# **How Lasers Work**

# Engine Block Bore Alignment with the L-706 Laser

#### L-706 Applications

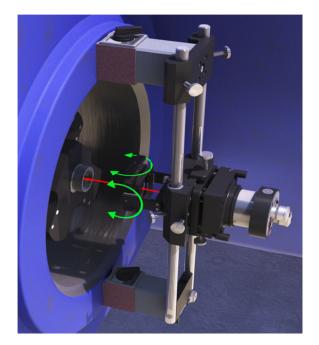
- Engine Crankcase Bores Compressor Bores
- Cylinder Bores 
   Stern Tube Shaft Bearings
- Tube-Support-Plate Bores

## How the Alignment System Works – Engine-Block Crankshaft Bores

#### **General Setup**

To perform alignments, the L-706 laser is mounted in the L-111 Laser Stand and the L-102 Laser Beam Translator is attached. The L-111 has coarse *angular* adjustment capabilities and the L-102 can *translate* (change the centering) the laser beam up/down and left/right without changing the angle.

The entire assembly is then mounted either on an instrument stand near the first reference bore or on the face of the bore.



The L-111 Laser Stand with L-102 Beam Translator mounted on the face of a bore.

The A-512/A-514 target/adapter is placed in the first bore and the L-102 Beam Translator is adjusted to center the laser beam to the target. The target is then moved to the far reference bore and the angular adjustments are used to tilt the laser to the center of the target. This process is repeated until the target reads zero at both locations.

The laser is now parallel to the end reference bores and the target can be moved to (or a second target can be placed in) the inner bores for alignment checks. In addition, boring-bar bearings can be installed and aligned using our T-218 Bore Alignment Target, which fits directly into the bearing.

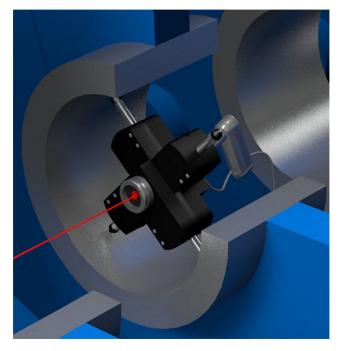


L-706/L-111/L-102 with A-512/A-514 aligned to end bores

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

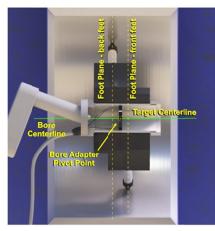
The A-512 Target is designed so that the PSD is centered axially between the 4 feet of the A-514 Adapter, 2 of which are offset axially from the other 2. This, in effect, puts the PSD on the pivot point of the adapter and allows the angle of incidence to the laser beam to vary by up to 45°. This means 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/pole 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. The weight of the handle/pole keeps the target centered in the bore.

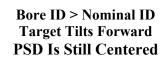


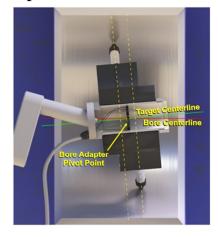
A-512 Target in A-514B Self-Centering Bore Adapter mounted in a bore

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



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



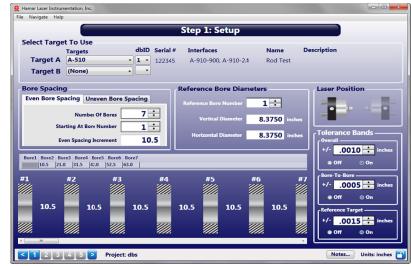


Bore ID < Nominal ID Target Tilts Back PSD Is Still Centered

## Bore Alignment Procedure Using L-706, L-111, L-102 and Bore9

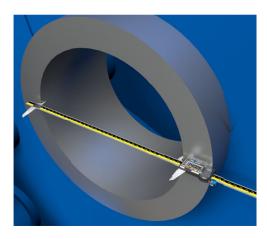
#### Step 1: Setup

- a. Open Bore9 and select the target and computer interface.
- b. Enter the number of bores, the distance between the bores, the bore diameters, and select the alignment tolerances.



Bore9 – Step 1: Setup

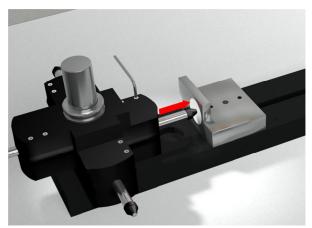
c. Measure the nominal bore ID. Use the A-514G Leg-Setting Gage to set the legs of the A-514 Bore Adapter to the nominal bore ID.





A-514GS Leg-Setting Gage for A-514 Adapters

d. Push the leg against the stop and tighten the set screw. Repeat for all four legs.



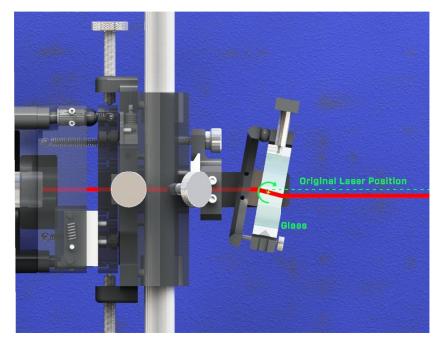
A-514GS Leg-Setting Gage - positioning the legs of A-514B Bore Adapter

e. Insert the A-512 into the A-514 Adapter and insert them into the near bore, making sure the adapter's level vial is level.



#### How it Works – The L-102 Beam Translator

The L-102 uses a parallel-sided piece of glass to redirect the laser beam to center it into a bore target. So the laser beam passes through the glass and reflects off entrance surface and goes up/down, or left/right, and comes out the exit surface with the beam parallel to the input beam. Therefore the angel of the beam is not affected by tilting the optic. The greater the tilt, the greater the amount the laser beam will move in position.



The L-102 has both coarse and fine centering adjustments and is used to center the laser beam to the A-512/A-514 Target in the near reference bore.

- f. Adjust the L-102 Beam Translator to zero the R-1307 Readout and center the laser into the first reference bore (the graphic below shows how the L-102 moves the height of the laser beam, but not the angle).
- g. The laser is now centered in the near reference bore.





#### Step 2: Remove Target Mounting Error (optional)

*Note:* Step 2: Remove Target Mounting Error of the Bore9 program may be skipped if measuring bore straightness only, or if aligning bores to .0005" (0.013 mm) or less.

Press **Record** to record data for the target in the NORMAL position. Rotate the target 180 degrees (INVERTED position) and reinsert into the *near* bore. Press **Record** to record data for the target in the INVERTED position. Rotate target 180 degrees again back to the NORMAL position and reinsert into the *near* bore. The TSCE Mounting Error Offset is calculated and applied to each target reading. This removes any remaining centering errors in the target and adapter.



#### Step 3: Laser Buckin (Setup)

a. Follow the on-screen instructions to enter distances from the laser to the *near* bore (D1) and from the near bore to the *far* bore (D2). If needed, insert the target into the *near* bore and readjust the L-102 to zero the display and center the laser into the bore. Press **Record** to record data for the *near* bore.





Bore9 - Step 3: Enter distances between end (reference) bores

Step 3c: Provide Distances	
Enter distances for D1 and D2 then click 'Next'	
Distance from Laser Pivot to Near Target	D1 0
Distance from Near Target to Far Target	D2 0

Step 3c: Enter distances between end (reference) bores

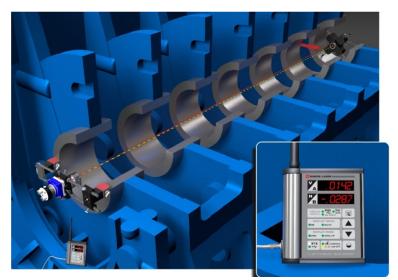
Target	Vertical	Horizontal
Near Target	.0190	.0053
Far Target		
Set Point		
Retake Data		

#### Step 3d: Results data showing near point

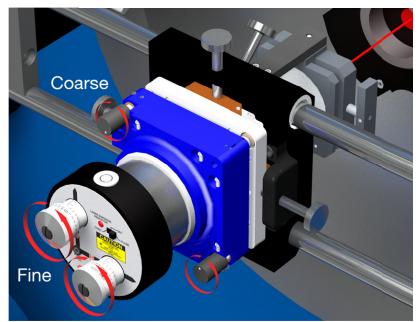


Step 3e: Results data showing far point recorded and set point calculation

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



Adjusting the angle of the L-706 to center it at the far bore.



L-706 Bore Laser and L-111 Laser Stand showing fine and course angular adjustments.



The L-706 aligned to the center of both end bores.

c. With buckin offsets applied in the Bore9 software, steer the laser using the Pitch and Yaw knobs (angular adjustment) on the L-706 until the H and V displays are zero.

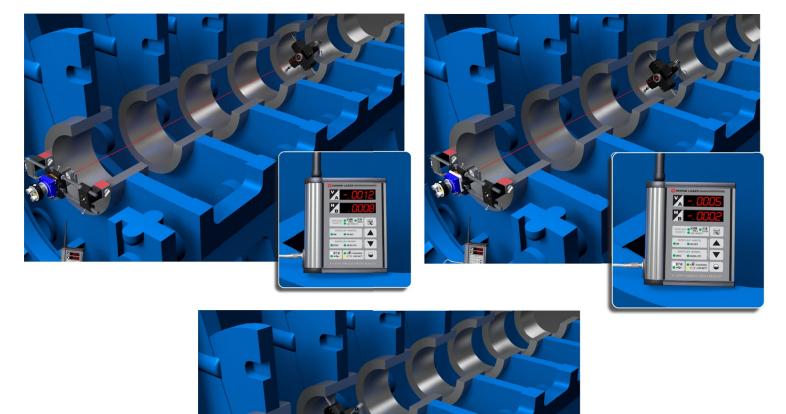
d. Repeat the process to confirm zero at both end bores. The laser is now "bucked in" (aligned or concentric) to the centerline of the near and far reference bores.

## Step 4: Record Data

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



Bore9 - Step 4: Record Data



#### **Step 5: Results**

- a. Step 5: Results displays a graph of the results and a summary of the alignment. There are several different options to view the data and whatever plot reference is chosen is printed in the report:
  - a. *Concentricity Plot Bores:* this plot converts the Vertical & Horizontal values into 1 concentricity value and shows the angle of the radius for each bore. The user can choose any combination of bores to use as the reference and Bore9 will replot the data and alignment results.
  - b. *Straightness Plot Bores*: this plot shows the V & H values for each bore and plots them individually. The user can choose any combination of bores to use as the reference and Bore9 will replot the data and alignment results.
  - c. *Straightness Plot Best Fit*: this plot shows the V & H values for each bore and plots them individually. The summary data and graph are plotted relative to the least-squares, best-fit line calculated by Bore9.
  - d. *Straightness Plot Laser*: this plot shows the V & H values for each bore and plots them individually. The summary data and graph are plotted relative to the laser beam (raw data).



Bore9 – Step 5: Results – Concentricity Plot using the End Bores as a reference.

Bore9 – Step 5: Results – Straightness Plot using the Best Fit line as a reference.



Bore9 – Step 5: Results – Straightness Plot using the Best Fit line as a reference.

Bore9 – Step 5: Results – Straightness Plot using the Laser as a reference.

## **Bore9 Sample Report**

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Factory Nan Machine Inf Notes:																				
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Bore # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	0 12.0000 36.0000 48.0000 60.0000 72.0000 84.0000 108.0000 120.0000 132.0000 132.0000 136.0000 168.0000 168.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0158 .0158 .0158 .0158 .0152 .0150	.0137 .0155 .0129 .0083 .0124 .0144 .0156 .0146 .0127 .0095 .0153 .0130 .0131 .0162 .0070 .0143	♥ Piot (Raw) .0.154 .0.118 .0.011 .0.118 .0.0118 .0.0144 .0.118 .0.0199 .0.106 .0.106 .0.106 .0.158 .0.127 .0.152 .0.150	H Pice (Raw) .0.37 .0.155 .0.29 .0.83 .0.24 .0.24 .0.44 .0.156 .0.27 .0.95 .0.53 .0.30 .0.131 .0.62 .0.70 .0.43	V Diam 0 0 0 0 0 0 0 0 0 0 0 0 0		-0.003 0.015 0.015 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.0164 0.0154 0.0164 0.0154 0.0164 0.0154 0.0164 0.0154 0.0164	Ang Pos 228 217 218 239 216 219 219 212 217 218 223 217 218 228 217 218 228 217 218 228 221 217 218 223 217 218 225 221 225 221 225 225 225 225 225 225		Top Vi	ew H	orizonta	l Cento	er (Las	ser)	<b>)</b>	$\land$		¥
Bore # 1 2 3 4 5 6 7 8 9 10 11 12 13 13 24 15	0 12.0000 36.0000 48.0000 60.0000 72.0000 84.0000 96.0000 108.0000 132.0000 132.0000 132.0000 132.0000 166.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0158 .0158 .0158 .0127 .0152	.0137 .0155 .0129 .0083 .0124 .0124 .0124 .0156 .0146 .0127 .0095 .0153 .0130 .0131 .0131 .0162 .0070	V Piot (Raw) .01154 .0118 .0101 .0101 .0118 .0091 .0118 .0114 .0099 .0106 .0106 .0106 .0158 .0127 .0152	H Pice (Raw) .0137 .0155 .029 .083 .024 .0144 .0146 .0127 .0095 .0153 .0130 .0131 .0162	V Diam 0 0 0 0 0 0 0 0 0 0 0 0 0		-0.003 0.015 0.015 0.015 0.005 0.005 0.006 0.006 0.006 0.006 0.006 0.006 0.006 0.015 0.006 0.015 0.016 0.016 0.016 0.016 0.015 0.016 0.015 0.015 0.016 0.015 0.016 0	Ang Pos 228 217 218 239 216 219 223 217 218 223 217 218 228 217 218 228 217 218 228 2217 218 228 2217 218 228 2217 228 2217 228 229 229 229 229 229 229 229 229 229		Top Vi	ew H	orizonta	l Cento	er (Las	ser)	<b>)</b>	$\land$		¥
Bore 2 1 2 3 4 5 6 7 7 8 9 10 11 12 13 14 15 16 17	0 12.0000 36.0000 48.0000 60.0000 72.0000 84.0000 108.0000 120.0000 132.0000 132.0000 136.0000 156.0000 156.0000 168.0000 192.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0106 .0158 .0158 .0158 .0127 .0152 .0150 .0112	.0137 .0155 .0129 .0083 .0124 .0144 .0156 .0146 .0127 .0095 .0153 .0153 .0130 .0131 .0162 .0070 .0143 .0141	♥ Piot (Raw) .0.154 .0.118 .0.101 .0.118 .0.091 .0.118 .0.0144 .0.114 .0.0199 .0.106 .0.006 .0.016 .0.0158 .0.127 .0.152 .0.150 .0.150	H Pice (Raw) .0.37 .0.55 .0.29 .0.24 .0.24 .0.24 .0.24 .0.24 .0.24 .0.24 .0.27 .0.35 .0.20 .0.30 .0.31 .0.23 .0.30 .0.31 .0.24 .0.31 .0.25 .0.27 .0.95 .0.27 .0.95 .0.27 .0.95 .0.27 .0.95 .0.24 .0.24 .0.27 .0.95 .0.27 .0.27 .0.27 .0.27 .0.27 .0.27 .0.24 .0.24 .0.27 .0.24 .0.24 .0.24 .0.27 .0.27 .0.27 .0.23 .0.24 .0.24 .0.24 .0.27 .0.27 .0.23 .0.24 .0.24 .0.24 .0.25 .0.24 .0.27 .0.24 .0.24 .0.25 .0.24 .0.24 .0.27 .0.24 .0.24 .0.27 .0.24	) V Diam 0 0 0 0 0 0 0 0 0 0 0 0 0		-0.002 0.013 0.013 0.003 0.003 0.003 0.003 0.003 0.003 0.005 0.005 0.015 0.0164 0.0154 0.0164 0.0154 0.0164 0.0154 0.0154 0.0154 0.0154 0.0154 0.015 0	Ang Poi 228 217 218 239 216 219 219 223 217 218 223 217 218 228 217 218 228 217 218 228 217 218 228 217 218 228 221 217 218 228 221 223 217 218 229 223 217 218 229 223 217 218 229 223 217 218 229 223 217 218 229 223 217 218 229 223 217 218 229 223 217 218 229 223 227 228 227 228 227 228 227 228 229 223 227 228 229 223 227 228 229 229 223 221 229 223 221 229 223 221 229 223 221 229 223 221 229 223 221 229 223 229 229 229 229 229 229 229 229		Top Vi	ew H	orizonta	l Cento	er (Las	ser)	<b>)</b>	$\land$		¥
Bore 2 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	0 12.0000 36.0000 48.0000 60.0000 84.0000 108.0000 120.0000 132.0000 132.0000 136.0000 136.0000 192.0000 204.0000 216.0000 228.0000	0154 0118 0101 0138 0091 0118 0144 0112 0099 0.066 0.058 0.059 0.059 0.059 0.059 0.059 0.059 0.059 0.012	0137 0155 0129 0083 0124 0144 0156 0136 0131 0155 0130 0131 0153 0131 0142 0070 0131 0142 0070	V Piot (Raw) 0.154 0.118 0.0101 0.018 0.018 0.0144 0.012 0.0199 0.0106 0.0158 0.0158 0.0158 0.0152 0.0152 0.0150 0.0139 0.0992 0.0102	H Pick (Line) AG (Lin	) V Diam. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-0.003 0.014 0.015 0.014 0.015 0.016 0.015 0.016 0.016 0.015 0.016 0.015 0.016 0.015 0.016 0.016 0.015 0.016 0.016 0.020 0	Ang Pon 228 217 218 239 216 219 216 219 223 217 218 228 217 218 228 215 231 220 218 225 231 225 231 225 231 225 231 225 231 225 231 225 225 231 225 225 225 225 225 225 225 225 225 22		Top Vi	ew H	orizonta	l Cento	er (Las	ser)	<b>)</b>	$\land$		¥
Bore # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	0 12.0000 36.0000 48.0000 60.0000 84.0000 108.0000 120.0000 132.0000 132.0000 132.0000 136.0000 136.0000 126.0000 216.0000 228.0000 240.0000	0.154 0.118 0.101 0.138 0.091 0.118 0.091 0.118 0.091 0.104 0.019 0.104 0.104 0.009 0.016 0.0159 0.0159 0.0159 0.0159 0.0159 0.0159 0.0159 0.0121 0.0139	0.137 0.155 0.129 0.088 0.124 0.124 0.124 0.124 0.126 0.130 0.131 0.131 0.143 0.130	V Pict (Raw) 0.154 0.118 0.010 0.018 0.0118 0.0118 0.0118 0.0144 0.0112 0.0099 0.0106 0.0106 0.0106 0.0158 0.0127 0.0152 0.0150 0.0112 0.0139 0.0022 0.0102 0.0117	H Pick (Line) AG (Lin	) V Diam 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-0.003 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Ang Pos 228 217 218 229 216 219 223 217 218 223 217 218 228 215 231 217 218 228 225 221 230 218 228 221 221 228 228 228 228 228 228		Top Vi	ew H	orizonta	l Cento	er (Las	ser)	<b>)</b>	$\land$		¥
Bore 2 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	0 12.0000 36.0000 48.0000 60.0000 84.0000 108.0000 120.0000 132.0000 132.0000 136.0000 136.0000 192.0000 204.0000 216.0000 228.0000	0154 0118 0101 0138 0091 0118 0144 0112 0099 0.066 0.058 0.059 0.059 0.059 0.059 0.059 0.059 0.059 0.012	0137 0155 0129 0083 0124 0144 0156 0156 0155 0155 0153 0153 0153 0153 0153 0153	V Piot (Raw) 0.154 0.118 0.0101 0.018 0.018 0.0144 0.012 0.0199 0.0106 0.0158 0.0158 0.0158 0.0152 0.0152 0.0150 0.0139 0.0992 0.0102	H Pick (Line) AG (Lin	) V Diam. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-0.003 0.014 0.015 0.014 0.015 0.016 0.015 0.016 0.016 0.016 0.015 0.016 0.015 0.016 0.016 0.016 0.020 0	Ang Pon 228 217 218 239 216 219 216 219 223 217 218 228 217 218 228 215 231 220 218 225 231 225 231 225 231 225 231 225 231 225 231 225 225 231 225 225 225 225 225 225 225 225 225 22		Top Vi	ew H	orizonta	l Cento	er (Las	ser)	<b>)</b>	$\land$		¥

Bore #	Dist	V Raw	H Raw	V Plot (Raw)	H Plot (Raw)	V Diam	H Diam	Rad	Ang Por
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