## **Application Note**

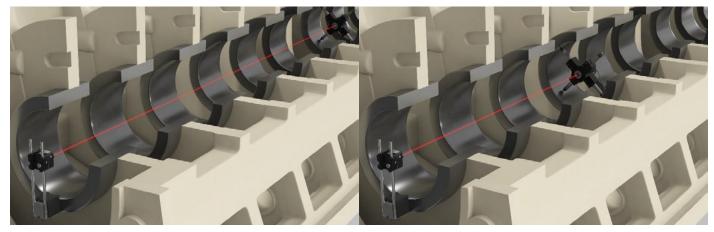
# Engine Block Bore Alignment with the L-703B Laser

#### L-703B 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

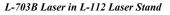




To perform alignments, the L-703B Laser is mounted in the L-112 Laser Stand and the L-103 Laser Beam Translator is attached. The L-112 has coarse *angular* adjustment capabilities and the L-103 can *translate* (change the centering) the laser beam up/down and left/right without changing the angle. The entire assembly is then mounted either on an instrument stand near the first reference bore or on the face of the bore.

The A-512/A-514 target/adapter is placed in the first bore and the L-103 Beam Translator is adjusted to center the laser beam to the target. The target







A-514A, B & C Self-Centering Bore Adapters

is then moved to the far reference bore and the angular adjustment 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 in 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.

#### Other Self-Centering Targets.

We also make several other self-centering targets (A-220, A-221 and A-510) that use customized set of tooling for each bore ID. These targets can align bores from .7 to 16 in. (18 to 400 mm) for applications such as extruder barrels, large gun barrels and compressors or for applications where there are only a few bore ID's.



Hamar Laser Instruments, Inc. 5 Ye Olde Road Danbury, CT 06810 Phone: 800.826.6185 Fax: 203.730.4611 Int'l: +1.203.730.4600 E-mail: sales@hamarlaser.com <u>www.hamarlaser.com</u> <u>Click here</u> for a list of our distributors.

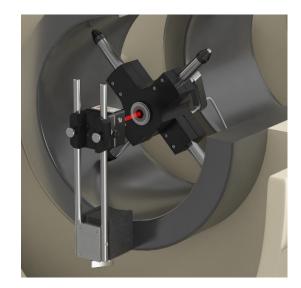


## How it Works - the A-512 Target and A-514 Bore Adapters

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.

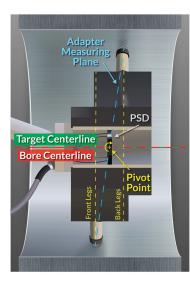
To insert the target into the bore, attach the handle/pole to the target and tip the target forward, which allows it to easily slide into the bore. Release the handle/insertion pole and the target/adapter "jam" into the bore, finding the center automatically. The weight of the handle/pole keeps the target centered in the bore.

The A-512 Target inserts into the A-514 Adjustable Self-Centering Bore Adapters and self-center into a bore to within .0007 in. (0.01 mm). These A-514 adapters cover a range of bore ID's from 3.75 to 40 in. (95-1,000 mm) and are can be set to the nominal bore ID over this range using our A-514GS Leg-Setting Gage.

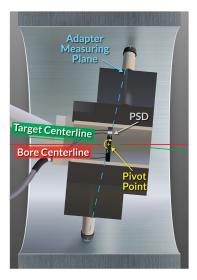


A-512 Target in A-514B Self-Centering Bore Adapter mounted in a bore

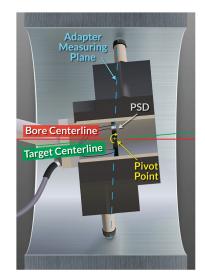
## Self-Centering Target Adapters and Bore Diameter Changes



Adapter OD = Nominal Bore ID Target is square to centerline



Bore ID > Nominal ID Target tilts forward but PSD is still centered

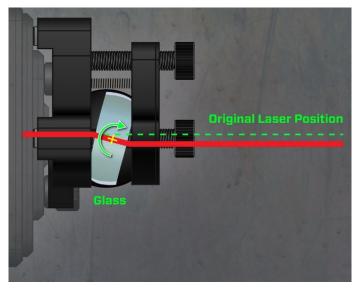


Bore ID < Nominal ID Target tilts back but PSD is still centered

## How it Works – The L-103 Laser Beam Translator

The L-103 uses a parallel-sided piece of glass to redirect the laser beam to center it into a bore target. It works by the laser beam passing through the glass and reflecting off entrance surface and going up/down, or left/right, and coming out the exit surface with the beam being parallel but offset from the input beam. The angle of the beam is not affected by tilting the optic. The greater the tilt, the greater the position change of the laser beam. The resolution of the adjustment is .00005 in. (0.001 mm). It has a range of  $\pm$ .040 in. ( $\pm$ 1 mm)

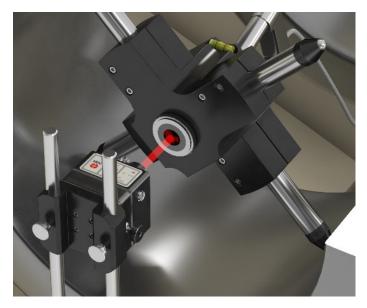
The L-103 is attached to the L-703B Laser with powerful magnets. To translate the beam, there are 2 adjustment screws, one for horizontal movement and one for vertical. When the target is centered in the near bore with in  $\pm$  .040 in., the L-103 is then used to finely adjust the position of the laser beam to be centered to the target. This makes the laser setup go much faster and easier than trying to move the magnetic base or the laser up/down the posts.



L-103 Laser Beam Translator Showing Beam Position Change with Tilted Optic



L-703B Laser with L-103 Beam Translator

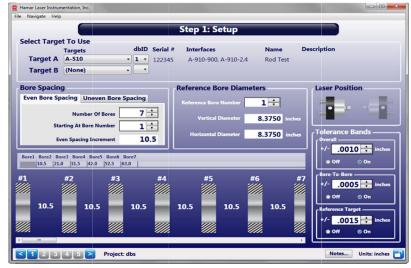


L-703B Laser with L-103 Beam Translator with Laser Beam Centered to A-512 Target

## How it Works – Bore Alignment Procedure Using L-703B, L-112, L-103 and Bore9

#### Step 1: Setup

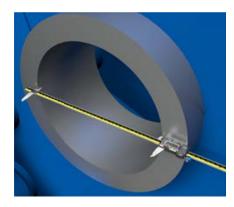
- a. Open Bore9 and select the target and computer interface.
- b. Enter the number of bores, the distance between the bores, the bore diameters, and select the alignment tolerances.



Bore9 – Step 1: Setup

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

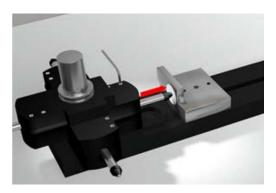
Note: If using the A-220, A-221, A-510 Targets and Self-Centering Bore Adapters, then the matching customized set of bore adapter tooling would be assembled with the target.





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

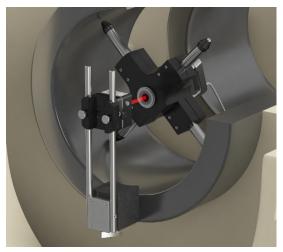
d. Slide the A-514A, B or C onto the A-514GS gage. Insert the stop-pin and insert a leg into one of the mounting holes. Push the leg against the stop and tighten the set screw. Repeat for all four legs. This sets all 4 legs to the same length to a high degree of accuracy – usually below .0002 in. (0.005 mm).



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 both into the near bore, making sure the adapter's level vial is level, which aligns the target's V&H measurement axes with the bores V & H axes.





L- 703 Laser with A-512/A-514 Target in near bore

- f. Adjust the L-103 Beam translator to zero the R-1307 Readout and center the laser into the first reference bore (see the graphic on page 2 that shows how the L-103 moves the height of the laser beam, but not the angle).
- g. The laser beam is now centered to the A-512 Target located in the near reference bore.



L-103 Laser Beam Translator Adjustments

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

*Note:* Step 2: Remove Target Mounting Error of the Bore9 program is usually 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.



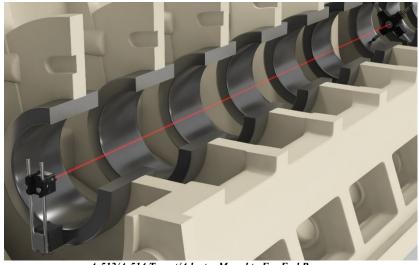
### Step 3: Laser Buckin (Setup)

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). With the target in the *near* bore and zeroed, press **Record** to record data for the *near* bore.

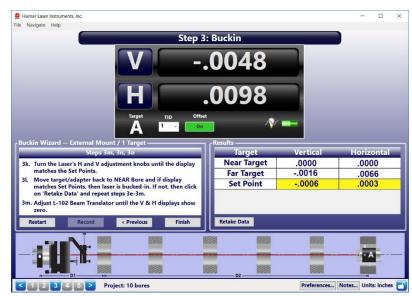


Bore9 - Step 3: Data Taken Near Bore

a. Move the target to the *far* bore and press **Record**. A calculation of the laser *Set Points* will be made to aid the laser setup and offsets will be applied to on-screen live data. This allows the user to steer the laser to zero instead of the calculated offsets, making the setup process a faster and easier.



A-512/A-514 Target/Adapter Moved to Far End Bore



Bore9 - Step 3: Data Taken Far Bore and Set Points Calculated

b. With Buckin Offsets applied in the Bore9 software, tilt the laser beam using the Pitch and Yaw knobs (angular adjustment) on the L-703B until the H and V displays equal the set point or are very close.



Adjusting the H & V angles on the L-703B to center it at the far bore

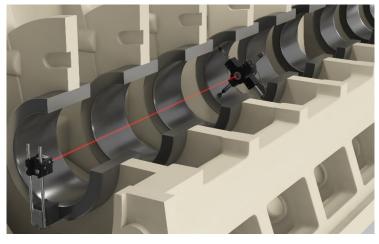
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File Navigate Help			
Step 3:	Buckin		
<b>V</b>	0004		-
	0002		
Buckin Wizard External Mount / 1 Target	Results	-	
Steps 3m, 3n, 3o	Target	Vertical	Horizontal
3k. Turn the Laser's H and V adjustment knobs until the display	Near Target	.0000	.0000
matches the Set Points. 31. Move target/adapter back to NEAR Bore and if display	Far Target	0016	.0066
matches Set Points, then laser is bucked-in. If not, then click	Set Point	0006	.0003
on 'Retake Data' and repeat steps 3e-3m. 3m. Adjust L-102 Beam Translator until the V & H displays show zero.			
Restart Record < Previous Finish	Retake Data		
			• • A
	D2	22	
<12345 Project: 10 bores		Preferences	Notes Units: inches

Bore9 - Step 3: Laser Steered to Zero (Bucked-In)

- c. Move the target back to the *near* bore to confirm the values are the same as they were at the *far* bore.
- d. If needed, repeat the process to confirm the same value 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**. Inserting the target and taking a measurement only takes 5-10 seconds. Continue moving the target to each bore until all data is taken.



A-512/A-514B Target/Adapter Measuring an Inner Bore

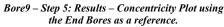


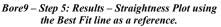
Bore9 – Step 4 – Data Recorded for All Bores

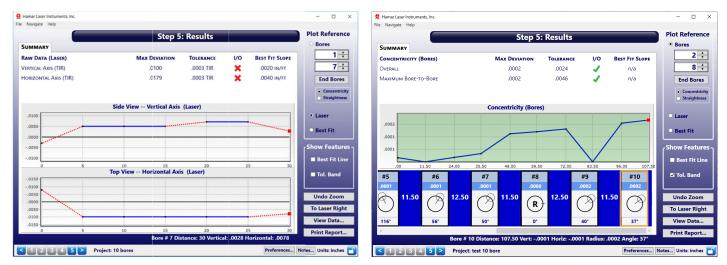
#### **Step 5: Results**

- 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 one 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. The best fit calculation removes any remaining slope error in the data due to the laser not being perfectly bucked in to the end bores.
  - 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 Laser as a reference.

Bore9 – Step 5: Results – Concentricity Plot using Bores 2 & 8 as a reference.

## **Bore9 Sample Report**

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			Proj	ect: 30bo	res				
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Phone/FAX: Company EN									
company Er	viai:		Machi	ne Inform	ation				
actory Nan									
Nachine Info Notes:	ormation:								
			Alignment Results						
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	Dist 0 12.0000			V Plot (Raw)	H Plot (Raw)			0.02 0.915 0.01 0.905 0 -0.905 0 Red	Top View Horizontal Center (Laser)
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1 2 3 4 5	12.0000 24.0000 36.0000 48.0000	.0154 .0118 .0101 .0138 .0091	.0137 .0155 .0129 .0083 .0124	V Plot (Raw) .0154 .0118 .0101 .0138 .0091	H Plot (Raw) .0137 .0155 .0129 .0083 .0124	0 0 0 0	0 0 0 0	0.02 0.315 0.01 0.005 0 -0.005 0 .2266 .0195 .0164 .0161	Top View Horizontal Center (Laser)       4     96     144     192     240     288     33       49     96     144     192     240     288     33       228     227     228     228     229     226     226     240     288     33
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1 2 3 4 5 6	12.0000 24.0000 36.0000 48.0000	.0154 .0118 .0101 .0138 .0091	.0137 .0155 .0129 .0083 .0124	V Plot (Raw) .0154 .0118 .0101 .0138 .0091	H Plot (Raw) .0137 .0155 .0129 .0083 .0124	0 0 0 0	0 0 0 0	0.02 0.315 0.01 0.005 0 -0.005 0 .2266 .0195 .0164 .0161	Top View Horizontal Center (Laser)       4     96     144     192     240     288     33       49     96     144     192     240     288     33       228     227     228     228     229     226     226     240     288     33
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1 2 3 4 5 6 7 8	12.0000 24.0000 36.0000 60.0000 72.0000 84.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112	.0137 .0155 .0129 .0083 .0124 .0124 .0144 .0156 .0146	V Piot (Raw) .0154 .0101 .0101 .0101 .0138 .0091 .0118 .0144 .0112	H Plot (Raw) .0137 .0155 .0129 .0083 .0124 .0124 .0126 .0146	0 0 0 0 0 0 0	0 0 0 0 0 0 0	0.02 0.015 0.01 0.005 0 0 7.44 0.0206 0.0195 0.0195 0.0164 0.0154 0.0154 0.0184	Top View Horizontal Center (Laser)       4     96     144     192     240     288     33       4     96     144     192     240     288     33       7
1 2 3 4 5 6 7 8 9	12.0000 24.0000 36.0000 48.0000 60.0000 72.0000 84.0000 96.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099	.0137 .0155 .0129 .0083 .0124 .0144 .0144 .0156 .0146 .0127	V Plot (Rew) .0154 .0118 .0101 .0138 .0091 .0118 .0114 .0112 .0099	H Plot (Raw) .0137 .0155 .0129 .0083 .0124 .0144 .0144 .0146 .0146	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0.02 0.415 0.01 0.005 0 -0.005 0 -0.005 0 -0.005 0 -0.005 0 0 -0.005 0 0 -0.015 0 0 -0.015 0 0 -0.005 0 0 -0.015 0 -0.015 0	Top View Horizontal Center (Laser)       4     96     142     240     286     33       40     96     144     192     240     286     33       228     228     226     240     286     33       228     226     226     233     226     226     226     226     226     226     236     227     226     226     227     226     226     226     227     226     226     227     226
1 2 3 4 5 6 7 8 9 10	12.0000 24.0000 36.0000 48.0000 60.0000 72.0000 84.0000 96.0000 108.0000 120.0000 132.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106	.0137 .0155 .0129 .0083 .0124 .0124 .0156 .0146 .0156 .0146	V Plot (Rew) .0.154 .0.118 .0.101 .0.118 .0.091 .0.118 .0.144 .0.099 .0.106	H Plot (R=w) .0137 .0155 .0129 .0083 .0124 .0124 .0144 .0156 .0146 .0127 .0095	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	0.02 0.415 0.01 0.005 0 -0.005 0 -0.005 0 -0.005 0 0 -0.0154 0.0154 0.0154 0.0154 0.0154 0.0154 0.0154 0.0154 0.0154 0.0150 0.0150 0.0150 0.0150000000000	All     96     144     192     240     248     33       228     227     228     223     227     228     223     227     228     28     28     28     28
1 2 3 4 5 6 7 8 9 10 11	12.0000 24.0000 36.0000 48.0000 60.0000 72.0000 84.0000 96.0000 108.0000 120.0000 132.0000 132.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0158 .0158	0137 0155 0129 0083 0124 0144 0156 0146 0146 0146 0153 0095 0153 0130 0131	V Piot (Raw) .0154 .0118 .0101 .0138 .0091 .0118 .0114 .0114 .0112 .0099 .0106 .0106 .0106 .0158	H Plot (Raw) .0137 .0155 .0129 .0083 .0124 .0124 .0124 .0156 .0146 .0127 .0095 .0153 .0130 .0131			0.02 0.115 0.01 0.005 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Top View Horizontal Center (Laser)       40     96     144     192     240     284     33       228     227     228     33     33       228     227     284     33       228     228     240     284     33       228     229     229     229     229     229     240
1 2 3 4 5 6 7 8 9 10 11 12 13 14	12.0000 24.0000 36.0000 48.0000 60.0000 72.0000 84.0000 96.0000 108.0000 120.0000 132.0000 144.0000 156.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0118 .0144 .0112 .0099 .0106 .0106 .0158 .0158 .0158	.0137 .0155 .0129 .0083 .0124 .0124 .0124 .0156 .0146 .0127 .0095 .0153 .0130 .0130 .0131 .0162	V Piot (Raw) .0154 .0101 .0101 .0138 .0018 .0118 .0118 .0114 .0112 .0099 .0106 .0106 .0158 .0158 .0127	H 9404 (9200) 0.0137 0.0155 0.0129 0083 0.124 0.124 0.144 0.0156 0.146 0.0127 0.095 0.153 0.0130 0.0131 0.0162			0.02 0.115 0.01 0.005 0 0 -0.206 0.195 0.164 0.161 0.154 0.161 0.154 0.122 0.124 0.124 0.124 0.225	Top View Horizontal Center (Laser)   48 96 144 192 240 288 33   208 228 240 288 33   228 228 288 33   228 228 288 33   228 228 288 33   228 228 288 33   228 228 288 33   228 228 288 33
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	12.0000 24.0000 36.0000 48.0000 94.0000 96.0000 108.0000 120.0000 132.0000 132.0000 132.0000 132.0000 132.0000 144.0000 156.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0118 .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	♥ Piot (Raw) 0.154 0.115 0.010 0.010 0.018 0.009 0.018 0.0144 0.0112 0.0099 0.0106 0.0106 0.0158 0.0158	H 9904 (9200) 0.0137 0.0155 0.0129 0.024 0.0124 0.0124 0.0144 0.0156 0.0146 0.0127 0.095 0.0153 0.0130 0.0131 0.0162 0.0070			0.02 0.115 0.01 0.005 0 -0.206 0.195 0.164 0.161 0.154 0.161 0.154 0.122 0.124 0.126 0.212 0.124 0.126 0.212 0.124 0.125 0.205 0.205 0.205	Top View Horizontal Center (Laser)       Image: Colspan="2">Image: Colspan="2" Image: Colspan="" Image: Colspan="2" Image: Colspan="2"
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	12.0000 24.0000 36.0000 48.0000 60.0000 34.0000 96.0000 108.0000 132.0000 134.0000 136.0000 168.0000 180.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0106 .0106 .0158 .0158 .0127 .0152 .0150	.0137 .0155 .0129 .0083 .0124 .0144 .0156 .0146 .0127 .0095 .0153 .0130 .0131 .0162 .0070 .0143	♥ Pick (Raw) 0.154 0.118 0.019 0.019 0.018 0.091 0.018 0.0118 0.0144 0.0112 0.099 0.0106 0.0106 0.0158 0.0158 0.0127 0.0152 0.0150	H Piot (Raw) 0.137 0.155 0.129 0.083 0.124 0.124 0.156 0.146 0.127 0.095 0.153 0.130 0.131 0.162 0.070 0.143			0.02 0.115 0.01 0.005 0 -0.206 0.195 0.164 0.161 0.154 0.161 0.154 0.161 0.126	Top View Horizontal Center (Laser)       48     96     144     192     240     288     33       48     96     144     192     240     288     33       228     228     228     33     34     34     34     35       228     229     240     288     33     35     35       228     229     228     229     228     35     3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	12.0000 24.0000 36.0000 48.0000 60.0000 96.0000 108.0000 132.0000 134.0000 136.0000 168.0000 188.0000 192.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0106 .0106 .0158 .0158 .0157 .0152 .0150 .0112	.0137 0155 0129 0083 0124 0144 0.156 0.146 0.127 0.095 0.153 0.130 0.131 0.162 0.070 0.143 0.141	V Pick (Paw) 0.154 0.118 0.0101 0.0101 0.018 0.014 0.012 0.0196 0.0106 0.0158 0.0158 0.0159 0.0152 0.0150 0.0120	H Piot (Raw) 0.137 0.155 0.129 0.083 0.124 0.124 0.156 0.146 0.127 0.095 0.153 0.130 0.131 0.162 0.070 0.141			0.02 0.315 0.01 0.305 0 -0.30 0 -0.305 0 -0.30 0 -0.305 0 -0.305 0 -0.305 0	Top View Horizontal Center (Laser)   41 96 144 192 240 288 33   208 228 228 23   228 228 288 33   228 228 288 33   228 228 288 33   228 228 288 33   229 288 33 34   229 288 33 34   228 236 235 231   230 236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	12.0000 24.0000 36.0000 48.0000 84.0000 96.0000 108.0000 132.0000 134.0000 136.0000 136.0000 136.0000 139.0000 180.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0106 .0106 .0158 .0158 .0158 .0158 .0152 .0150 .0112 .0139	.0137 .0155 .0129 .0083 .0124 .0144 .0156 .0146 .0127 .0095 .0153 .0130 .0131 .0162 .0070 .0143 .0141 .0088	V Pick (Paro) 0.154 0.118 0.0101 0.0101 0.018 0.014 0.016 0.0106 0.0106 0.0158 0.0159 0.0159 0.0159 0.0159 0.0159 0.0159	H Plot (Paux) 0.137 0.155 0.129 0083 0.124 0.124 0.156 0.126 0.127 00153 0.130 0.131 0.162 0.0131 0.162 0.0141 0.141			0.02 0.315 0.01 0.305 0 0 0.206 0.195 0.206 0.195 0.164 0.164 0.164 0.164 0.164 0.186 0.2012 0.186 0.205 0.2	Top View Horizontal Center (Laser)       4     96     144     192     240     288     33       208     228     228     237     228     33       228     228     228     33     34     96     144     192     240     288     33       228     228     228     237     228     33     34     34     35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	12.0000 24.0000 36.0000 48.0000 60.0000 96.0000 108.0000 132.0000 134.0000 136.0000 168.0000 188.0000 192.0000	.0154 .0118 .0101 .0138 .0091 .0118 .0144 .0112 .0099 .0106 .0106 .0106 .0158 .0158 .0157 .0152 .0150 .0112	.0137 0155 0129 0083 0124 0144 0.156 0.146 0.127 0.095 0.153 0.130 0.131 0.162 0.070 0.143 0.141	V Pick (Paux) 0.154 0.118 0.0101 0.0101 0.018 0.014 0.012 0.0196 0.0106 0.0158 0.0158 0.0159 0.0152 0.0150 0.0120	H Piot (Raw) 0.137 0.155 0.129 0.083 0.124 0.124 0.156 0.146 0.127 0.095 0.153 0.130 0.131 0.162 0.070 0.141			0.02 0.315 0.01 0.305 0 -0.30 0 -0.305 0 -0.30 0 -0.305 0 -0.305 0 -0.305 0	Top View Horizontal Center (Laser)   41 96 144 192 240 288 33   208 228 228 23   228 228 288 33   228 228 288 33   228 228 288 33   228 228 288 33   229 288 33 34   229 288 33 34   228 236 235 231   230 236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236   236 236 236
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	12.0000 24.0000 36.0000 48.0000 96.0000 96.0000 108.0000 132.0000 136.0000 136.0000 136.0000 180.0000 192.0000 294.0000 216.0000	0154 0118 0101 0138 0091 0118 0118 0118 0118 0118 0106 0106 010	0.137 0.155 0.129 0.083 0.124 0.124 0.124 0.124 0.124 0.156 0.153 0.153 0.131 0.153 0.133 0.131 0.154 0.075 0.0153 0.131 0.154 0.01540000000000000000000000000000000000	V Pick (Paw) 0.154 0.118 0.0191 0.018 0.014 0.018 0.0144 0.012 0.0199 0.016 0.158 0.0158 0.0159	14 964 (Law) 0237 0255 0129 0083 024 024 024 0256 024 0256 0257 0095 0230 0333 0332 0333 0332 0333 0332 0243 0334 0336 0338 0336 0336 0337 0338 0336 0338 0338 0338 0338 0338 0338 0338 0338 0356 0338 0338 0338 0338 0338 0338 0338 0338 0338 0338 0338 0338 0338 0338 0338 0356 0338 0348 0356 0357 0358 0			0.02 0.315 0.01 0.405 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Top View Horizontal Center (Laser)       41     96     144     192     240     288     33       228     228     228     228     33       228     228     228     33       228     228     228     33       228     228     228     33       229     228     33     34       228     228     231     35       228     228     228     35       228     228     228     35       228     228     228     35       228     228     228     35       228     228     35     35       228     228     35     35       228     228     35     35       228     228     35     35       228     228     35     35       228     228     35     35       328     35     35     35       329     35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	12.0000 24.0000 36.0000 48.0000 96.0000 108.0000 108.0000 132.0000 1344.0000 1356.0000 188.0000 188.0000 189.0000 294.0000 216.0000 228.0000	.0154 .0118 .0101 .0333 .0091 .0118 .0121 .0104 .0104 .0106 .0106 .0106 .0150 .0150 .0150 .0150 .0150 .0122 .0150 .0122	0.377 0.555 0.129 0.083 0.124 0.124 0.124 0.124 0.036 0.131 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035	V Pick (Raw) .0.154 .0.118 .0.101 .0.118 .0.011 .0.118 .0.0144 .0.112 .0.099 .0.106 .0.106 .0.106 .0.158 .0.158 .0.159 .0.152 .0.150 .0.150 .0.150 .0.152 .0.150	H P(4) (Long) 0137 0155 0129 0083 0244 0356 0344 0356 0130 0133 0130 0333 0130 0333 0130 0333 0144 0352 0070 0443 0344 0355 0126 0268			0.02 0.015 0.010 0.005 0 0 0.005 0 0 0 0 0 0 0 0 0 0 0	Top View Horizontal Center (Laser)       41     96     144     192     240     288     33       208     228     228     228     33       228     228     228     33       228     228     33     34     35       228     228     228     33     35       228     228     235     33     35       228     225     228     35     35       228     226     228     35     35       228     226     228     35     35       226     228     35     35     35       226     228     35     35     35       226     228     35     35     35       226     228     35     35     35       228     228     35     35     35       228     228     35     35     35       228     228     35     35     35
1 2 3 4 5 6 7 8 9 9 10 11 12 13 14 15 16 17 18 19 20 21	12.0000 24.0000 36.0000 48.0000 96.0000 108.0000 108.0000 132.0000 134.0000 134.0000 135.0000 135.0000 192.0000 240.0000 240.0000	.0154 .0118 .0101 .0333 .0091 .0118 .0121 .0124 .0104 .0104 .0106 .0106 .0106 .0150 .0150 .0150 .0150 .0150 .0122 .0150 .0122 .0123	0.377 0.555 0.129 0.083 0.124 0.124 0.124 0.124 0.124 0.036 0.131 0.133 0.131 0.142 0.070 0.131 0.143 0.144 0.141 0.088 0.126	V Pick (Raw) .0.154 .0.118 .0.011 .0.118 .0.011 .0.118 .0.014 .0.014 .0.014 .0.014 .0.016 .0.016 .0.016 .0.0159 .0.0159 .0.0150 .0.0150 .0.0150 .0.0150 .0.012 .0.012 .0.012 .0.012 .0.012	H P(4) (Long) 0137 0155 0129 0083 0244 0356 0344 0356 0130 0130 0131 0137 0131 0137 0131 0137 0137 0131 0151 015			0.02 0.415 0.415 0.415 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Top View Horizontal Center (Laser)       4     96     142     240     286       228     228     286     286     228     237     286     286     229     240     286     286     216     2
1 2 3 4 5 6 7 7 8 9 9 10 11 12 13 14 15 16 17 18 19 20 21 22	12.0000 24.0000 36.0000 48.0000 84.0000 96.0000 108.0000 108.0000 132.0000 134.0000 1368.0000 1392.0000 204.0000 216.0000 228.0000 240.0000 252.0000	.0154 .0118 .0101 .0338 .0091 .0118 .0191 .0104 .0112 .0109 .0106 .0158 .0159 .0125 .01555 .01555 .01555 .01555 .01555 .015555 .015555555555	0.377 0.555 0.229 0.083 0.124 0.124 0.124 0.124 0.126 0.025 0.035 0.133 0.330 0.331 0.331 0.331 0.334 0.043 0.043 0.0443 0.0443 0.0443 0.026 0.008 0.026	V Pick (Raw) .0.154 .0.118 .0.011 .0.118 .0.011 .0.118 .0.014 .0.118 .0.014 .0.016 .0.0099 .0.106 .0.106 .0.105 .0.105 .0.152 .0.152 .0.152 .0.152 .0.153 .0.152 .0.153 .0.154 .0.155 .0.155 .0.155 .0.155 .0.155 .0.157 .0.155 .0.157 .0	H Pole (Law) 0137 0155 0129 0083 0244 0346 0346 0327 0055 0153 0153 0153 0153 0153 0153 0153 0153 0154 0244 0346 027 046 027 055 017 055 024 024 024 024 024 024 024 024			0.02 0.015 0.00 0.005 0 0 0.005 0 0 0 0 0 0 0 0 0	Top View Horizontal Center (Laser)       4     96     14     192     240     248     33       200     226     226     240     248     33       226     227     228     240     248     33       226     227     228     226     248     33       226     227     228     226     226     227       228     227     228     226     235     231     236

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