert the target module into the bore adapter from the right hand side. Insert and tighten (using a 3/32 in. Allen wrench) the two screws that secure a target to the bore adapter. The target module is now configured for an *alignment* procedure.

Configuring for Barrel Measurement

Loosen the screws and remove the target cell module from the bore adapter. Reverse and rotate the adapter until the *Bore Measurement Mode* label, with arrows pointing to the right, is in view. Re-insert the target module in the reversed bore adapter and tighten the screws using a 3/32 in. Allen wrench. The target module is now configured for a *measurement* procedure.

Attaching the Insertion/Retraction Pole

The insertion/retraction pole is equipped with a threaded target cell connector, a universal joint within a retainer tension spring and an aluminum pole drilled axially with reference holes.

To complete the A-510 Target assembly, the pole unit screws onto the back of the target cell housing at a preset, machined angle (the pole can be attached either before or after the module is inserted in the adapter).

The A-510 Target is now complete and ready to attach to the readout or interface.

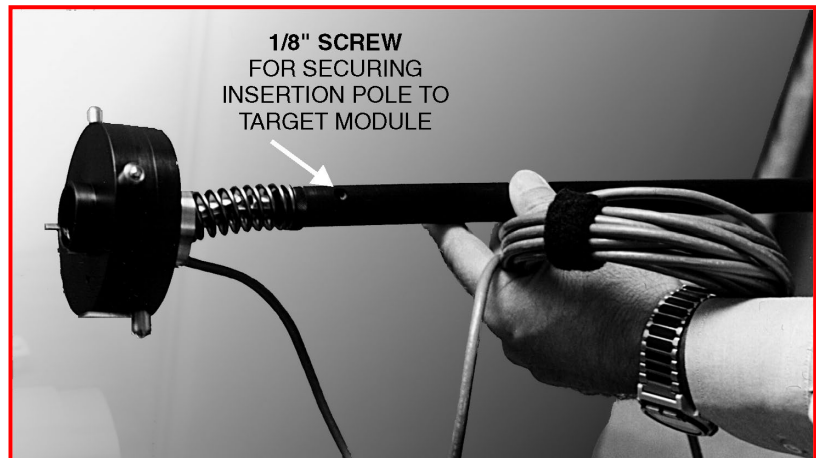


Figure 13 – Attaching the Insertion/Retraction Pole

Bore9 Software

Hamar Laser's new Bore9 software supports all of Hamar's past and present bore alignment equipment to create a powerful tool for measuring and aligning up to 50 bores. This comprehensive and easy-to-use program measures bore straightness (axis centering) and diameter change when using our targets in measuring mode. Applications include engine blocks, extruder barrels, hydraulic cylinders, large-bore gun barrels, printing press bearings, rotary compressors and turbines.

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.

- 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 **NORMAL-Inverted**, which briefly describes the method.

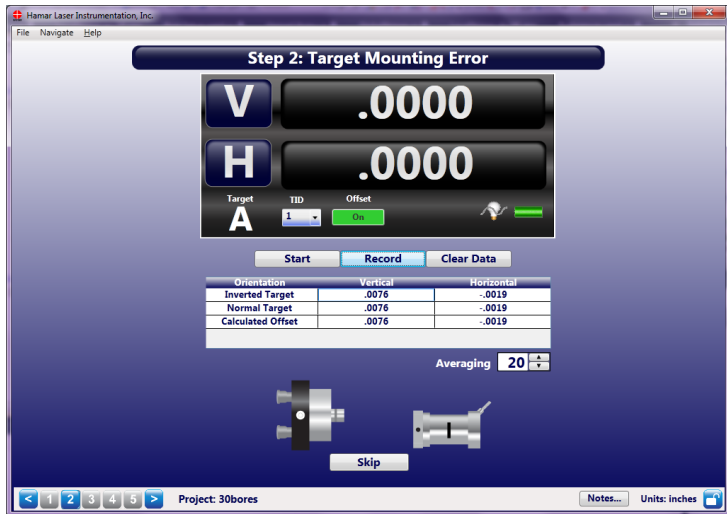


Figure 14 – Removing the Target Mounting Error

- 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.



Figure 15 – Bore9 Results Screen

Using Bore9, Step 3 – Buckin (Laser Setup)

Buckin (laser setup) calculates set points for making a laser parallel to two reference points, usually the end bores. Use the **Step 3: Buckin Wizard** to guide you through the Buckin process.

While performing **Step 3: Buckin**, the following options are available:



Restart – click to restart the Laser Buckin procedure.

Record – click when instructed to record data for laser setup.

Previous – click to return to the previous steps of the procedure.

Next – click to proceed to the next set of steps in the procedure.

Finished – **Next** becomes **Finished** when the last steps of the procedure display. Click **Finished** to proceed to **Step 4: Record Data**.

Select **Extruder Mount** if using the L-705 to align an extruder barrel to the gearbox.

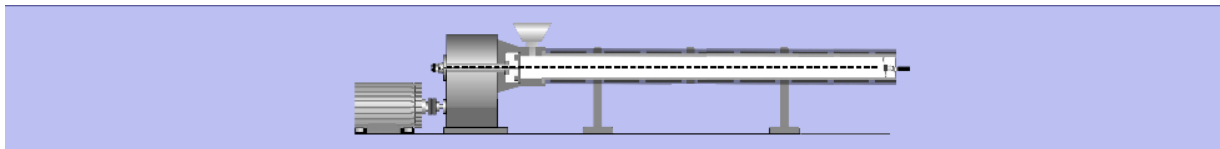
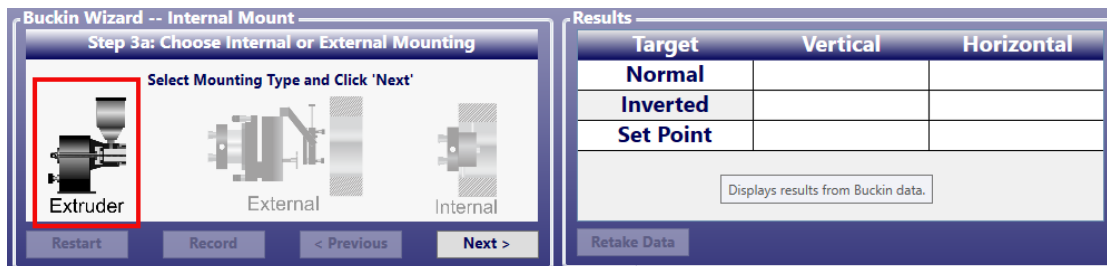


Figure 16 – Bore Setup Display showing Extruder Mount

Extruder Mount

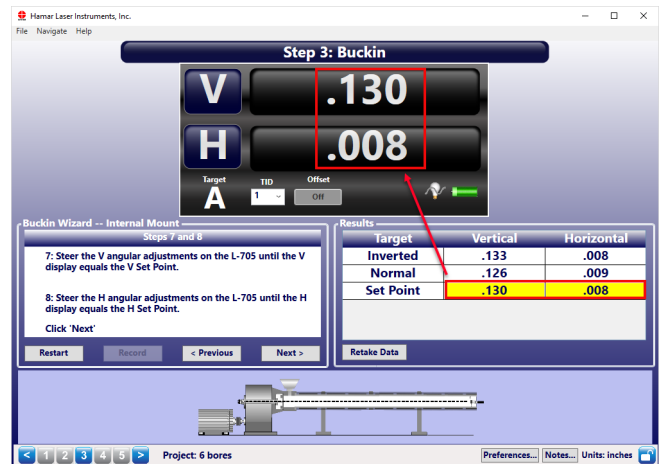


1. Select the laser mounting by clicking the **Extruder Mount** graphic. Click **Next**.
2. Place the A-705 Chuck Fixture into the counter bore in the gearbox and tighten in place. Place the L-705 into the A-705 and rotate it so the top level is centered in the circle.
3. Perform a Rough Buck-in of the laser to gearbox AOR to get the laser roughly aligned to the AOR. See Appendix H beginning on Page 63.
4. To perform the Fine Buck-in, rotate the gearbox spindle (with the A-705/L-705) 180 degrees to the Inverted position, making sure to center the bubble in the circle. Click **Record**.

| Results | | |
|-------------|----------|------------|
| Target | Vertical | Horizontal |
| Inverted | .133 | .008 |
| Normal | | |
| Set Point | | |
| Retake Data | | |

| Results | | |
|-------------|----------|------------|
| Target | Vertical | Horizontal |
| Inverted | .133 | .008 |
| Normal | .126 | .009 |
| Set Point | .130 | .008 |
| Retake Data | | |

5. Rotate the gearbox spindle (with the A-705/L-705) 180 degrees to the **NORMAL** position, making sure to center the bubble in the circle. Click Record.
6. Bore9 calculates a *Set Point*, which is the average of the two sets of readings.
7. Turn the Vertical micrometer on the L-705 until the V display equals the **Vert Set Point**, and then turn the Horizontal micrometer until the H display equals the *Horiz. Set Point*.
8. The laser is now bucked-in to the gearbox axis of rotation (AOR).
9. Repeat Steps 1-6 to verify the laser is bucked-in.
10. Go to **Step 4: Take Data**.

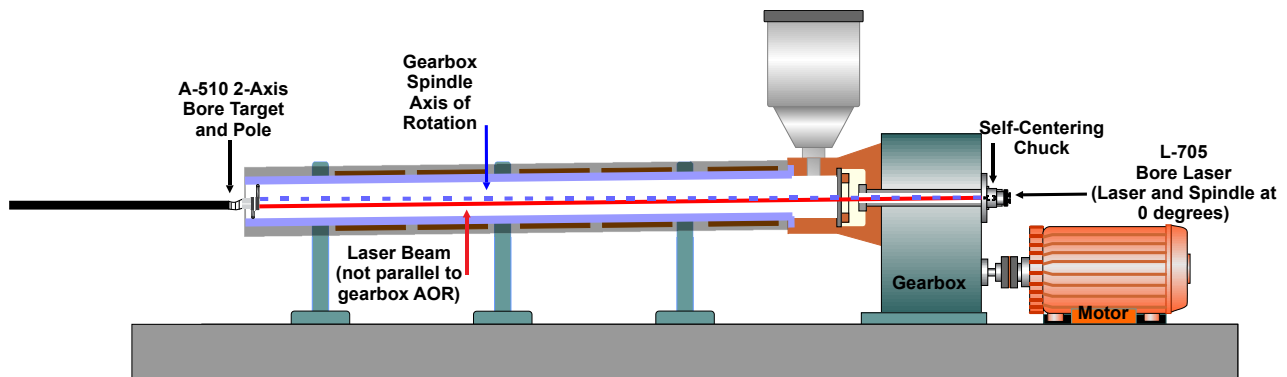


L-705 Extruder Alignment System (Overview of Basic Setup)

To perform an alignment, Hamar Laser's NORMIN procedure (see Appendix A beginning on Page 42 for a full description of the NORMIN procedure) is used to put the laser beam on the axis of rotation of the gearbox, which is then projected down the barrel to the target. It works like this:

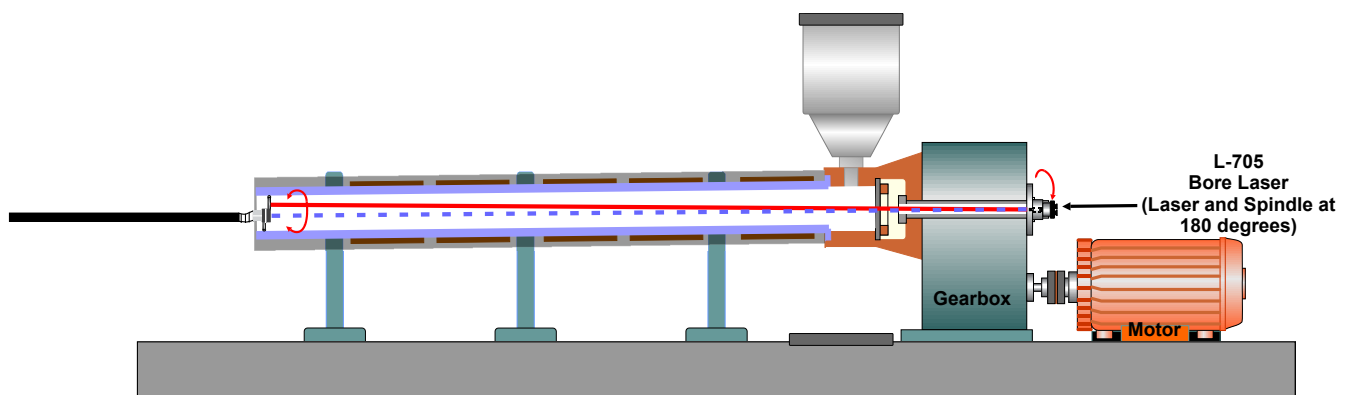
L-705 Extruder Alignment System – Basic Setup/Laser in Normal Position

1. Insert the laser and the self-centering laser fixture into the gearbox counter bore and the A-510 Target and A-510LST Bore Adapter into the free end of the barrel. Write down the H (horizontal) and V (vertical) readings.

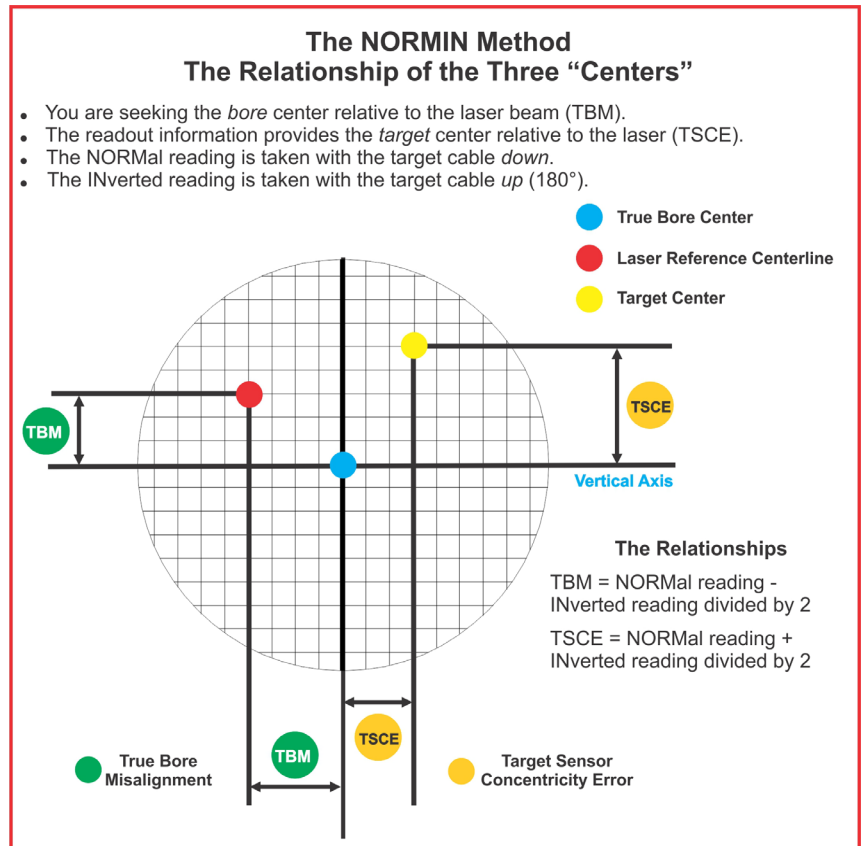


2. Rotate the gearbox by hand until the laser is inverted, using the built-in levels to determine the inverted position. Write down the second set of readings.

L-705 Extruder Alignment System – Laser in Inverted Position



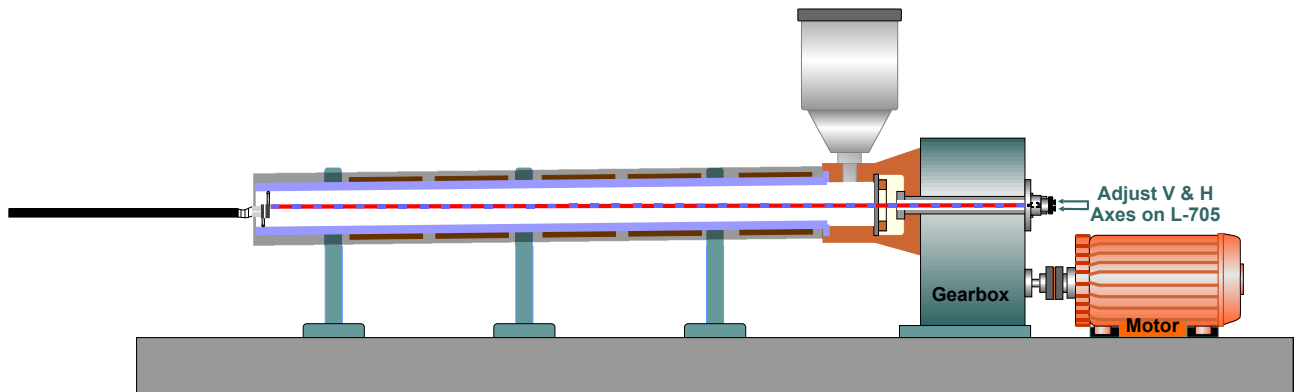
3. Average the horizontal values for NORMal and INverted, and then average the vertical values. The results determine the setpoints for the horizontal and vertical axes (see example below).



| | | | |
|------------------------------------|------------------|--------------------------------------|------------------|
| 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. |

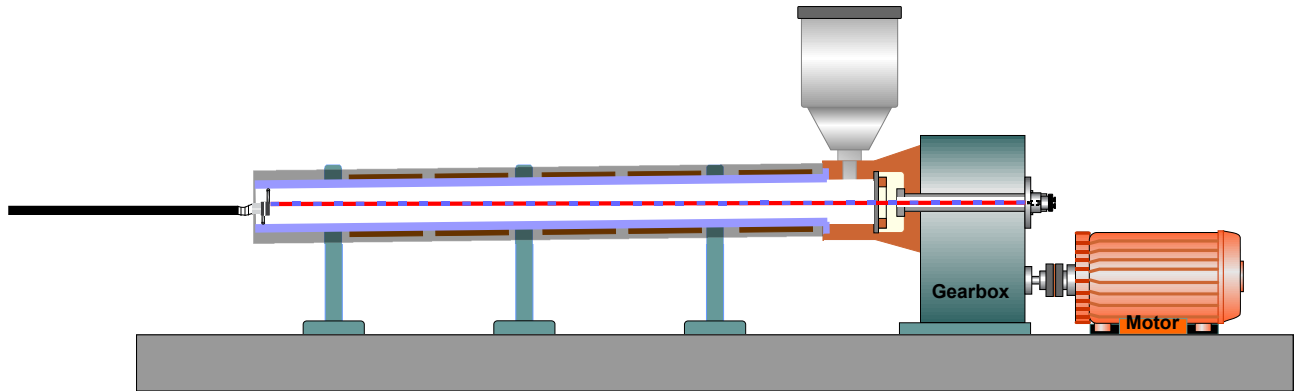
L-705 Extruder Alignment System – Adjust Laser Until Readout Displays the Set Points

4. Turn the angular adjustment micrometers until the setpoints display on the readout.

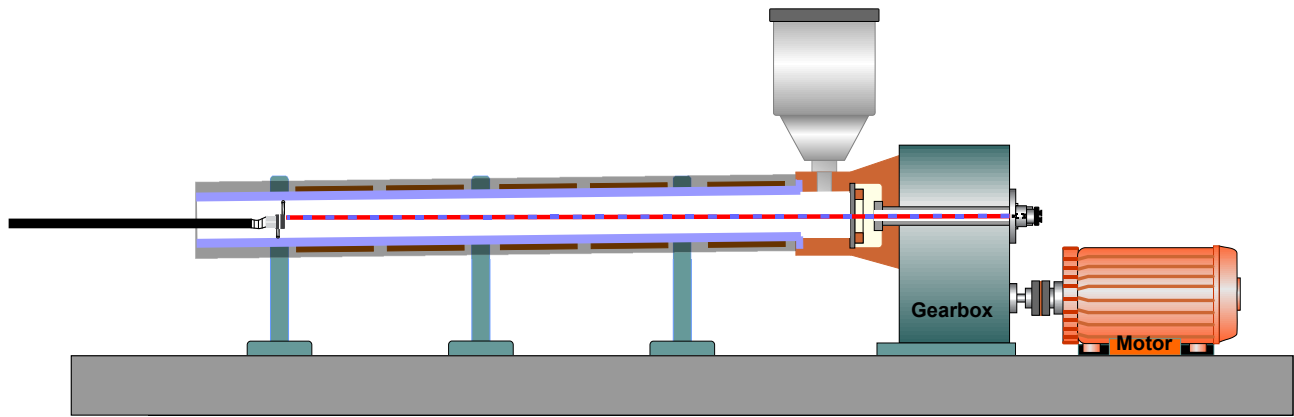


L-705 Extruder Alignment System – Laser Beam Concentric to Axis of Rotation

5. The reading produced from the NORMIN procedure is then a measure of the misalignment of the free end of the barrel to the gearbox axis of rotation. Leaving the laser and target in the barrel, the barrel can then be shimmed or moved until the readout displays .000 in. in both axes. If there is more than one adjustment point for the barrel, the target can be inserted into that point and it can be shimmed or moved until the readout reads .000 in.



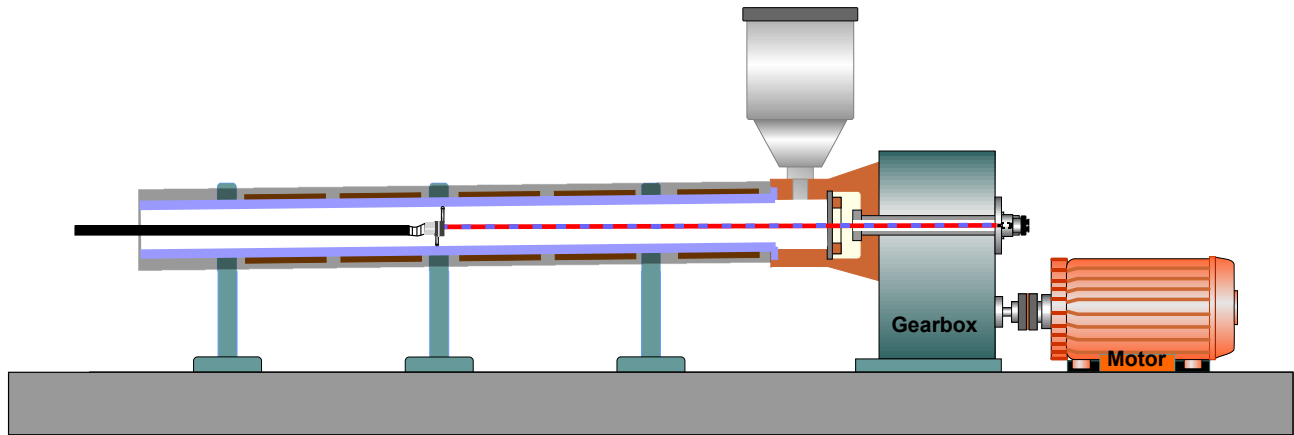
L-705 Extruder Alignment System – Target Inserted to First Adjustment Point



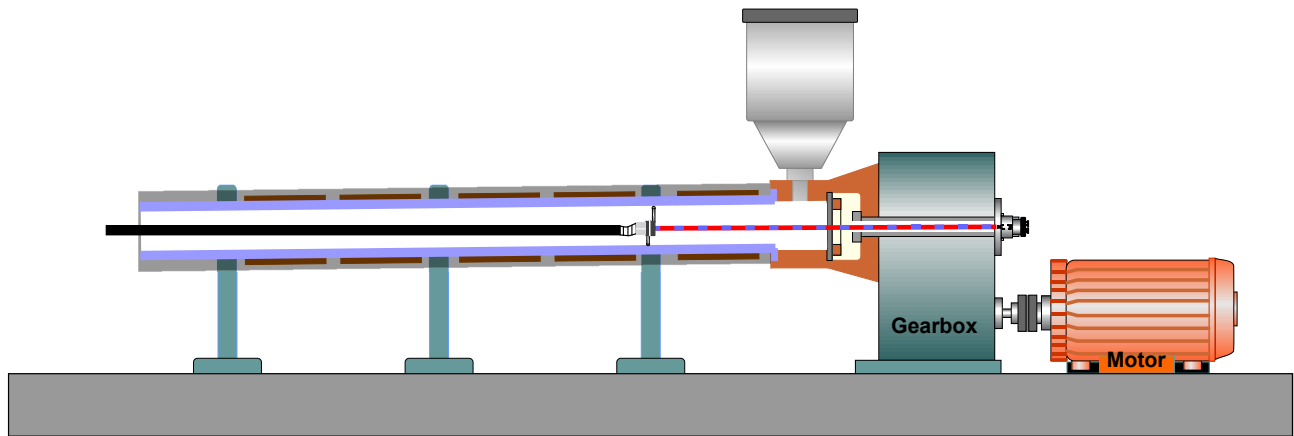
6. If there is more than one adjustment point for the barrel, then the target can be inserted into the barrel at the point just above the second support and the barrel can be shimmed or moved until the readout reads .000 in.

Note: It is always advisable to move the target back to the first support point and check to see if adjusting the barrel at the second point caused the alignment at the first support to be slightly out of tolerance.

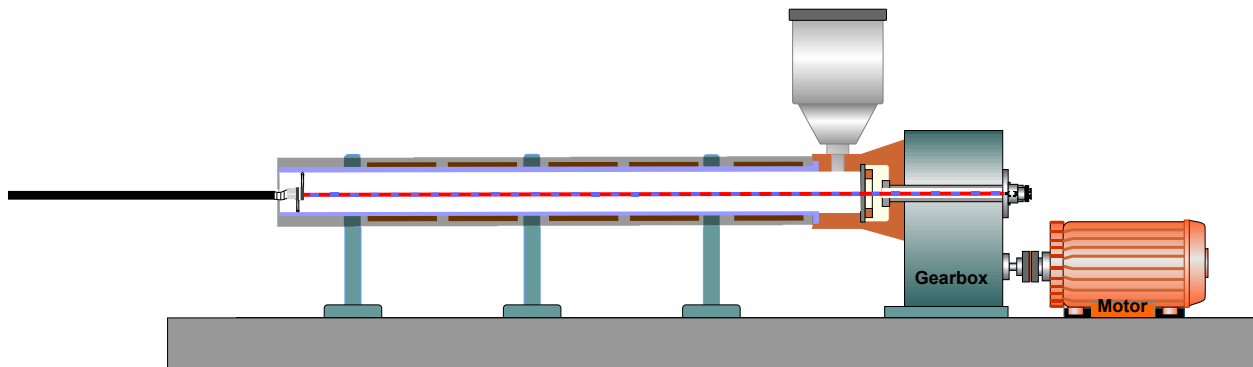
L-705 Extruder Alignment System – Target Inserted to Second Adjustment Point



L-705 Extruder Alignment System – Target Inserted to Third Adjustment Point



L-705 Extruder Alignment System – Barrel Aligned to Gearbox



Aligning Extruders

Hamar Laser's Extruder Alignment System is designed to align extruder barrels *and* to measure the inner diameter of a barrel or bore. Any bore from 1.5 in. (38 mm) to 14 in. (356 mm) can easily be measured with this alignment system, which consists of the L-705 Laser and gearbox adapter, the A-510 Target, barrel adapter, an insertion pole, and a digital readout or computer interface. This alignment system is highly accurate and easy to use.

Note: Bores as small as 1.5 in. require a customized, single-unit A-510 target and adapter. The standard A-510 Target can measure bores as small as 2 in.

The system may be used in two ways:

Extruder Barrel Alignment

The laser beam is projected down the center of the extruder barrel, extending the visible equivalent of the gearbox axis-of-rotation. The A-510 Target is secured in the far end of the barrel in Self-Centering mode (see Page 11). The target senses the presence of the laser beam, and the positioning data is displayed on the readout or computer interface.

The laser is adjusted using the micrometers on the rear of the laser, which tilt the laser beam until it is concentric with the gearbox axis of rotation (it may also be necessary to tilt the gearbox itself until the laser beam is aligned to the target center). The end of the extruder barrel is then moved in both the horizontal and vertical axes until the barrel end is aligned with the projected laser beam.

-OR-

Extruder Barrel Diameter Measurement

To measure barrel diameter, the target cell is reconfigured for Measurement mode (see Page 11). The target is then reinserted in the end of the barrel and qualified to the laser beam.

Normal (target cable down) and inverted (target cable up) readings are recorded at chosen locations along the inside of the extruder barrel. Diameter deviations and barrel straightness can be measured, and the data can be saved and plotted.

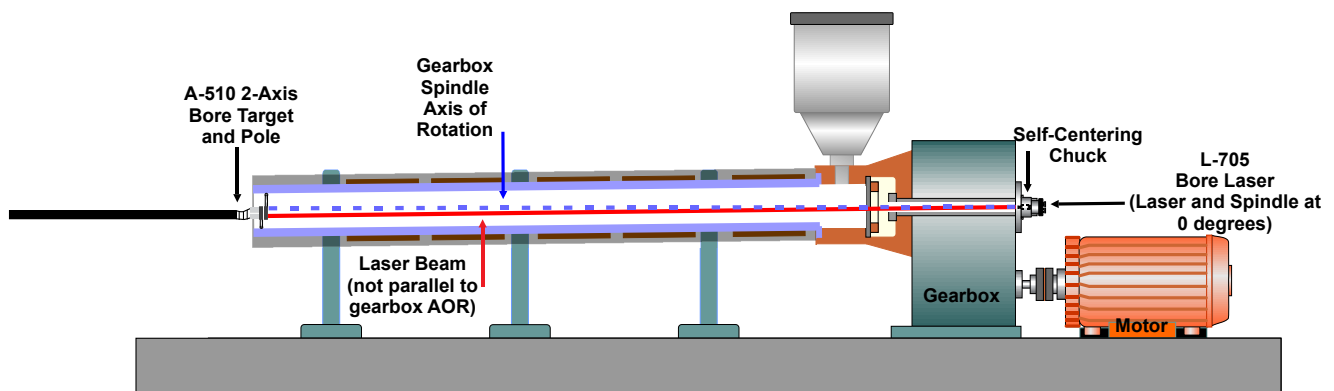


Figure 17 – Extruder Alignment with the Bore Laser System

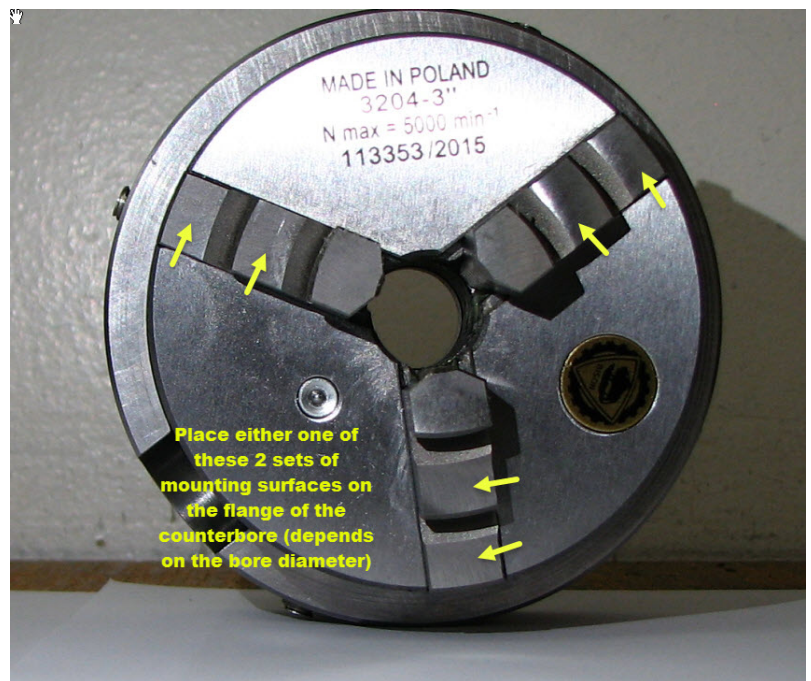
Setting up the Equipment – A-705 Gearbox Spindle Laser Fixtures

The L-705 Laser is held in the counterbore of a gearbox spindle by one of our four chuck fixtures:

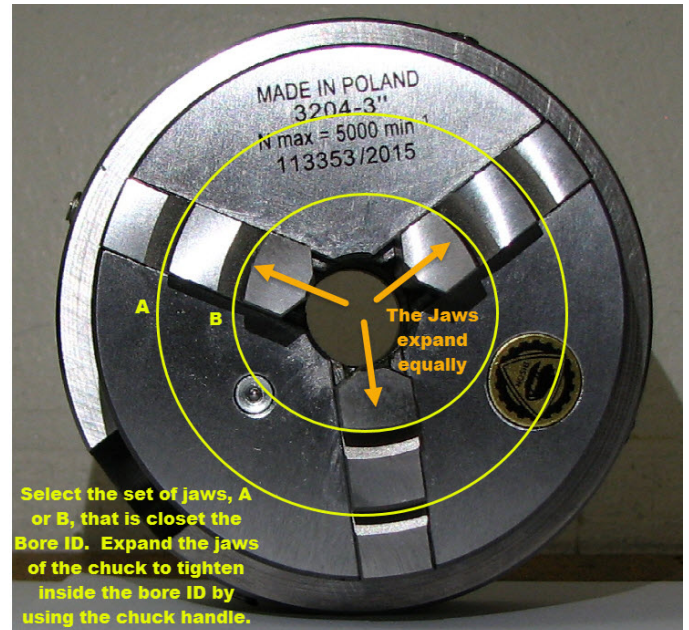
- *A-705 Self-Centering Chuck Fixture* – for counterbores from .755 in. to 3.250 in. (19 mm to 82.5 mm). This chuck centers itself into the counterbore. The mounting plate on the back is fixed and has been centered to the jaws of the chuck to within .0005 in. (0.013 mm).
- *A-705A Adjustable Chuck Fixture* – for counterbores from .755 in. to 3.250 in. (19 mm to 82.5 mm). The mounting plate on the back of this chuck is adjustable for those applications where the mounting surface in the counterbore is not well machined or for other poor mounting surfaces. With the L-705 inserted into the mounting plate, the plate is centered using an indicator.
- *A-705L Large-Bore Self-Centering Chuck Fixture* – for counterbores from 3.1 in. to 5.2 in. (79 mm to 131 mm ID). The mounting plate on the back is fixed and has been centered to the jaws of the chuck to within .0005 in. (0.013 mm).
- *A-705AL Large-Bore Adjustable Chuck Fixture* – for counterbores from 3.1 in. to 5.2 in. (79 mm to 131 mm ID). The mounting plate on the back of this chuck is adjustable for those applications where the mounting surface in the counterbore is not well machined or for other poor mounting surfaces. With the L-705 inserted into the mounting plate, the plate is centered using an indicator.

Assembling the A-705 Chuck Fixture and Installing the L-705 Bore Laser

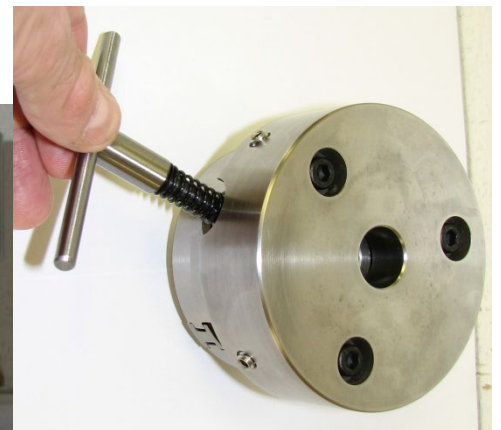
1. Install the A-705 Chuck into the counterbore, using the flat surfaces on the chuck to mount on the bore flange.



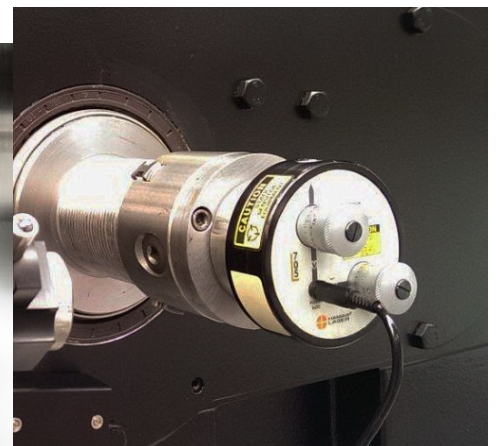
- Pick the set of chuck jaws that best matches the bore ID.



- Use the chuck key to expand the jaws in the bore ID to firmly hold the chuck fixture in place. Make sure to push the chuck flush against the flange of the bore as you tighten the chuck key.



- Place L-705 in the center hole and rotate the laser so that the level on the top of the flange reads level.

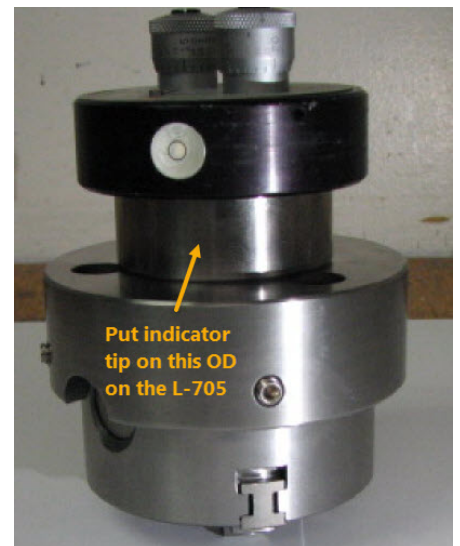


For the A-705 and A-705L Self-Centering Chucks, the chuck setup procedure is now complete. Please proceed to Step 12. For the A-705A and the A-705AL, please continue with Step 5.

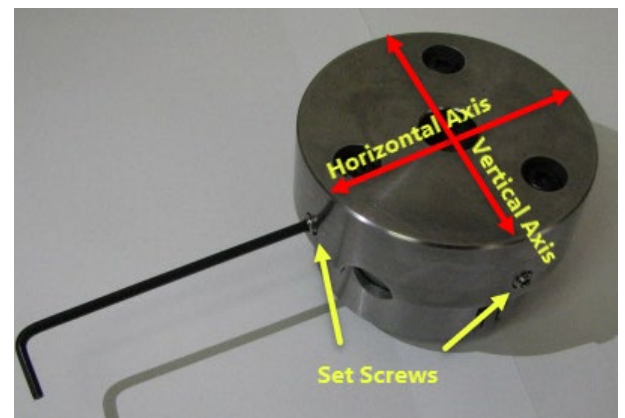
5. Loosen the large bolts on the A-705A mounting plate. Note that there is a spring washer underneath the bolt heads. Without too much pressure, re-tighten the bolts without collapsing the spring washers. The spring pressure will hold the chuck plate in place while the gearbox is being rotated but will also allow the plate to be moved with the set screws. If the bolts are tightened too much, the plate will not slide with the set screws.



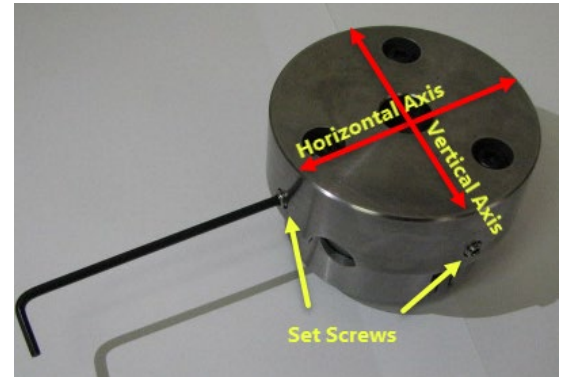
6. With the L-705 installed, take a dial/digital indicator and set it up so it is touching the 2.250 in. (57.2 mm) OD of the L-705 Laser.



7. Assuming the indicator tip is at 3:00, loosen the set screws for the Horizontal Axis and zero the indicator.



8. Rotate the gearbox 180 degrees. Read the indicator value and divide it by 2. Adjust the Horizontal Axis set screw until the indicator reads the averaged number. For example, after rotating the gearbox 180 degrees, if the indicator reads .030 in. (0.76 mm), then the set point is .015 in. (0.38 mm), so turn the set screw until the indicator reads .015 in. (0.38 mm). Lightly tighten the opposite set screw to hold the Horizontal Axis and rotate 180 degrees again. The indicator should still read .015 in. Repeat if necessary to get the same reading at 0 and 180 degrees.
9. Repeat Step 8 for the Vertical Axis.
10. Lightly tighten all the set screws. Zero the indicator again and slowly rotate the gearbox 360 degrees. The indicator should not show more than $\pm .001$ in. (0.025 mm) of deviation. This means the housing of the L-705 is now centered to axis of rotation of the gearbox.
11. Tighten all the large bolts on the mounting plate and redo Step 10 to ensure the plate didn't move when tightening the bolts. Proceed to the Laser Buck-in.



12. Set the micrometers to their nominal positions. The laser should be in the 12:00 position. When the laser is in place, set the micrometers to their NOMINAL positions, indicated on the laser housing. For further information, see **Adjusting the L-705 Laser** on Page 3.



13. Power on the laser. For the location of the On/Off Switch and lighted LED, see Figure 1.

Inserting the A-510/A-510STA Target and Self-Centering Adapter

1. Pull back on the target cable.

After attaching the target adapter to the A-510 Target, hold the target by the pole in one hand and grasp the cable firmly in the other hand. This flexes the target/adapter unit downward so that it can be pushed into the barrel.

Note: Pull on the target cable to either insert or remove the target from the barrel. Pull the cable gently. Excessive force can break wires that attach the cable to the target.

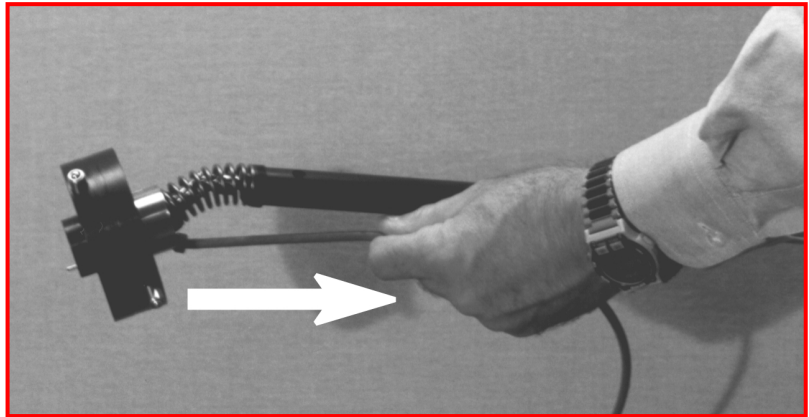


Figure 18 – Pulling Back the Target Cable

2. Insert the target.

While pulling back on the cable, insert the target in the end of the barrel to be aligned.



3. Release the cable.

As soon as the target is in place in the barrel end, release the cable. The target will center itself securely in place. It is important to make sure that the target cable is at the 6 o'clock position before releasing the cable.

Note: To release the target, pull the cable and remove.

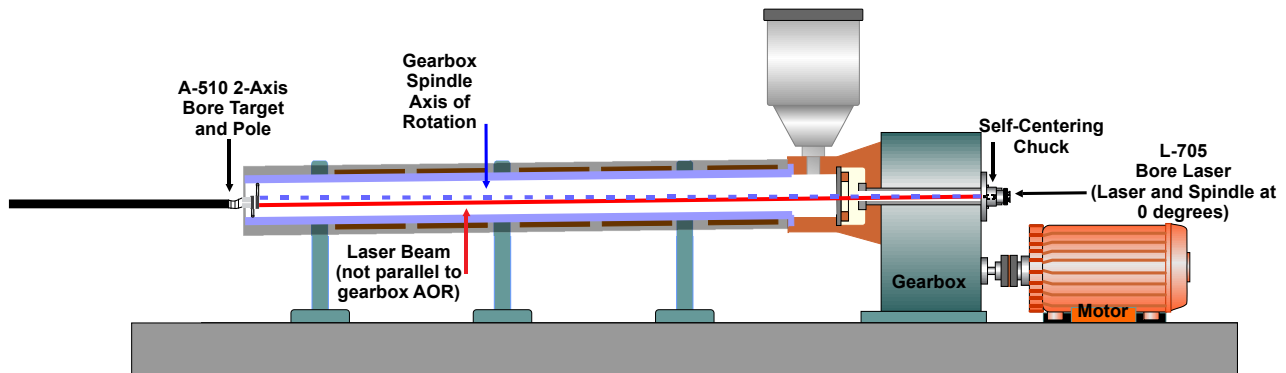


Figure 19 – Target inserted in barrel with R-1307 Readout

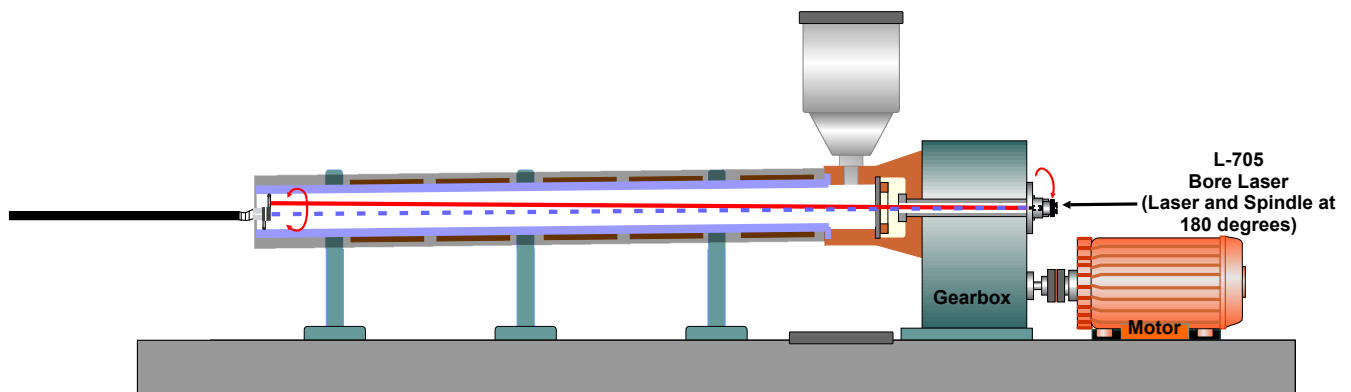
Qualifying the L-705 Laser

Before beginning alignment procedures, the laser beam needs to be made roughly parallel to the axis of rotation (AOR) of the gearbox. This is called *qualifying* the laser and ensures that the adapter is positioned so the laser beam will hit the target during barrel alignment. Coarse qualification can be performed using either the *Target Method* or the *Visual Method*. A variation of the NORMIN procedure (see Appendix A) is used for these coarse qualification procedures, except that the laser, gearbox adapter, and gearbox shaft are rotated rather than the target.

L-705 Extruder Alignment System – Basic Setup/Laser in Normal Position



L-705 Extruder Alignment System – Laser in Inverted Position



Coarse Qualifying the L-705 Laser Using the Visual Method

Note: This procedure is performed without the target inserted in the barrel.

- 1. Cover the far end of the barrel with white paper.**
Using a compass, draw a circle the same size as the bore diameter on a piece of white paper. Mark the center of the circle. Tape the paper to the far end of the barrel. The laser beam must be visible through the paper.
- 2. Mark the laser beam location on the paper.**
With the laser placed in the Normal (upright) position, draw a small circle where the laser beam hits the paper.

3. **Invert the laser, gearbox adapter and the gearbox shaft as a unit, and mark the laser beam location on the paper.** Using the bubble levels as a reference, rotate the gearbox output shaft, the laser, and the adapter *as one unit* a total of 180° until the level bubble on bottom of the laser is on top and centered. Draw a small circle where the laser beam hits the paper.

Note: The laser, adapter, and gearbox output shaft must be rotated *as one unit* -- do not rotate the laser by itself. **Ensure that the circular level bubble is centered, or the results will not be accurate.**

4. **Measure to find the setpoint and adjust the laser beam.** Using a ruler, measure the distance between the centers of both circles and mark the halfway point (see illustrations below). This is the **setpoint**. Turn the vertical and horizontal micrometers until the laser beam is centered on the setpoint mark.

5. **Invert the laser, gearbox adapter and the gearbox shaft as a unit to ensure that the laser beam remains at the setpoint.**

Following the instructions in Step 3, invert the laser, gearbox adapter and the gearbox output spindle *AS A UNIT* to ensure that the laser beam is still centered on the setpoint mark. If not, adjust the vertical and horizontal micrometers until the laser beam remains stable on the setpoint.

6. **Measure the distance from the setpoint to the mark at the center of the circle.**

If the distance from the setpoint to the mark at the center of the circle is ¼ in. or greater, move the end of the extruder barrel until the center mark lines up with the setpoint mark (see Figure 20).

7. **Complete the set up procedures.**

Remove the paper and insert the target in the extruder barrel, as described on Page 31.

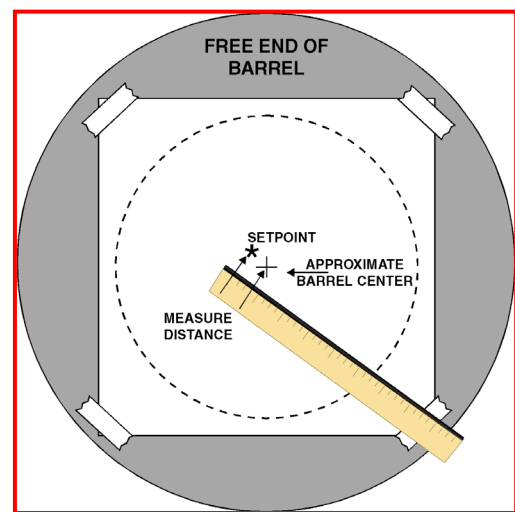
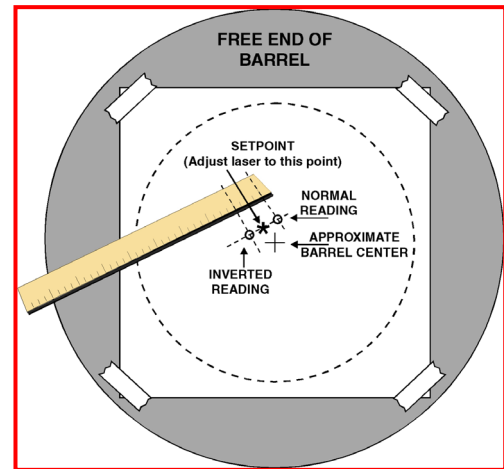


Figure 20 – Coarse qualification using the Visual Method

Coarse Qualifying the L-705 Laser Using the Target Method

1. **Insert the target.**

Insert the target into the barrel as far as possible (see the instructions for inserting the target on Page 31). Depending on the length of the barrel, this may require adding additional extensions to the insertion pole provided with the target.

2. **Take a Normal center reading.**

With the laser placed in the Normal (upright) position, record the readings (vertical and horizontal) displayed on the readout.

3. **Invert the laser, gearbox adapter and the gearbox shaft AS A UNIT.**

Using the bubble levels as a reference, rotate the gearbox output spindle, the laser, and the adapter *as one unit* a total of 180° until the level bubble on bottom of the laser is on top and centered.

Note: The laser, adapter, and gearbox output shaft must be rotated *AS ONE UNIT* -- do not rotate the laser by itself. **Ensure that the circular level bubble is centered, or the results will not be accurate.**

4. **Take an Inverted center reading.**

With the laser placed in the Inverted position, record the readings (vertical and horizontal) displayed on the readout.

5. Average the Normal and Inverted readings to find the setpoints for each axis.

Find the sum of the readings and divide by 2 (the number of readings) to qualify the laser to the gearbox axis-of-rotation.

$$\frac{\text{Normal reading} + \text{Inverted reading}}{2}$$

2

Calculations for vertical and horizontal readings must be done separately. The formulas for vertical and horizontal setpoints are:

$$\frac{\text{Normal V} + \text{Inverted V}}{2} = \text{V SETPOINT}$$

$$\frac{\text{Normal H} + \text{Inverted H}}{2} = \text{H SETPOINT}$$

For examples of calculations using these formulas, see Page 35.

6. Adjust the micrometers on the laser until the readout shows the calculated setpoints.

Turn the vertical and horizontal micrometers until the readout display shows the vertical and horizontal setpoints calculated in Step 5. Reposition the target at the far end of the barrel and proceed with the fine qualification procedure described on Page 35.

Note: To double-check the settings, rotate the laser back to the Normal position. The numbers on the readout display should remain the same. If the readout numbers change significantly between the Normal and Inverted positions, (more than $\pm .001$ in. per 10 ft. of barrel) repeat Steps 2 - 6 before continuing the alignment.

Fine Qualification and Performing Alignments

Fine qualification of the L-705 Laser to the gearbox axis-of-rotation is a crucial step in performing barrel alignment and bore diameter measurement procedures. Once a laser has been qualified, the projected laser beam will be an extremely accurate and repeatable extension of the true gearbox axis-of-rotation and, by extension, any screws or sleeves that are keyed in place.

Using the NORMIN Procedure, (see Appendix A) position readings are collected with the laser in both the Normal and the Inverted positions. These readings are averaged and micrometer control position is adjusted to split the difference and center the laser beam.

1. **Ensure that the target is inserted in the far end of the barrel (see *Inserting the Target* on Page 31).**
2. **Take a Normal center reading.**

With the laser placed in the Normal position, record the readings (vertical and horizontal) displayed on the readout.

3. **Invert the laser, gearbox adapter and the gearbox shaft *as a unit*.**

Using the bubble levels as a reference, rotate the gearbox output shaft, the laser, and the adapter *as a unit* a total of 180 degrees until the level bubble on bottom of the laser is on top and centered.

Note: The laser, adapter, and gearbox output shaft must be rotated *as a unit*. Do not rotate the laser by itself. **Ensure that the circular level bubble is centered, or the results will not be accurate.**

4. **Take an Inverted center reading.**

With the laser placed in the Inverted position, record the readings (vertical and horizontal) displayed on the readout.

5. **Average the Normal and Inverted readings to find the setpoints for each axis.**

Find the sum of the readings and divide by 2 (the number of readings) to qualify the laser to the gearbox axis-of-rotation.

$$\frac{\text{Normal reading} + \text{Inverted reading}}{2}$$

Calculations for vertical and horizontal NORMIN readings must be done separately. The formulas for vertical and horizontal setpoints are:

$$\frac{\text{Normal V} + \text{Inverted V}}{2} = \text{V SETPOINT}$$

$$\frac{\text{Normal H} + \text{Inverted H}}{2} = \text{H SETPOINT}$$

The following examples illustrate calculations for the vertical and horizontal setpoints:

| | |
|---------------------------|---------------------------|
| $V_N = -.016$ | $H_N = -.016$ |
| $V_I = \underline{+.008}$ | $H_I = \underline{-.008}$ |
| $-.008$ | $-.024$ |
| Divide by 2 | Divide by 2 |
| V Setpoint = $-.004$ | H Setpoint = $-.012$ |
| $V_N = +.016$ | $H_N = +.016$ |
| $V_I = \underline{+.008}$ | $H_I = \underline{-.008}$ |
| $+.024$ | $+.008$ |
| Divide by 2 | Divide by 2 |
| V Setpoint = $+.012$ | H Setpoint = $+.004$ |

6. Adjust the micrometers on the laser until the readout shows the calculated setpoints.

Turn the vertical and horizontal micrometers until the readout display shows the vertical and horizontal setpoints calculated in Step 4. The laser beam is now parallel to the axis of rotation (AOR) of the gearbox spindle. The displayed vertical and horizontal values are the amount that the end of the barrel is misaligned relative to the gearbox AOR.

***Note:** To double-check the settings, rotate the laser back to the Normal position. The numbers on the readout display should remain the same. If the readout numbers change significantly between the Normal and Inverted positions (more than ± 0.001 in. per 10 ft. of barrel), repeat Steps 1 - 5 before continuing the alignment.*

7. Adjust the barrel until the target position is centered.

With the target mounted approximately over the adjustment point of the barrel, adjust the barrel until the readout displays .000 in. for both the vertical and horizontal axes. If there is more than one adjustment point for the barrel, move the target to the next adjustment point and repeat the adjustment procedure. Continue adjusting the barrel until all the targets reads zero over all the adjustment points.

8. Lock the barrel in position.

Lock the barrel into position so that the target readout display remains zeroed after all bolts are tightened.

Measuring Barrel Wear

The Extruder Package can also be used to measure wear in an extruder barrel. This is done by taking measurements at a number of points along the inside of the barrel, then calculating the change in a parameter called the Target Centering Error (TCE) at each measured point. Target Centering Error is defined as the distance between the electrical center of the target and the mechanical center of the bore or barrel. The results can be compared to a reference diameter to plot actual diameters. The amount of wear at any given point along the barrel can then be determined.

The following procedure assumes that the user will manually record, calculate, and plot the readings. If a computer interface is used, a bore measurement program is available which records, calculates and plots the data for the user. For instructions on using the Bore program, see the Bore9 software manual.

For this procedure, the laser should be qualified to the barrel (as in the previous procedure), and the target must be assembled in Measurement Mode (see Page 11).

Reconfiguring the A-510 Target

The following is the procedure for converting the target from Self-Centering to Measurement Mode. For more information, see *Configuring and Assembling the A-510 Target* on Page 11.

- 1. Remove the A-510 Target.**

Loosen the two retaining screws on the back of the target body. Remove the target body (with or without the pole attached) from the adapter.

- 2. Flip the adapter.**

Flip the adapter over so that the target cell module can be inserted into the adapter in Measurement mode.

- 3. Reinsert the target.**

Slide the target assembly into the adapter using the location pin as an assembly cue. Tighten the two retaining screws on the back of the target.

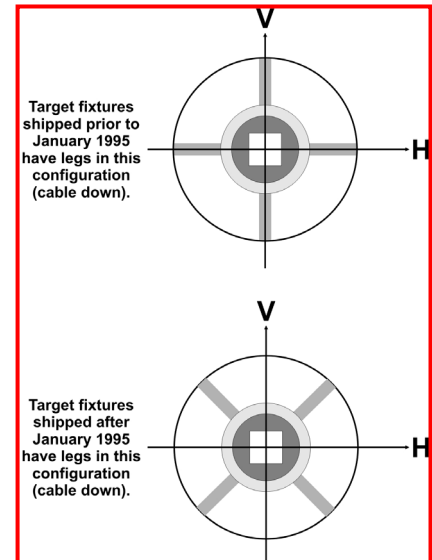


Figure 21 – Target configurations

Taking Measurements

1. Insert the target assembly into the barrel at the reference location.

Choose a location in the barrel where the diameter is known. This is the *reference location*. Pull on the release cable and insert the reconfigured A-510 Target into the extruder barrel with the cable down (Normal position). Move the target to the reference location and pull back firmly on the target pole to wedge the target in place.

2. Take a Normal reading at the reference location.

Take a reading with the target in the Normal position and record the numbers on a worksheet.

3. Rotate the *target assembly* to the inverted position.

Pull on the target cable to release the pressure and rotate the whole target assembly 180° (use the hole in the target pole or the target fixture legs as a guide. When the A-510 Target is rotated 180 degrees, the pole will need to be elevated and supported to keep the target positioned correctly). **Do not move the laser assembly!**

Note: Be sure to keep the target assembly in the same axial location in the barrel when inverting it.

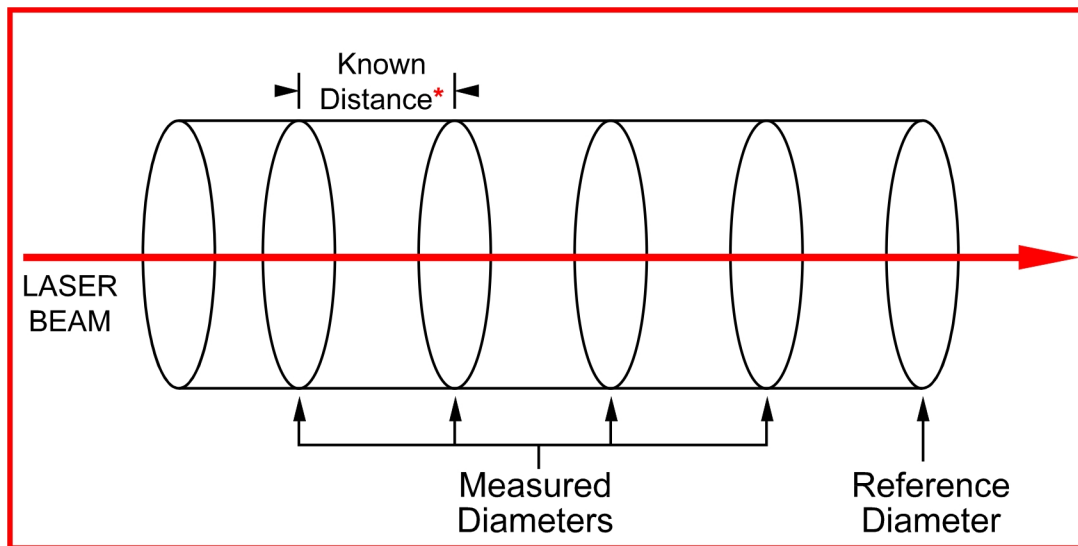
4. Take an Inverted reading.

Take a reading in the Inverted position and record the readings.

5. Repeat Steps 1 - 4 at each measured point.

Determine the number of points to be measured. Using the holes on the target pole, drilled on 1 ft. (305 mm) centers, move the target to each location and take Normal and Inverted readings. Record the numbers on a worksheet.

Note: If the user wishes to take measurements using specific intervals other than one foot, the distances can be marked on the target pole with pieces of tape.



* The A-510 Target has built-in markers for 1 ft. spacing, but the user can select any desired distance between the measured points.

Figure 22 – Taking measurements at specific intervals

Calculating Bore Diameters

Once the measurements have all been taken, a few simple calculations will provide detailed information on the internal diameter of the extruder barrel. 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 the barrel diameter, the user calculates the offset between the target center and the barrel 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:

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

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:

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

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: $(\text{RDT} - \text{MDT}) \times 2$

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:

$$\text{Measured Point Diameter} = \text{Reference Location Diameter} + (\text{MDT} - \text{RDT}) \times 2$$

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 | | | | |

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

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

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

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 24 on Page 41).

| 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 23 -- Chart for Readout Data

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

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

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

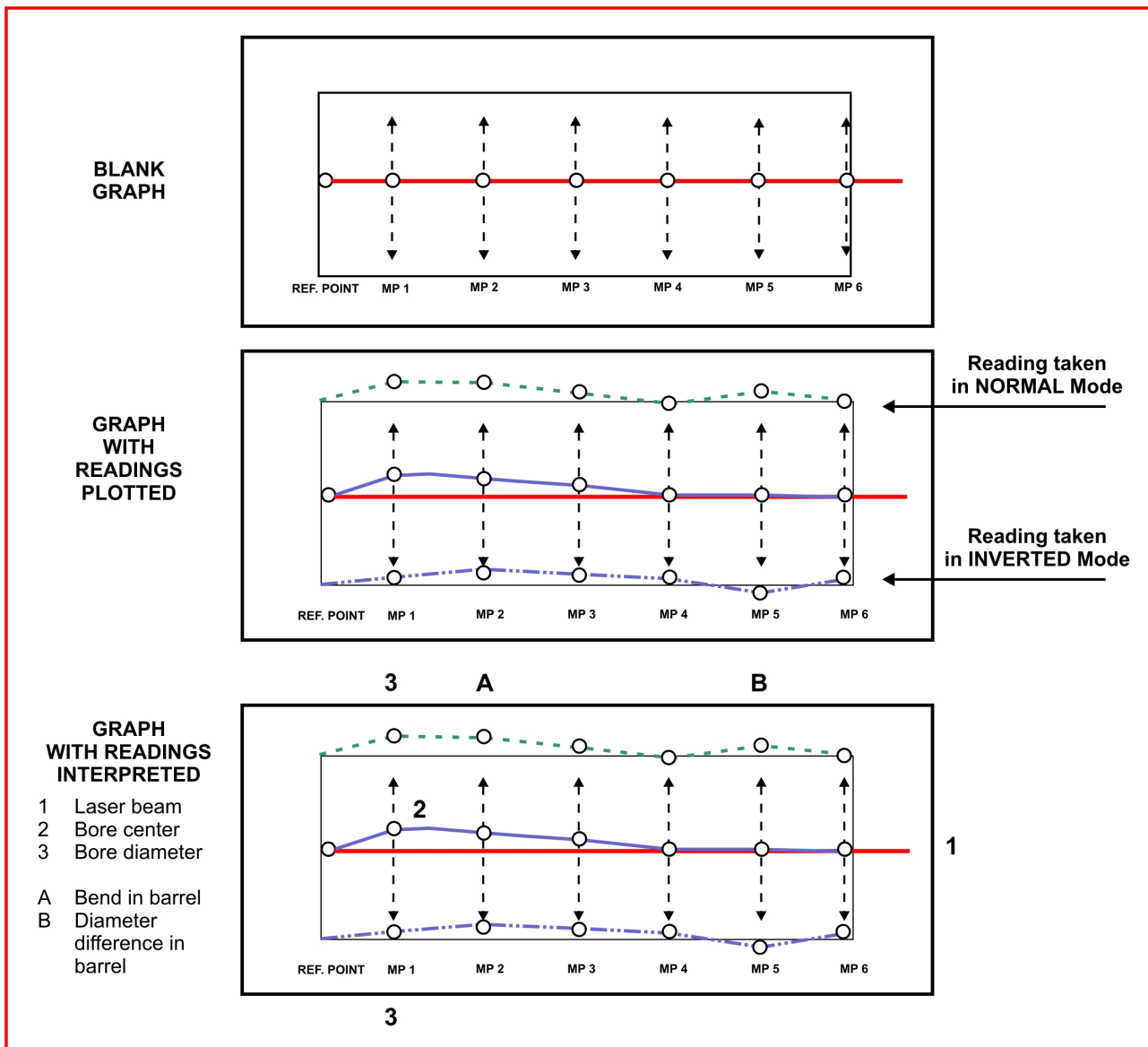


Figure 24 – Sample plot of readout data

Checking Straightness with Bore9 Software

The straightness of a single bore can easily be checked without having to use the NORMIN procedure, as long as an alignment is not required. Fixture the laser into one end of the bore and place the self-centering target (A-510) in the other end. Adjust the laser so the readings are zero (.000 in. or .0000 in.) and start taking measurements. The A-510 target pole is used to push and position the target into each measuring point, and can take measurements up to 30 ft. (9.144 m) into a bore. See Page 18 for a description of the Bore9 Software.

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.

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 27.

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 26 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.).

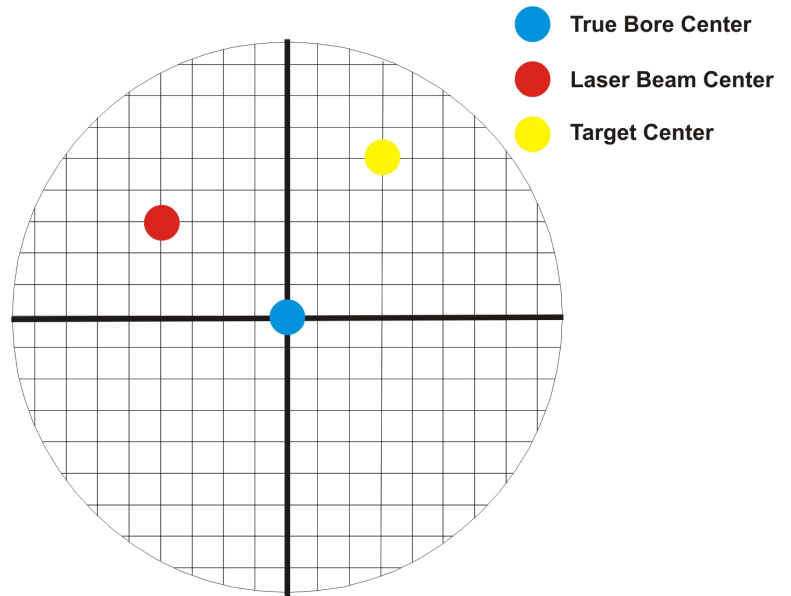


Figure 26 – Target in the NORMal position

Figure 27 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 27, 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.

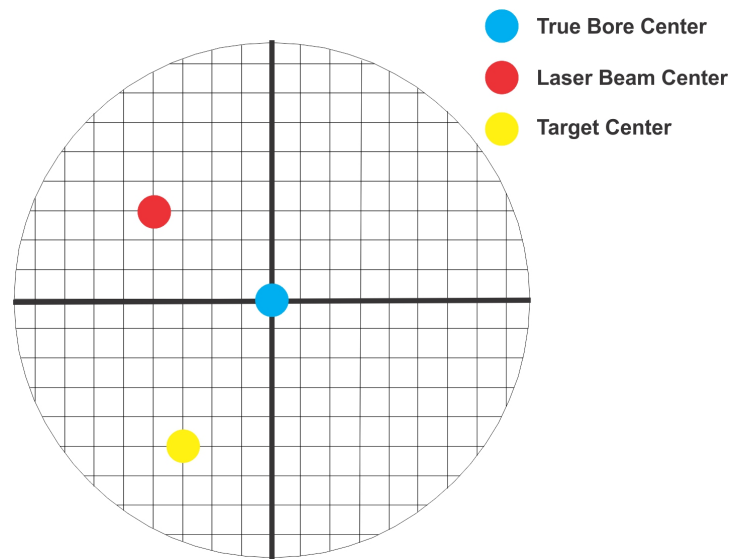


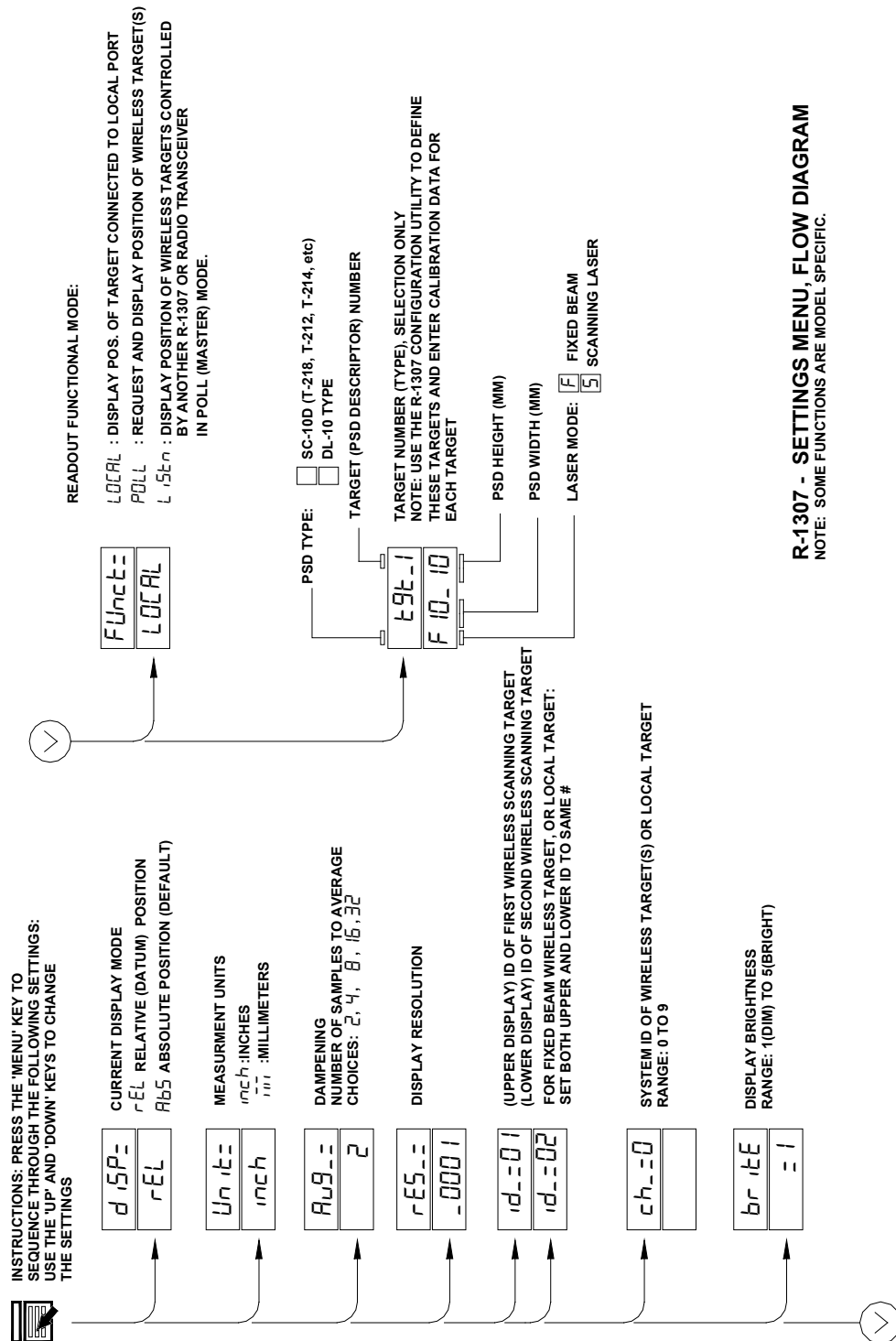
Figure 27 – Target in the INverted position

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

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

Appendix C – The R-1307 Menu

For a complete description of the functions of the MENU key, please see the R-1307 manual.



Appendix D – The A-910 Radio Transceiver/Hub

Front Panel Features

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



Figure 28 – The A-910 Radio Transceiver/Hub FRONT PANEL

Rear Panel Features

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



Figure 29 – The A-910 Radio Transceiver/Hub REAR PANEL

See Appendix E for radio specification details.

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

Using the R-1307 with a Cabled (Local) Target and the A-910 Radio Transceiver

Setting the Target Network ID and System ID for the R-1307 Readout

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 Readout/Target Network ID

Press the MENU button until the *upper* display shows $id = nn$ (nn is also equal to the R-1307 number and the matching Target number with the current Target ID (nn) blinking. Use the UP and DOWN arrow keys to set the Target ID.

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.

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.

Note that **nn** must be set to the same number as the channel switch setting of the A-910 radio transceiver (see Figure 28, #5).

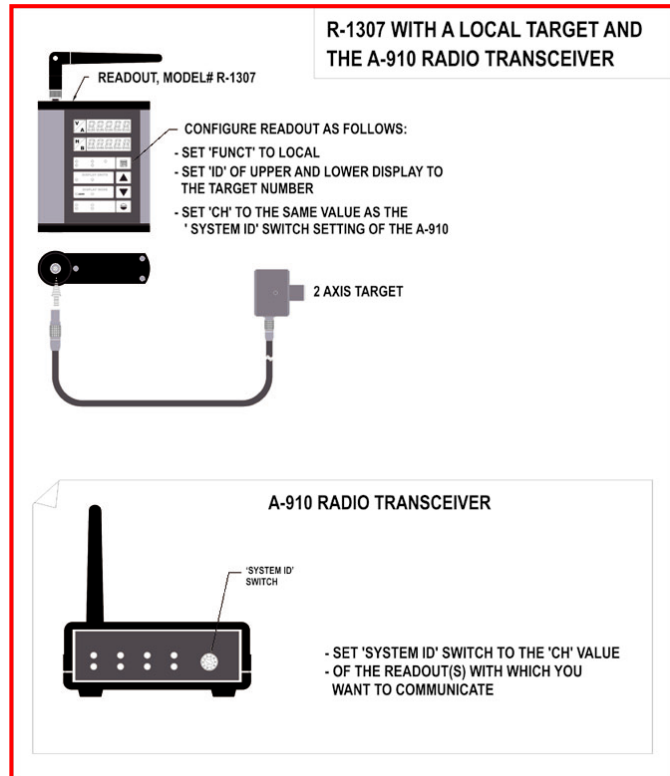


Figure 30 -- R-1307 with Cabled (Local) Target and A-910 Radio Transceiver

Miscellaneous Display Messages

- HLI -

r 1.00

...

- - -

ch = nn

r Ad id

FAULT

PSd

EEt_n

UncAL

Startup Message. Lower Display shows firmware Revision Number.

3 moving dots. Wireless target is not responding to a polling request from Readout. Check ID and Channel settings. Check Target(s).

3 dashes. Target detected but the laser is not on target. Check laser.

Radio channel cannot be selected because no Radio is present or detected.

Standard message for R-1307C. For Models R-1307 or R-1307W, this message indicates a fault in the radio module.

Indicates a problem with the connection to the Cabled (Local) Target's Position Sensing Device (PSD). Check plugs and cable(s).

Target 'n' descriptor does not contain target calibration data.

See Appendix C on Page 45 for the complete R-1307 menu.

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

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

This driver is required for the A-910-2.4ZB Transceiver and to communicate with targets via the computer's USB port. The driver creates a virtual COM Port that is recognized by the applications as a standard serial port.

***Note:** You must pre-install this driver prior to connecting the device(s) to the computer through the USB port.*

Installing the Driver

1. Insert the A-910-2.4ZB Radio Programmer CD in the CD ROM drive.
2. Select **My Computer**, locate the CD ROM icon and click to open it.
3. Select the USB Drivers folder.
4. Select the correct Operating System installed on your computer (Windows 2000, Windows XP, etc.) and open the folder.
5. Locate the **CP210x_VCP** icon and click to initiate the installation process. The **Install Driver** dialog box displays.
6. Click **Browse** to select an installation folder different from the default folder (optional).
7. Click **Install** to continue. Once the installation is complete, the **Installation Successful** message displays (see Figure 31).

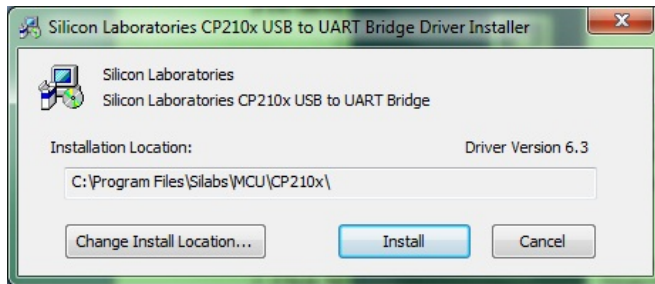


Figure 31 - USB Common Driver Install

Installing the A-910 Utility Software

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

Configuring the Hardware and Utility Settings

1. Insert the A-910-ZB dongle into any unused USB Port (see Figure 32). The computer should automatically assign a COM port number to the dongle.
2. Start the A-910 Utility Software. The software should display the COM port assigned to the Zigbee Dongle (see Figure 33). If the utility does not automatically detect the COM port, it must be manually selected (see *Manually Selecting a COM Port* on Page 50).
3. The Target System ID or R-1307 CH (channel) is the number associated with the A-1519/1520 targets or R-1307 Readout. If using both the A-1519/1520 targets and an R-1307 Readout, both need to be set to the same system ID and channel (see Figure 34). Also see *Setting the Target System ID and Network ID* on Page 51 and the R-1307 user's manual.



Figure 32 – A-910-2.4ZB Dongle



Figure 33 – A-910 Utility showing the COM Port, System ID and Channel settings

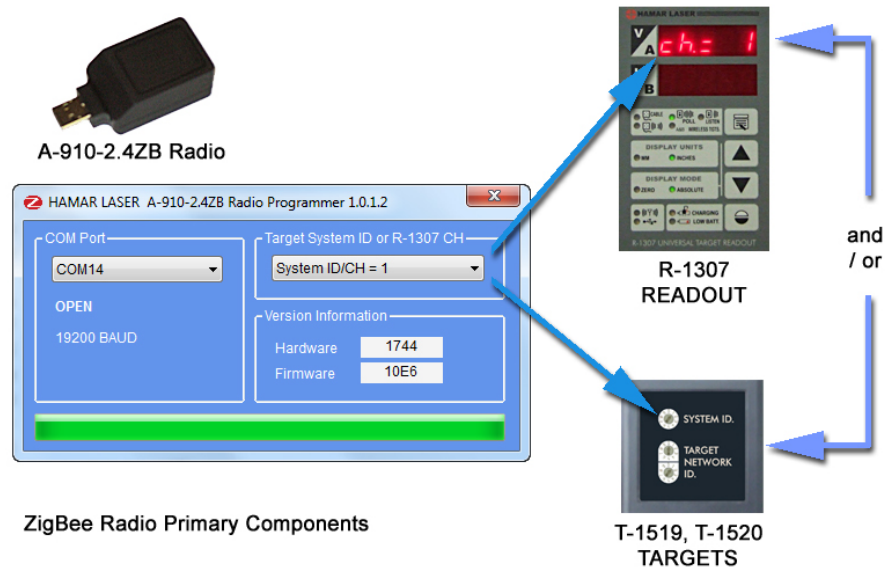


Figure 34 – System ID Setup

Manually Selecting the COM Port

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

Windows XP

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

Windows 7

1. Click the **Start** button and select **Control Panel**.
2. Click the **System** icon.
3. In the **System** window, click on the Device Manager link located under the **System** heading.
4. In Device Manager, scroll down to **Ports**. Expand the listings under **Ports** to reveal all the ports installed.
5. Locate **SILICON LABS CP210x USB to UART Bridge (COM x)** as shown in Figure 35.
6. Note the COM Port listed and select that COM Port in the A-910 Zigbee Utility software using the drop-down arrow (see Figure 33).

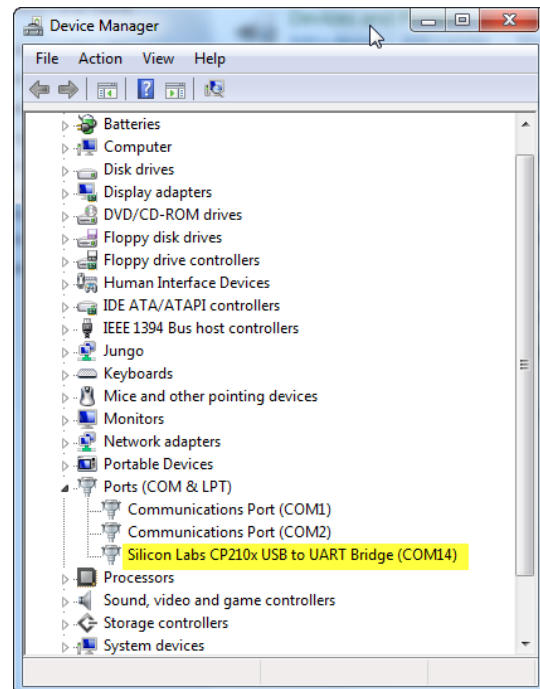


Figure 35 – Device Manager showing COM Port for A-910 Dongle

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

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

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

There are three rotary DIP switches located on the right side of the target, shown in Figure 36:

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

Setting the System ID

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

Using a small screwdriver, rotate Switch 1 to align the arrowhead with the System ID number (0-9). Figure 36 shows the System ID switch set to 1.



Figure 36 – Unitarget ID Switch set to 1

Appendix E – Agency Certifications

Agency Certifications for the 2.4 GHz Radio Transceiver

FCC (United States of America) Certification

Contains FCC ID: OUR-24XSTREAM

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



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

IC (Industry Canada) Certification

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



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

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

Technical Data:

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

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

Agency Certifications for the 900 MHz Radio Transceiver

FCC (United States of America) Certification

Contains FCC ID: OUR-9XCITE

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



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

IC (Industry Canada) Certification

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

Appendix F – Discontinued Components

Model R-307V 2-Axis Large Number LED Readout

The dual-window R-307V displays the results of any vertical and/or horizontal offset of the target from the laser beam using large LED displays to provide easy viewing at a long distance. Results may be displayed in three resolutions, user-selectable from .001 in., .0001 in. or 0.01 mm.

The R-307V has a FAST response setting for short distances and a SLOW response setting for long distances to add damping or electronic averaging to the readout circuit. Dashes in the display windows show immediately when the laser is off-target.

Note: A single R-307V Readout may be used with Hamar Laser targets T-212, T-218, and A-510. Two R-307V Readouts may be connected to each other for use with Hamar Laser's 4-axis targets, such as the T-261, to provide both vertical and horizontal center and vertical and horizontal angle information.



Figure 37 – R-307V Readout

Model R-307 2-Axis LCD Readout

The Model R-307 is a portable, two-axis readout, used for measuring a stationary laser beam. The readout can be powered by the supplied 115 or 220V AC adapter/charger or by an internal 9V rechargeable battery. In addition to a **Low Battery LED** on top of the unit, there are two manual switches on the top of the readout housing; the **Power Switch** and the **Scale Selector Switch**.

The **Power Switch** has three positions; OFF, SLOW, and FAST. When there is a great deal of air turbulence, the user can set the readout to the SLOW setting. This will average out some of the readout variations caused by heat, fog, or particulate matter in the atmosphere. Under normal conditions, set the Power Switch to FAST.

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

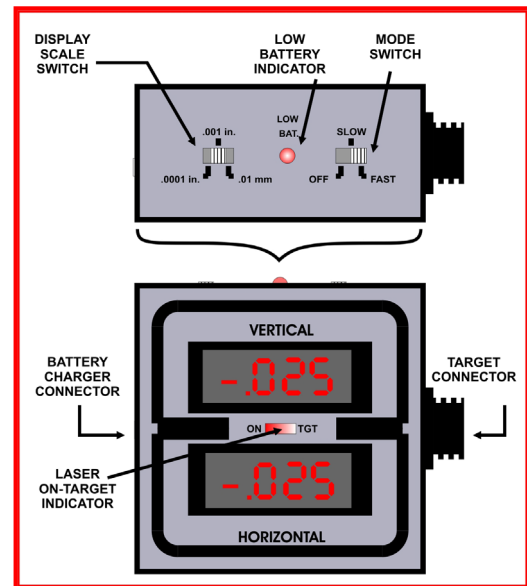


Figure 38 -- The R-307 Readout (Top and Front Views)

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

The Scale Selector

Switch sets the unit to display readings of either inches or millimeters. On some readouts, both English and metric scales are accommodated. Other units provide only metric data settings.

Note: Because of the limited number of decimal places available on a hand held LED readout, the number .0250 in. will display on the .0001 in. scale as 25.0 thousandths of an inch while the true value of the .001 in. and the 0.01 mm scales reads directly.

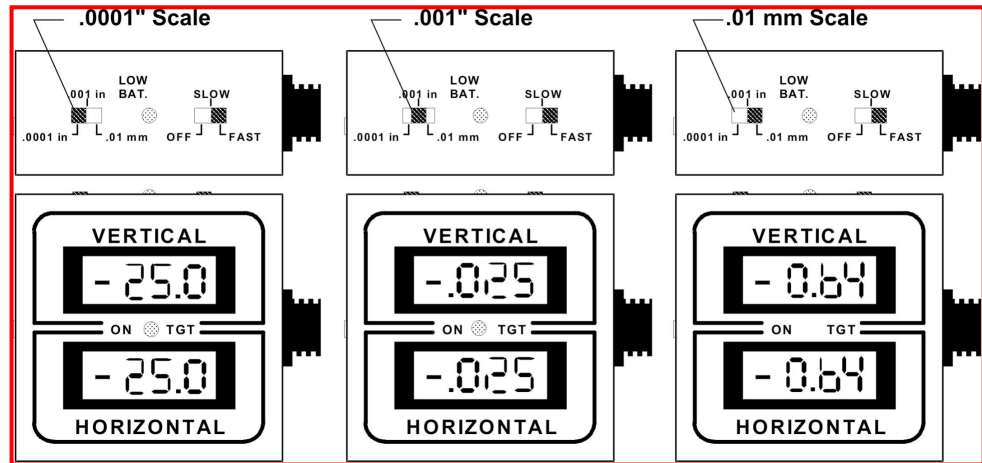


Figure 39 – Scale Selector Switch

Setting Up the R-307 2-Axis LCD Readout

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

Warning: Targets are matched to specific R-307 Readouts. For example, Target #1 must be connected to Readout #1 or the calibration is void.

1. Connect the Target to the Readout.

Push the connector at the end of the 10-foot target cable onto the R-307 Readout plug and screw the locking collar into place.

2. Decide on a Readout power source.

Plug in the AC adapter/charger if operating near an electrical outlet and the battery charge is low.

3. Set the Scale Switch to the .001 scale.

The Scale Selector Switch (see Figure 38) sets the unit to display readings of either inches or millimeters. Switching between scales shows that the number .0234 in. will read as 23.4 on the .0001 in. scale, .023 on the .001 in. scale and 0.59 on a 0.01 mm scale.

4. Turn on the power switch.

The power switch has three positions: OFF, SLOW and FAST. When there is a great deal of air turbulence, set the readout to the SLOW setting and watch the numbers on the display adjust slowly. This will average out some of the readout variations caused by heat, fog or particulate matter in the atmosphere. Under normal conditions, the power switch should be set to fast.



Figure 40 – Connecting the target to the readout

Calibrating the R-307 2-Axis LCD Readout

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

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

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

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

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

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

As the table shows, a 5 percent deviation of the numbers displayed on the readout is quite small. In most procedures the operator will center the target in the path of the laser beam so that all readings are deviations from the null center point and are displayed as close to 0.000 as possible on the readout. As with most electronic devices, accuracy is a matter of tuning the receiver to the signal. For further information, see the sections of this manual titled *Calibration Checking Procedure* on Page 57 and *The Calibration Trimpot* on Page 59 for more detailed information.

Calibration Checking Procedure

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

1. Set the Readout Scale Switch

Set the Readout Scale Switch to the scale with the highest resolution (the .0001 in. setting).

2. Manually center and square the target to the oncoming laser beam

Make sure that the target is mounted in the target stand with the cable hanging down from the lowest (6 o'clock) position on the target.

3. Mechanically center target with the micrometers on the target stand

Adjust the vertical axis first by turning the micrometer on the target stand until the vertical readout display window reads 0.000. Be sure to center in such a way as to remove the micrometer backlash (if you happen to turn the micrometer dial beyond the desired position, you will have to back the micrometer off and, once again, approach the desired measurement). Complete the mechanical centering by adjusting the horizontal axis micrometer control until the remaining readout display (R-307) reads 0.000.

4. Read and record the micrometer settings (not the readout display)

Once the readout displays 0.000 (both windows on the R-307) the corresponding micrometer settings should be noted on a worksheet (see Page 58 for a sample worksheet).

5. Turn the vertical axis micrometer +.025 in. (one full turn)

Turn the vertical axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.

6. Read and record the number on the vertical readout display window

Record the readout number on the worksheet.

Note: While adjusting only the vertical micrometer, watch both readout windows for changes. If the numbers in both windows change, the target will need to be rotated until it is square to the laser beam.

7. Re-zero the Display using both micrometers

Turn both micrometers until the readout display reads 0.000 in both axes.

8. Change the vertical axis micrometer -.025 in. (one full turn)

Turn the vertical axis micrometer control one full revolution (-.025 in.). Be sure to eliminate micrometer backlash.

9. Read and record the number on the readout display

Record the readout number on the worksheet.

10. Re-zero the Display using the vertical micrometer

Turn the vertical micrometer until the readout display reads 0.000.

Checking the Horizontal Calibration

1. Turn the horizontal axis micrometer +.025 in. (one full turn)

Turn the horizontal axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.

2. Read and record the number on the readout display

Record the readout number on the worksheet.

3. Re-zero the display using both micrometers

Turn both micrometers until the readout display reads 0.000 in both axes.

4. Change the horizontal axis micrometer -.025 in. (one full turn)

Turn the horizontal axis micrometer control one full revolution (-.025 in.). Be sure to eliminate micrometer backlash.

5. Read and record the number on the readout display

Record the readout number on the worksheet. To calculate the percentage of error in the readout display for a move of .025 in., see *Calculating Error in Calibration* on Page 58.

Calculating Error in Calibration

1. Calculate the difference between actual micrometer travel and change in the readout display

Determine the difference between the actual .025in. micrometer move and the number displayed on the readout window.

- If the .025 in. physical micrometer move is displayed as a number between **23.7 and 26.3**, (within 5 percent or 1.3 units on the .0001 in. scale) the readout is correct and ready for use.
- If the difference (error) of the .025 in. physical micrometer move is greater than 5 percent, the readout will need to be calibrated to the target (see *Calibration Checking Procedure* on Page 57).
- If the error is greater than 15 percent, return the target and readout to the factory for repair.

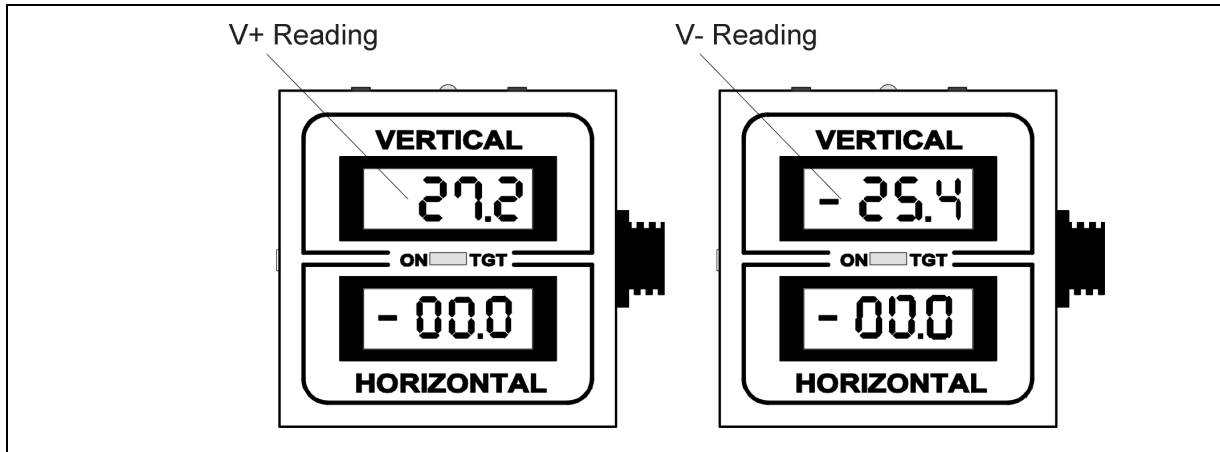


Figure 41 – Readout plus and minus readings

Error Calibration Worksheet (Scale .0001 in.)

| Micrometer move/Axis | Readout Display | Absolute Value | Percent Error |
|--|-----------------|----------------|---------------|
| +0.025 in./Vertical V+ | (+) 27.2 | .0272 | 8.8% |
| -0.025 in./Vertical V- | (-) 25.4 | .0254 | 1.6% |
| $\left[\frac{(\text{Absolute Reading Value} - .025)}{.025} \right] \times 100 = \% \text{ Error}$ $\frac{.0272 - .025}{.025} = .088 \times 100 = 8.8\%$ | | | |

2. For vertical calibration errors greater than 5 percent and less than 15 percent:

If the V+ calibration is greater than 5 percent (1.3 units on the .0001 in. scale for a .025 in. move) and less than 15 percent (3.8 units on the .0001 in. scale for a .025 in. move), an operator can recalibrate the readout by following the directions for adjusting the calibration trimpots beginning on Page 59.

3. For vertical calibration errors less than 5 percent:

If the total vertical calibration error is less than 5 percent, proceed with a check of the horizontal calibration error.

The Calibration Trimpot

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

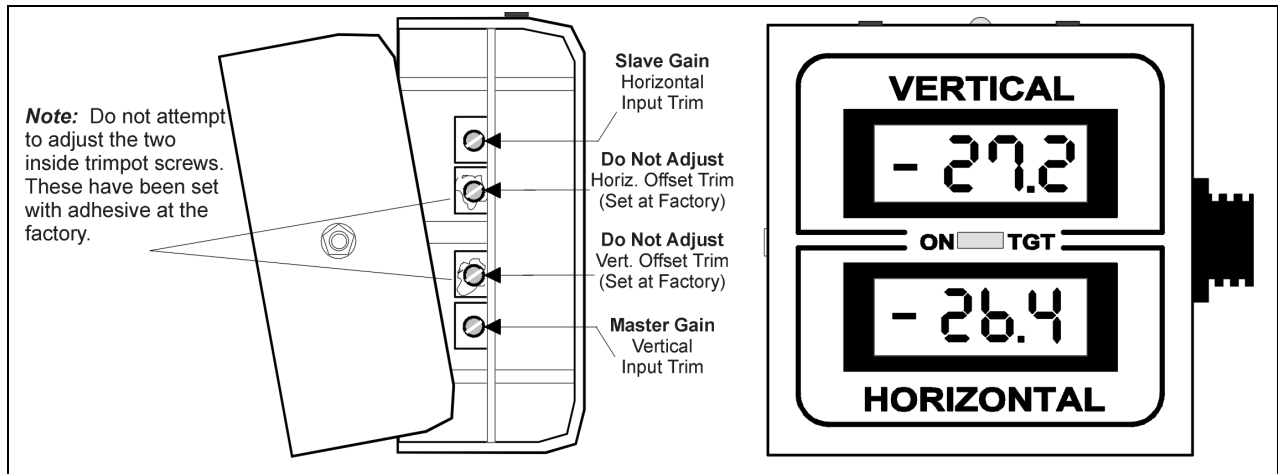


Figure 42 - R-307 Readout opened with trimpots exposed

1. Unscrew the screws on the back of the readout housing

Separate the top and bottom half of the readout to gain access to the **Master (vertical) and Slave (Horizontal) Input Trim Screws**.

2. Set the Readout Scale Switch

Set the Readout Scale Switch to the .0001 in. scale (highest resolution).

The Calibration Trimpot is located on the side of the circuit board on the inside of the readout. The trimpots are actually small screws that can be manually turned with a small, flat-head screwdriver (see Figure 42). On the Model R-307 Readout, two of the four trimpot screws (the inside pair) have been glued into position and should be left alone. If these screws have been tampered with or turned, return the readout to the factory for service.

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

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

To calculate:

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

Adjusting the Vertical Trimpot

1. Manually center and square the target to the oncoming laser beam

Make sure that the target is mounted in the target stand with the cable hanging down from the lowest (6 o'clock position) on the target.

2. Mechanically center target with the micrometers on the target stand

Adjust the vertical axis first by turning the micrometer on the target stand until the vertical readout display window reads 0.000. Be sure to center in such a way as to remove the micrometer backlash (turn the micrometer dial beyond and then back to the desired measurement). Complete the mechanical centering by adjusting the horizontal axis micrometer control until the remaining readout display reads 0.000.

3. Read and record the micrometer settings (not the readout display)

Once the readout displays 0.000 in both windows, the corresponding micrometer settings should be noted on a worksheet.

4. Turn the vertical axis micrometer +.025 in. (one full turn)

Turn the Vertical axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.

5. Adjust the Master Gain (Vertical Input Trim Screw)

While watching the numbers in the vertical window of a readout, use a small, flat-head screwdriver to adjust the set of the Master Gain (vertical input trim screw). Turn the screw until the vertical window on the readout reads **25.0**.

6. Re-zero the Vertical axis control Micrometer

Reset the Vertical Axis Control Micrometer until the display reads 00.0.

7. Adjust the Master Gain (Vertical Input Trim Screw)

If the readout display shows -25.4 for a micrometer move of -.025 in., adjust the Master Input Trimpot until the readout reads $(-25.4 + .2) = -25.2$. While watching the numbers in the vertical window of a readout, change the set of the Master Gain (vertical input trim screw) with the screwdriver. To trim out half of the difference between the displayed move and the micrometer move, adjust the trimpot so that the numbers in the vertical display read out with half of the error removed. Adjusting the -25.4 display reading to -25.2 trims out half the error on the readout display for an -.025 micrometer move.

8. Re-zero the Vertical Micrometer

Reset the Vertical Axis Control Micrometer until the display reads 00.0. *Close the Readout housing and tighten all screws. Review results.*

If you would like to see the effect of the calibration trimpot adjustments, recheck the V+ reading with a +.025 in. micrometer turn. You will notice that the display will not register as exactly +.025 in. When you recheck the vertical readout window with a +.025 in. micrometer move, the number 24.8 will be displayed in the vertical window of the readout. In this example, you have read -25.4 for a -.025 in. vertical micrometer move, adjusted the trimpot Master Input gain and "split" the difference.

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

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

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

Adjusting the Horizontal Trimpot

Calibrating the Horizontal Axis Display

1. Turn the horizontal axis micrometer +.025 in. (one full turn)

Turn the horizontal axis micrometer control one full revolution (+.025 in.). Be sure to eliminate micrometer backlash.

2. Adjust the Slave Gain (Horizontal Input Trim Screw)

While watching the numbers in the Horizontal window of a readout, use a flat-head screwdriver to adjust the set of the Slave Gain (Horizontal input trim screw). Turn the screw until numbers in the vertical display read **25.0** on the .0001 scale.

3. Re-zero the micrometers

4. Turn the horizontal axis micrometer -.025 in. (one full turn)

Turn the horizontal axis micrometer control one full revolution (-.025 in.). Be sure to eliminate micrometer backlash.

5. Read and record the number on the readout display

6. Adjust the Slave Gain (Horizontal Input Trim Screw)

If the readout display shows -25.4 for a micrometer move of -.025 in.: Adjust the Slave Input Trimpot until the readout shows $(-25.0 + -.07) = -25.7$.

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

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

After adjustment, the readout display will show a smaller amount of error for both H+ and H- readings.

***Note:** Following this procedure will allow readout calibration as perfectly as possible with an analog electronic device.*

7. Re-zero the micrometers

Calibration of the readout is complete when numbers on the vertical/horizontal axis readout windows fall within 5 percent of corresponding micrometer moves.

8. Close the R-307 Readout housing and tighten all screws.

Appendix G – 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.

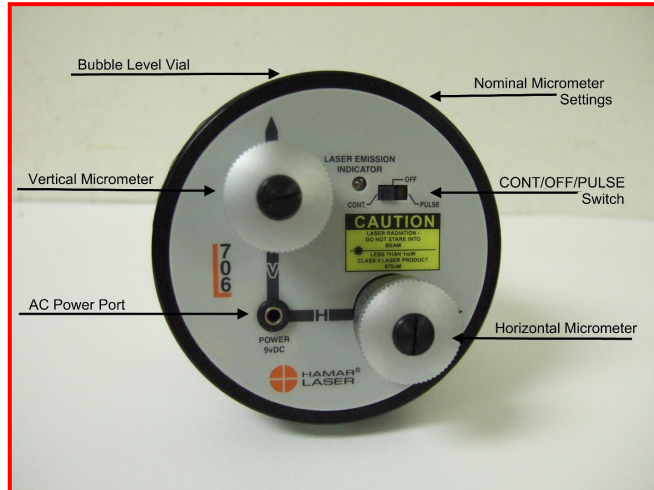
1. Blow off dust.
2. Using a soap-saturated lens tissue around a swab, wipe the optic gently. Repeat as necessary.
3. Repeat using a distilled water-saturated lens tissue wrapped around a swab.
4. Repeat using an alcohol-saturated lens tissue wrapped around a swab.
5. Repeat using an acetone-saturated lens tissue wrapped around a swab.

Appendix H – Laser Buckin for Gearbox AOR (Manual Method)

Laser Buckin AOR Procedure

Insert L-705/706/708 laser into spindle fixture and set the micrometers to the Nominal Settings. Turn on the laser to either **Pulsed Mode** (standard) or **Continuous Mode** (legacy).

1. Rotate the laser to the INverted position (Vertical Arrow pointed at 6:00) until the bubble is centered in the level vial window.
Note: *There is a bubble vial on both the top (NORMal) and bottom (INverted) of the laser.*
2. Insert the target and bore adapter into the far bore location.
3. Ensure the laser is hitting the target. If not, then use *Rough Laser Buckin Using the Visual Method* described on Page 32 to visually buck in the laser.
4. Connect the R-1307 Readout (or R-358) and turn it on, making sure to match the laser mode (Pulsed or Continuous) in Step 1. See Page 5 for more details on changing the laser mode in the R-1307. Insert A-910-2.4ZB Radio Receiver into the USB port on the computer.
5. Open Bore9 and follow the steps in this manual to configure the target to the readout so that the displays are showing live data.
6. Write down the V and H values for the INverted Position.
7. Rotate the spindle (holding the laser) 180 degrees to the NORMal position until the bubble is centered in the level vial window. Write down the V and H values.
8. Find the sum of the readings and divide by 2 (the number of readings) to calculate the laser *Set Points*.



(Normal reading + Inverted reading)

2

Calculations for vertical and horizontal readings must be done separately. The formulas for vertical and horizontal set points are:

$$\frac{(\text{Normal V} + \text{Inverted V})}{2} = \text{V SET POINT}$$

$$\frac{(\text{Normal H} + \text{Inverted H})}{2} = \text{H SET POINT}$$

Example of calculating the Vertical Set Point.

$$\begin{array}{rcl} V_N & = & -.016 \\ V_I & = & +.008 \\ & & \hline & & -.008 \end{array}$$

Divide by 2

$$V \text{ Set Point} = -.004$$

$$\begin{array}{rcl} V_N & = & -.016 \\ V_I & = & -.008 \\ & & \hline & & -.024 \end{array}$$

Divide by 2

$$V \text{ Set Point} = -.012$$

9. Turn the V & H micrometers (adjustment knobs on the L-708) until the V display value equals the *V Set Point* and the H display value equals the *H Set Point*.
10. Rotate the laser to the INverted position.
11. The V and H values should be the same as when the laser is in the NORMal position. If not, then repeat Steps 7 thru 11 until the values are the same within your desired tolerance.