Application Note 2

Bore Alignment with the L-708 Bore Alignment Sysetm

L-708 Applications:

Engine Crankcase Bores
Compressor Bores
Stern Tube and Shaft Bearings

How the Alignment System Works

General Setup

To perform alignments, the L-708 Laser and A-512 Target must be inserted into their A-514 Self-Centering Bore Adapters. But first, both the laser and target A-514 adapter legs must be set to the nominal bore diameter using the A-514GS Leg-Setting Gage. The required accuracy for setting the legs to the bore diameter is not very high: about 0.05 mm. The key to achieving alignment accuracy for the A-514 adapters is to make all the legs the same length, which is easy to do with the A-514GS. The reason that setting the legs to the exact bore ID is not critical is because the A-514 Adapters can handle a large range of bore diameter changes: up to .020" (0.5 mm) and still give accurate alignment results.

Once the A-514 legs are set for both adapters, then the L-708/A-514 Adapter are inserted into the first (near) reference bore. The A-512/A-514 target/adapter are then placed in the second (far) reference bore and the R-1307 Readout is connected. Next, the angular adjustments on the L-708 are adjusted to tilt the laser beam to center it to the A-512/A-514. The laser is now concentric to the end bores and the A-512/A-514 target/adapter are moved to the inner bores for alignment checks. Since the laser provides live data, any alignment errors can be adjusted and the user can watch the readings update live in the readout.

How the A-512 Target and A-514 Adapters Work

The A-512 Target is designed so that the PSD is centered axially between the four feet of the A-514 Adapter, two of which are offset axially from the other two (see the graphic on Page 2). 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 45º. This means even if the bore diameter changes, the A-514 will still self-center giving an accurate measurement of the bore's alignment. To insert the target into the bore, attach the handle to the target and tip the target forward, which allows it to easily slide into the bore. Release the handle/insertion pole and the target/adapter "jam" into the bore, finding the center automatically (see picture bottom right). The weight of the handle keeps the target centered in the bore.

A-516 Self-Centering 2-Axis Bore Target

Measuring Bore Alignment

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

HAMAR LASER® ALIGN WITH THE BEST

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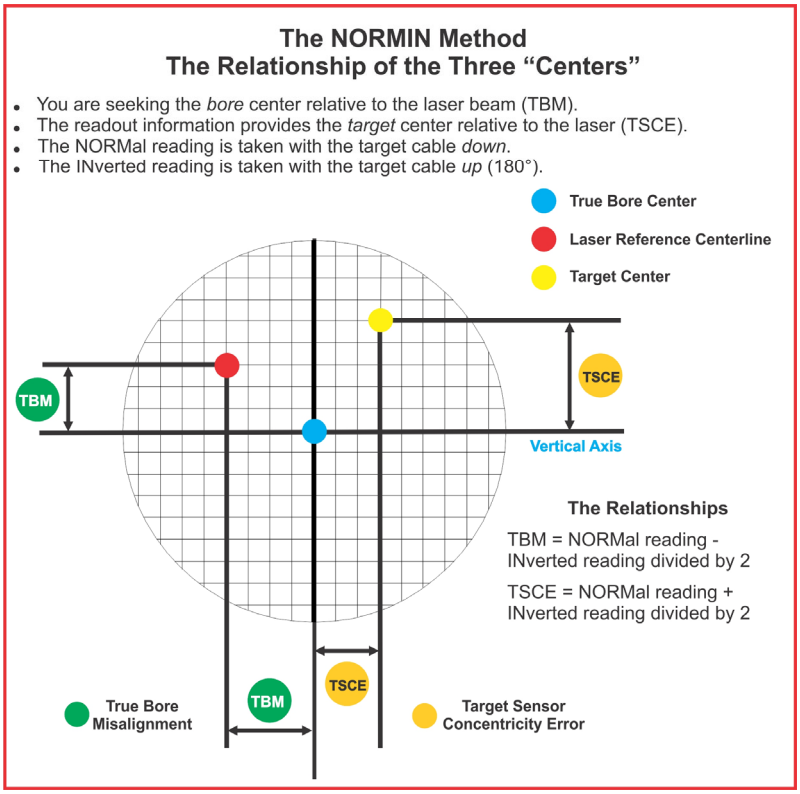
High-Tolerance Bore Alignment

For high-tolerance bore alignment applications, the remaining target sensor concentricity error (TSCE) must be calculated using the NORMIN method. TSCE is calculated by taking two readings, one with the target at the 12 o'clock position and a second at 6 o'clock (horizontal and vertical calculations are done separately). The second reading is added to the first and the result is divided by 2. This is the TSCE and shows how far off the center of the target is from the center of the bore. This calculation creates an offset that can then be subtracted from all subsequent bore measurements to get the true misalignment number. Our Bore9 software can easily calculate TSCE and even automatically remove it from the displayed reading.



Using Bore9 Software

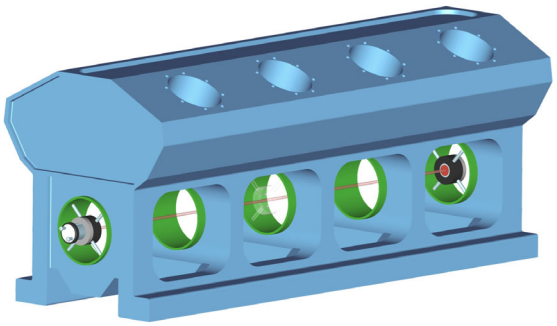
Hamar Laser's new Bore9 software supports all of Hamar's past and present bore alignment equipment to create a powerful tool for measuring and aligning up to 50 bores. This comprehensive and easy-to-use program measures bore straightness (axis centering) and diameter change when using our targets in measuring mode.

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 **NORM**al-**IN**verted, which briefly describes the method.
- In **Step 3 – Laser Setup**, on-screen instructions guide the user through setting up the laser and making it parallel to reference points.
- In **Step 4 – Record Data**, bore straightness data is recorded. There are several different sets of data that can be taken in this step.
- In **Step 5 –Results**, results of the recorded data are plotted on a graph and a least-squares, best-fit data algorithm is applied to generate the straightness results and to determine if they are in or out of tolerance. Plot data can be changed to reflect the position of the centerline of the bores relative to the end bores, selected bore numbers, the laser beam or a "Best Fit" line. The data for each point is recalculated automatically based upon which references are chosen. Reports are also generated in this step and can be customized to the four different bore references. Comments may be added and the report can be printed with a summary, a graph of the vertical and horizontal straightness, comments and a table showing the recorded data.

Bore Alignment Procedure Using the L-708, A-512, A-514 and Bore9

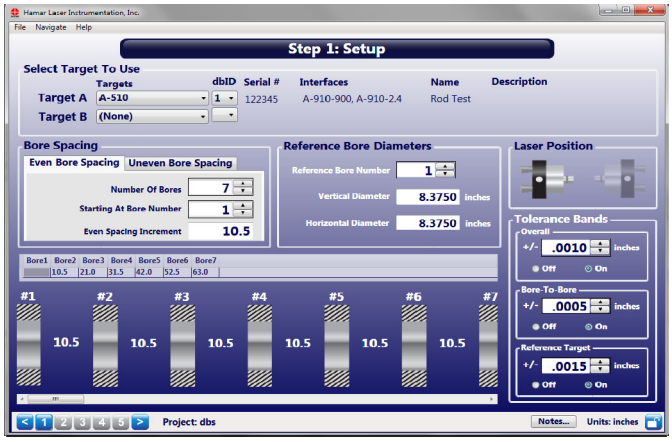
The L-708 Bore Laser provides a straight reference line to which any bore can be aligned and measured and allows centering to .0012" (0.03 mm). Setup is fast and easy. The A-514 Self-Centering Bore Adapters for both the laser and target are put on a leg-setting gage to adjust the legs to the desired bore radius. The L-708 and A-512 Targets are inserted into their bore adapters and then the laser and target assemblies are inserted into the two reference bores where they self-center. The laser's angular adjustments are used to set/tilt the laser to zero on the target, establishing the reference bore centerline. The target can be moved (or second target added) to inner bores for alignment checks. Since the alignment data in the readout updates in real time, any errors can be adjusted using the target as a live indicator.



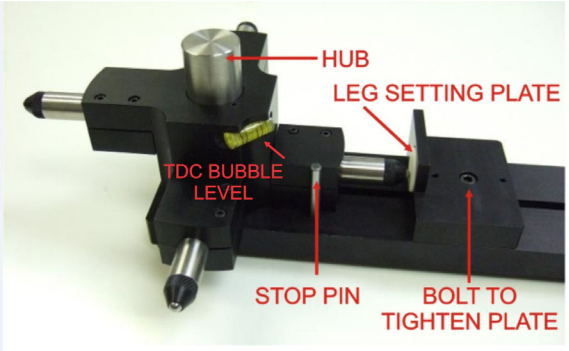
Step 1: Setup

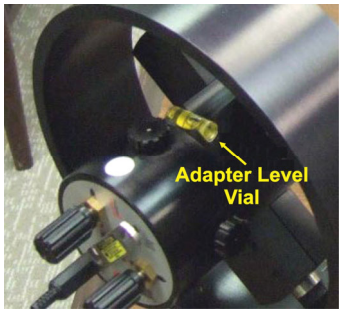
a. Open Bore9 and select the target and computer interface. Note that Bore9 is not required, but it is recommended.

b. Enter the number of bores, the distance between the bores, the bore diameters, and select the alignment tolerances. Note that you can select bore-to-bore alignment tolerance as well as an overall tolerance.

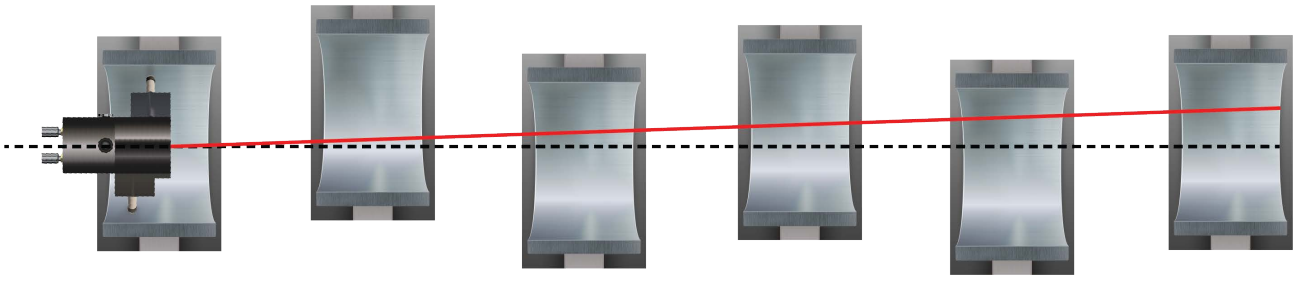


c. Measure the nominal Bore ID. Use the A-514G Leg-Setting Gage to set the legs of the A-514 Bore Adapters for both the laser and target to the nominal Bore ID.

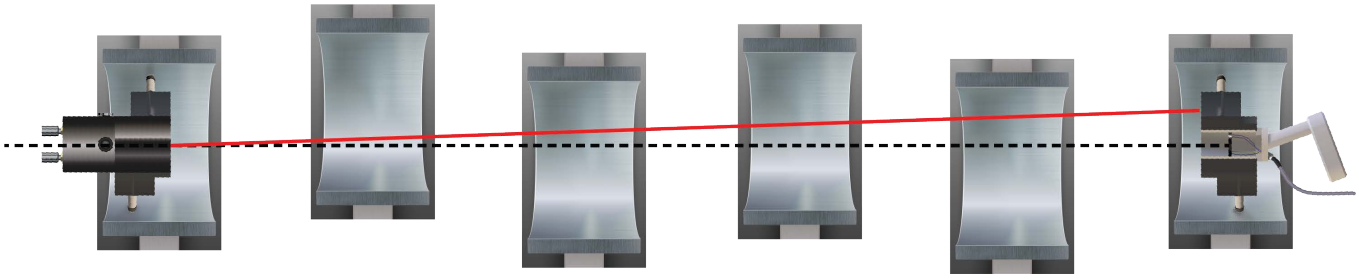




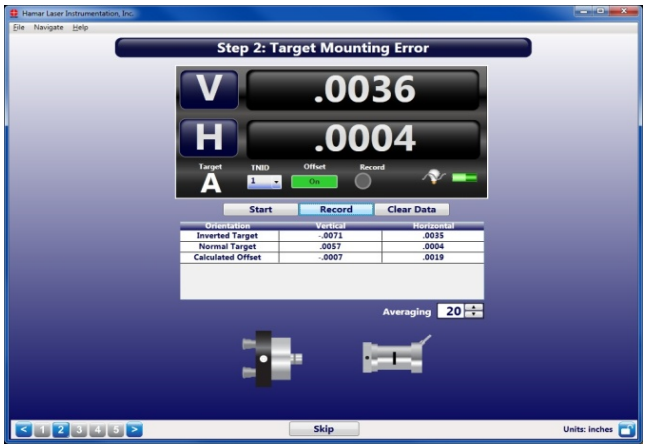
d. Insert the L-708 into the first A-514 Bore Adapter and insert the laser/adapter into the first (near) reference bore. Ensure that the level vial on top of the adapter is level. This orients the laser's Vertical and Horizontal adjustment axes to the Vertical and Horizontal axes of the bores.



e. Insert the A-512 Bore Target into the second A-514 Bore Adapter and then insert the target/adapter into the second (far) reference bore. Ensure that the level vial on top of the adapter is level. This orients the target's Vertical and Horizontal adjustment axes to the Vertical and Horizontal axes of the bores. Connect the R-1307 Readout and power it on.



Step 2: Target Mounting Error



a. Rotate the target 180 degrees (INVERTED position) and reinsert into the near bore. Press **Record** to record data for the target in the INVERTED position. A Mounting Error Offset will be calculated and applied to each target reading. This will remove any remaining centering errors in the target and adapter.
Note: *Step 2: Target Mounting Error of the Bore9 program may be skipped if measuring bore straightness or alignment tolerances are greater than .0005" (0.013 mm).*

Step 3: Laser Buckin

a. Select the laser mounting by clicking the Internal Mount graphic. Click **Next**.

b. Select the target to use for the laser setup. Click **Next**.

c. Follow the on-screen instructions to perform the laser setup.

Steps 3c, 3d, 3e: Internal Mount Setup

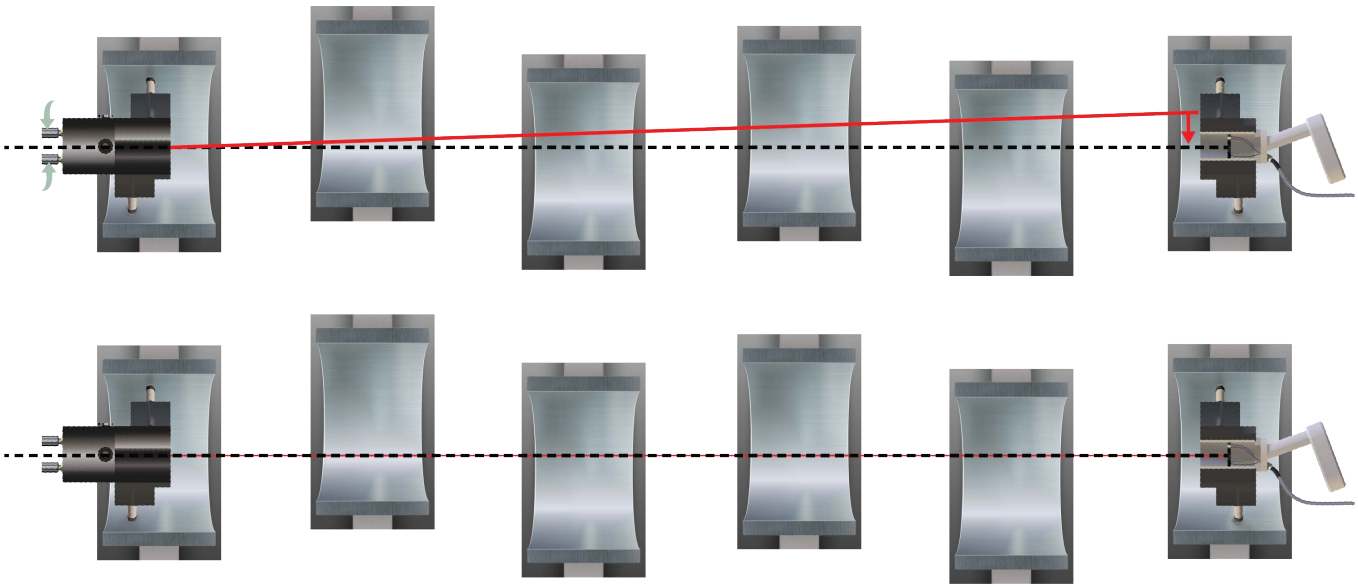
3c. Insert Laser and Self-Centering Bore Adapter into 1st end bore.

3d. Insert Target with Bore Adapter into 2nd end bore.

3e. Adjust Horizontal and Vertical Micrometers on Laser to adjust (tilt) the laser until the display shows zero.

d. Steer the laser using the Pitch (V) & Yaw (H) adjustment knobs on the L-708 so the reading on the R-1307 is zero. The laser is now concentric to the centerline of the two end (reference) bores.

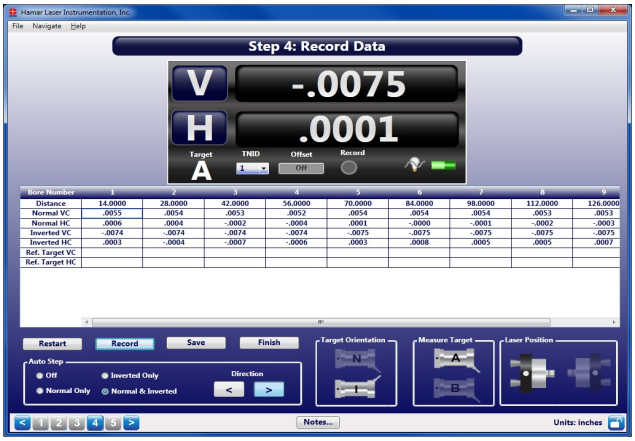
L-708 Target inserted in the A-514 Bore Adapter

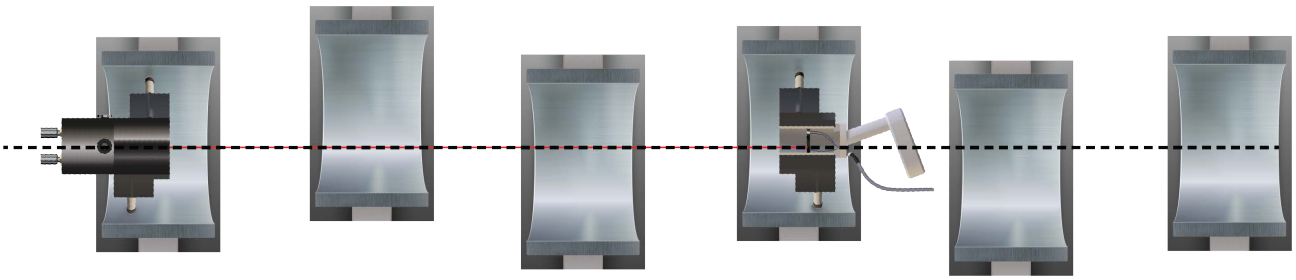


e. Click **Finish** to go to **Step 4—Record Data**.

Step 4: Record Data

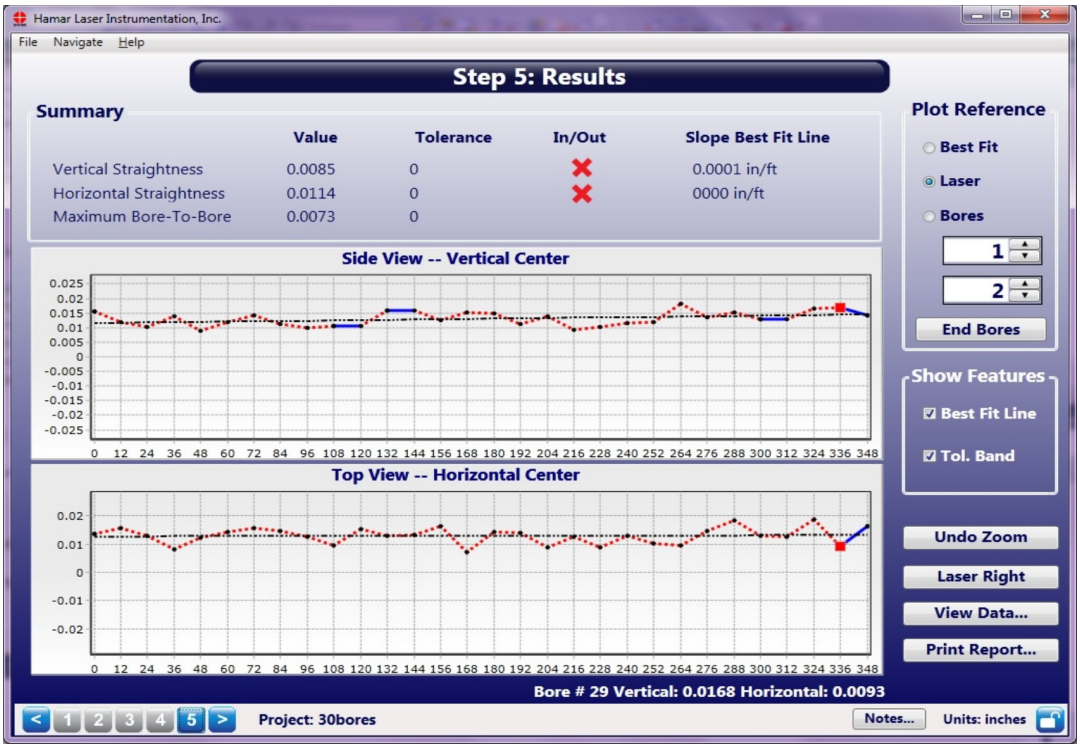
Move the A-512 Target/A-514 Adapter to the inner bores to measure for alignment and press **Record**. Continue moving the target to each bore until all data is taken.





Step 5: Results

Step 5—Results displays a graph of the results and a summary of the alignment.



Bore9 Sample Report

Bore9 Report

HAMAR LASER

Project: 30bores

Report Issued By

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

Machine Information

Factory Name:
Machine Information:
Notes:

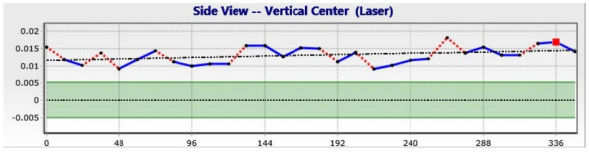
Alignment Results

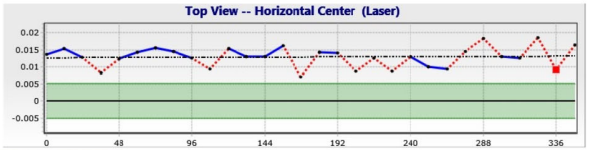
Alignment Check	Value	Tolerance (+/-)	BF Slope	Best Fit I/O	Plot I/O
Vertical Straightness (TIR)	.0085	.0051	.0001	✓	✗
Horizontal Straightness (TIR)	.0114	.0051	.0000	✗	✗
Vertical Bore To Bore (Max)	.0061	.0031		✗	N/A
Horizontal Bore To Bore (Max)	.0093	.0031		✗	N/A

Setup Information

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

Result Graphs





Alignment Data

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

Alignment Data (Continued)

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