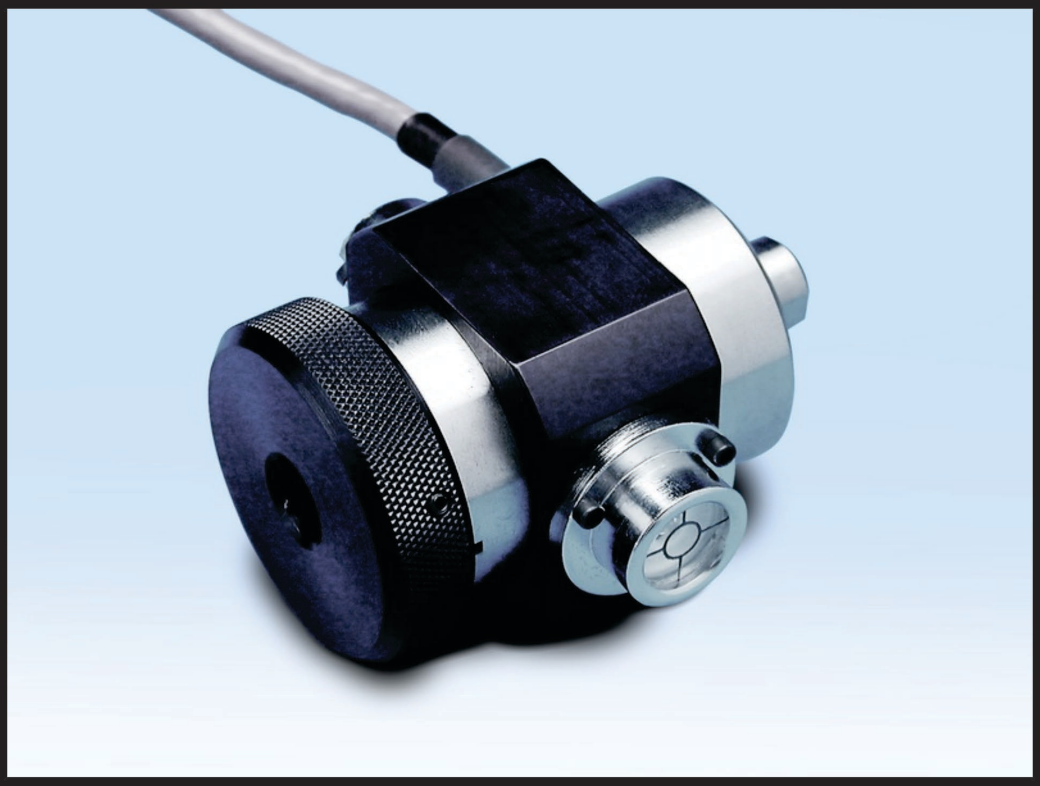

Operations Manual

T-212 4-Axis Target

March 2019

HAMAR LASER®

HAMAR LASER INSTRUMENTS, INC.
www.hamarlaser.com

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

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Introducing the T-212 4-Axis Target

The T-212 Target is a 4-axis target that measures:

- Vertical and Horizontal center
- Vertical (pitch) and horizontal (yaw) angle

The target works in two modes; *Centering* and *Angular*.

- **Centering Mode** detects vertical and horizontal displacement or movement. The resolution is .0001 in. (0.001 mm) using the R-1307, or .00001 in. (0.00025 mm) using the R-358 Computer Interface
- **Angular Mode** detects an angular (pitch and yaw) displacement or movement. The resolution using the R-1307 Readout is .0001 in/in (0.001 mm/25.4mm) or .00001 in/in. (0.00025 mm/25.4 mm) using the R-358 Computer Interface.

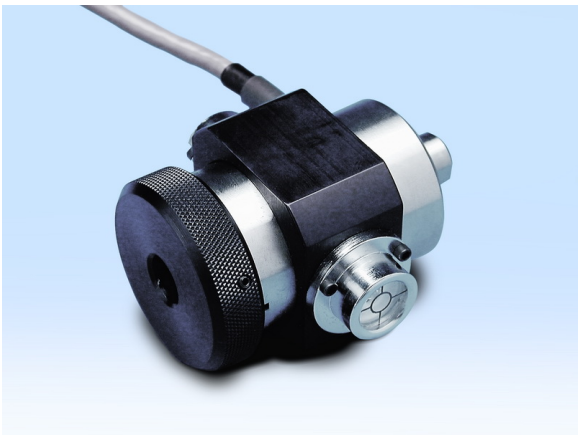


Figure 1 – *T-212 4-Axis Target*

Only one mode may be used at a time. To operate the target in *Centering Mode*, a small light shield is inserted in the front of the target (see Figure 2).

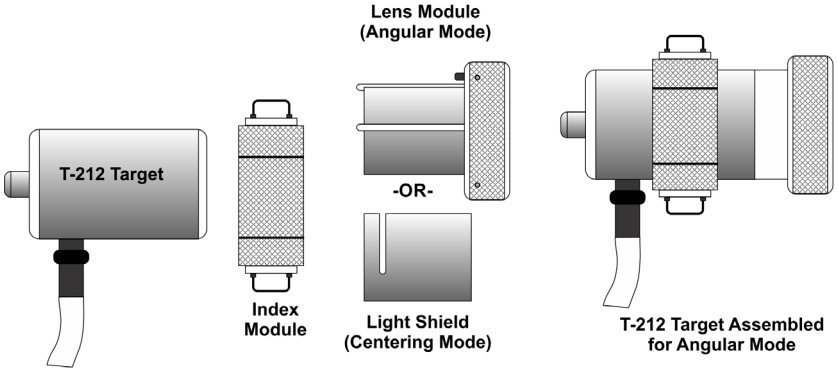


Figure 2 – *Centering and Angular Modes*

To switch to *Angular Mode*, remove the light shield and insert the lens module using the index pin (see Figure 3) to orient the lens properly. Rotate the module until the index pin is located opposite the slot in the body of the target, then slide the reference pin into the slot. The readings displayed in the Readout are converted to in/in. For example, when inserting the lens, .0023 displays on the V-axis of the readout. This means the target is tilting down by .0023 in/in. A minus (-) V-axis reading means the target is pointing up (see Interpreting Signs on Page 2).

For the H axis, a + reading means the target is pointing to the left (front of the target is to the left of the back) when looking down on top and in front of the target. A "-" H-axis reading means the target is pointing to the right (see Interpreting Signs on Page 2).

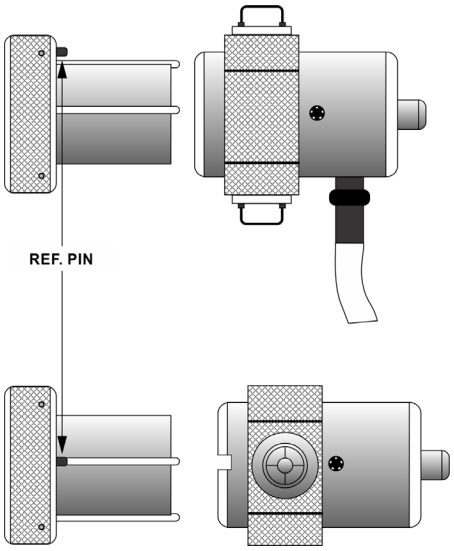


Figure 3 – *Reference Pin*

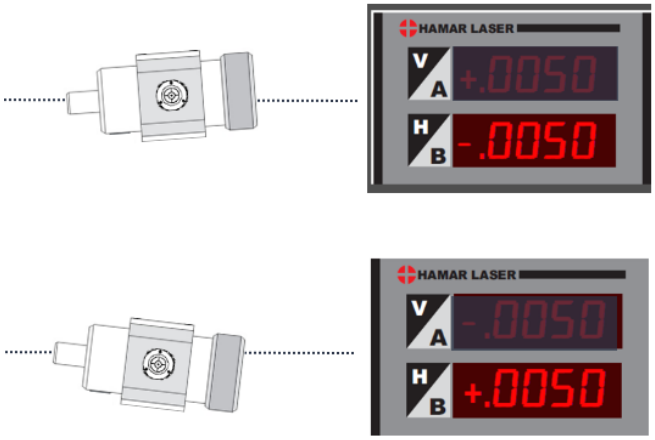
Level vials are used on the top and bottom of the T-212 to perform the NORMIN procedure (see The NORMIN Procedure on Page 5).

The T-212 Target's half-inch mounting stud is designed for use with Hamar Laser's target mounting fixtures. Custom mounting fixtures are simple to design—a ½ in. hole reamed square to a face is all that is required to hold the target.

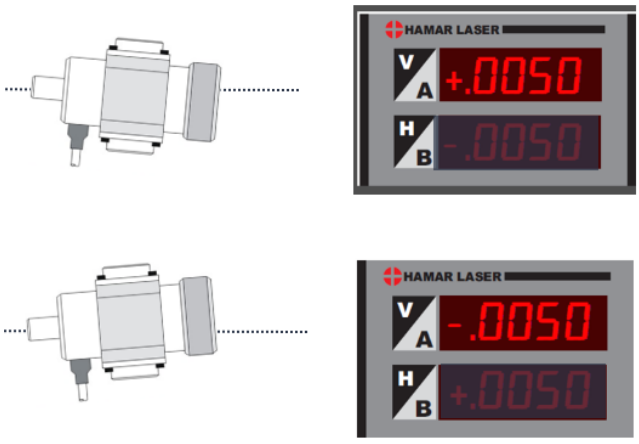
Interpreting Target Data Signs (+, -)

T-212 Target Angular Axes

Top View - H Axis Angle

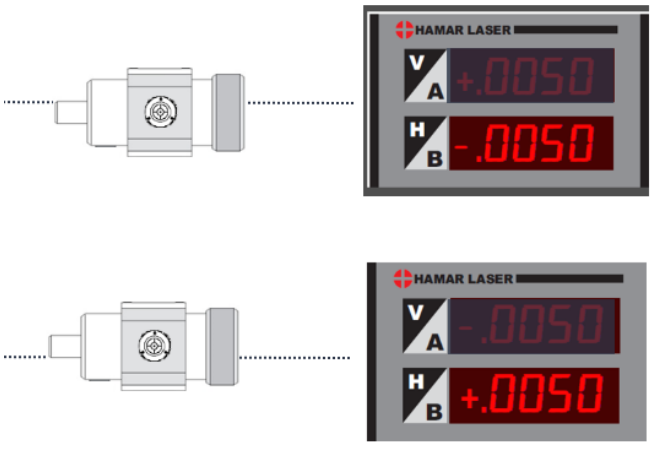


Side View - V Axis Angle

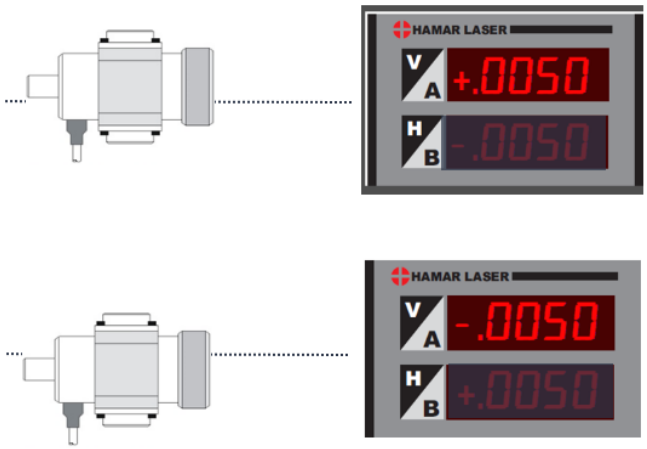


T-212 Target Center Axes

Top View - H Axis Center



Side View - V Axis Center



How the T-212 Target Measures Angle

Figure 4 shows how the T-212 Target measures angle. It uses a lens that has a 1-inch focal length, which means any deviations detected by the PSD sensor are expressed in inches/inch (mm/25.4 mm). To understand this better, imagine that there is another PSD sensor 1 inch behind the where the T-212's PSD is actually located. So any angular changes in the target will produce different readings for the PSD in the actual location versus the reading in the "virtual" location.

For example, if the readout shows a vertical reading of .001 in. in angular mode, this indicates the laser beam is located on the virtual PSD a .001in. higher than its location on the actual PSD.

Another way to think about is it's a lot like using a dial indicator to take a measurement for center in one location along on a bar (or bore) and moving along the bar (or down the bore) and taking a second measurement. When the second measurement is subtracted from the first, the results shows the pitch and yaw of the axis of the bar (or bore) relative to the mechanical axis used to support the indicator.

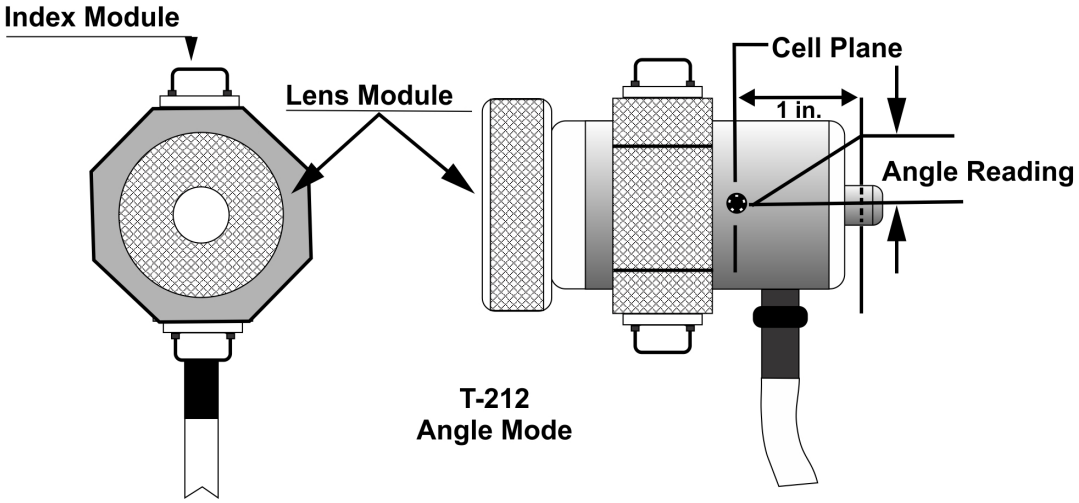


Figure 4 – *Measuring Angle with the T-212 Target*

With the T-212, this "subtraction" is accomplished automatically using an optical lens, so the user can view the angular pitch and yaw of the axis of the target relative to the axis of the laser beam on the readout without performing any calculations. The axis of the laser beam represents where the target *ought* to be, the axis of the target represents where is actually *is*, and the difference between the two displays on the readout.

How the T-212 Target Measures Center

With the lens module removed, the target operates in Centerin
insert the light shield in its place. There is no particular orienta

In Centering Mode, the target is sensitive to vertical and horiz
the plane of the cell and the readout displays the position of
target is high or low and left or right relative to the laser beam)

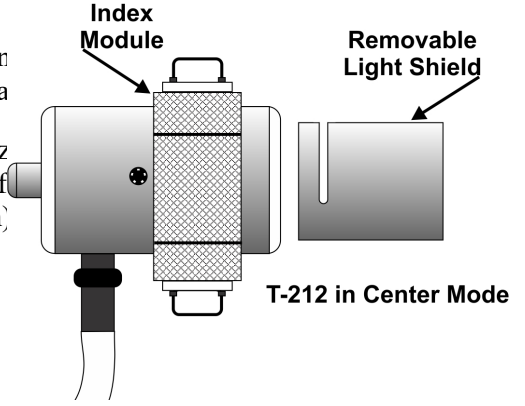


Figure 5 – *T-212 with Light Shield in Center Mode*

The Index Module

There is a removable index module (see Figure 5) mounted on the target to aid in the indexing of the target at 0 and 180 degrees. The procedure of indexing the target at 0 and 180 degrees is done when the target is used to check the alignment of an axis of rotation and the alignment of a bore. The module can be loosened and positioned in any orientation or removed from the target when it is not needed.

To use the Index Module, rotate the target so that the bubble level is showing "level," then take a reading. Rotate the target 180 degrees, re-level the target and take a reading.

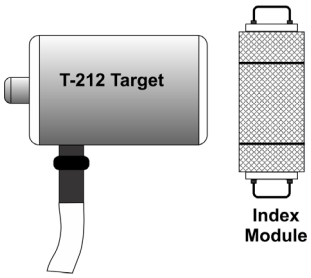


Figure 6 – *T-212 with Index Module*

Mounting Error Calculation

All T-212 targets are shipped with the target PSD aligned to the housing within .0005 in. TIR. In time, handling may cause the target cell to become out of center. To remove centering and fixture errors, use the NORMIN method of taking a normal reading, rotating the target 180 degrees and taking another reading, and splitting the difference between the two (see The NORMIN Procedure beginning on Page 5). This is done for the center values and angular values separately.

Appendix A - The NORMIN Procedure

The NORMIN method was developed by Hamar Laser Instruments as a way of compensating for laser or target mounting errors in bore or spindle work. The word is a contraction of "NORMal-INverted," which briefly describes the method. It is quite similar to the four clock readings taken with dial indicators but uses a laser and a target instead. The NORMIN method is used in conjunction with simple fixtures and targets that allow inexpensive, precision measurement. The target/fixture is set in the bore or spindle in the NORMal position (cable down) and the readings are recorded. Then the target/fixture is rotated 180 degrees to the INverted (cable up) position, and a second set of readings is obtained. The two sets of readings cancel out centering errors and provide a very accurate result.

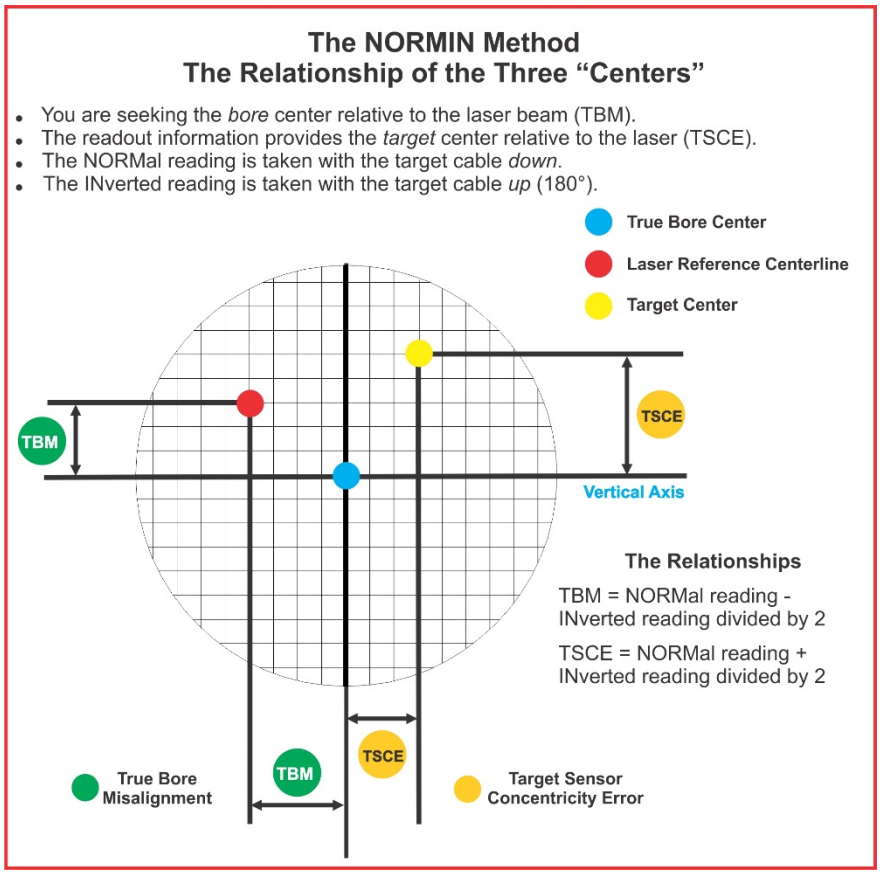


Figure 5 -- *Three centers of bore alignment*

There are three centers involved in bore alignments: True Bore Center, Target Center, and Laser Reference Centerline. If mounting fixtures were perfect, the Target Center would be located at the True Bore Center, and if perfectly aligned, the True Bore Center would be located at the laser beam center. In reality, however, they seldom line up. An example of the three centers with respect to one another is shown in Figure 7.

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

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

The readout always shows the displacement between the Target Center and the Laser Beam Center. When the Target Center is not on the True Bore Center, the numbers and the signs on the readout will change when the target is rotated because the Target Center is moved to a different location in relationship to the laser beam.

Figure 8 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.).

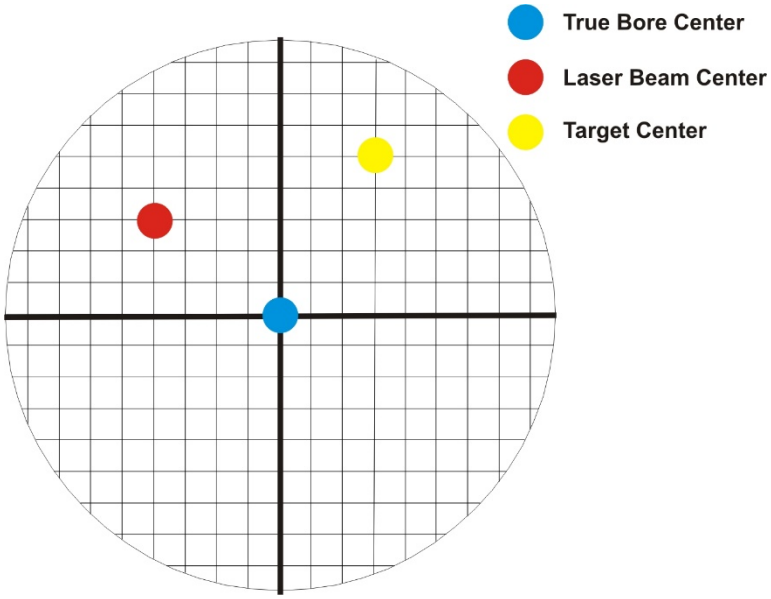


Figure 6 – *Target in the NORMal position*

Figure 9 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 9, 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.

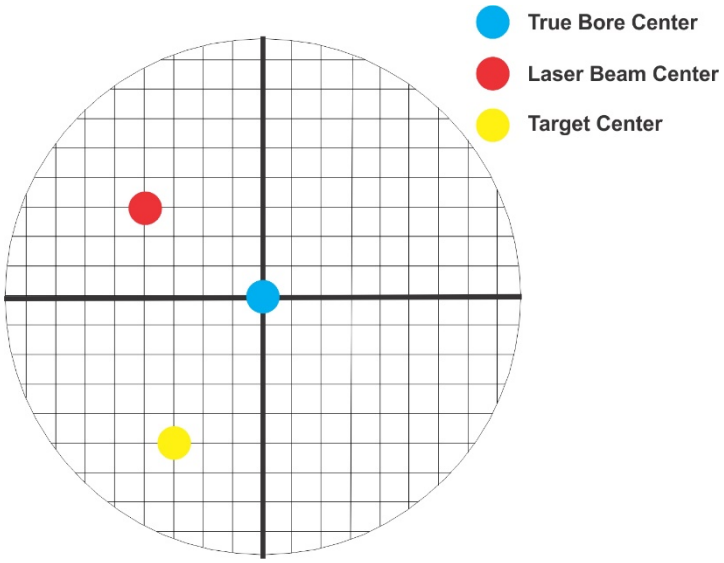


Figure 7 – *Target in the INverted position*

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.