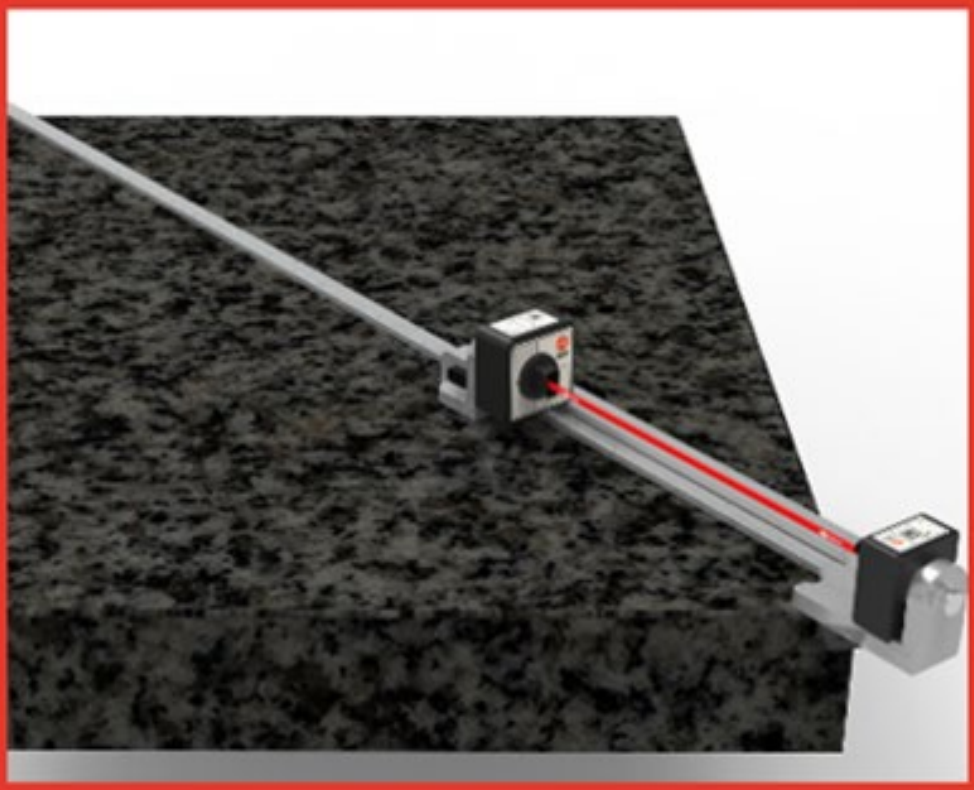

L-703SP Surface Plate Calibration System

Revision B3
March 2025

HAMAR LASER®
ALIGN WITH THE BEST

HAMAR LASER INSTRUMENTS, INC.
www.hamarlaser.com

5 Ye Olde Road, Danbury, CT 06810
Ph: +1-203-730-4600
Fax +1-203-730-4611

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Hamar Laser Instruments, Inc., warrants each instrument and other articles of equipment manufactured by it to be free from defects in materials and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument and other article of equipment which shall within one year after shipment of each instrument and other article of equipment to the original purchaser be returned intact to Hamar with transportation prepaid, and which Hamar's examination shall disclose to Hamar's satisfaction to have been thus defective; other than this express warranty, Hamar neither assumes nor authorizes any other persons to assume for it any other liability or obligation in connection with the sale of its products.

This warranty is not applicable to instruments or other articles of equipment manufactured by other companies and limited by a warranty extending for less than one year. In such an event, the more limited warranty applies to said instrument or article of equipment.

This warranty shall not apply to any instrument or other article of equipment which shall have been repaired or altered outside the Hamar factory, nor which has been subject to misuse, negligence, or use not in accord with instructions furnished by the manufacturer.

The software described in this manual is furnished under a license agreement and may be used or copied only in accordance with the terms of the agreement. It is against the law to copy the software on any medium for any purpose other than the purchaser's personal use.

5 Ye Older Road, Danbury, Connecticut 06810

Table of Contents

L-703SP Surface Plate Calibration System

The L-703SP Surface Plate Calibration System has been designed to quickly and very accurately check the calibration of surface plates using the Moody Method, following the ASME B89.3 Standard for Surface Plate Calibration. It uses Plane6 Surface Plate Calibration Software and specially designed fixtures to give a high degree of accuracy when calibrating surface plates.

System Components

The L-703SP Surface Plate Calibration System - includes the following components:

- L-703S Spindle & Straightness Laser
- T-1297 3-Axis Wireless Straightness Target with .00001 in. (0.25 μm) Resolution, 10x10 PSD, Bluetooth & Center/Scan Mode
- A-703SP-LM Surface-Plate Mounting Fixture for L-703SP Laser
- A-1297-SP High Accuracy, Flatness Measuring Base for T-1297 Target
- A-703SP-SE-A Target Straight-Edge and Ruler – 18 in. (457 mm)
- A-703SP-SE-B Target Straight-Edge and Ruler – 36 in. (914 mm)
- A-703SP-SE-C Target Straight-Edge and Ruler – 54 in. (1,373 mm) – 2 pieces
- A-703SP-SE-D Target Straight-Edge and Ruler – 72 in. (1,829 mm) - 2 pieces
- S-1409 Plane6 Surface-Plate Calibration Software for Win 10/11
- A-818 Shipping Case for L-703/L-705 Spindle & Extruder Systems
- A-819 Shipping Case for L-703SP Straight-Edges and A-703SP-LM

Computer System Requirements

- Physical memory (RAM): 8 GB recommended
- Processor: Intel Pentium4 or later version or AMD equivalent, 1.3 GHz minimum speed
- Available Hard Drive space: 20 GB minimum
- Video Resolution: 1366 x 768 minimum (32-bit color) with hardware acceleration and dedicated video memory.
- Windows 10/11 professional editions.
- Bluetooth 2.0 and higher

System Features

- Geometry laser, not interferometer with resolution of 10 μin. (0.25 μm).
- Fast, easy setup – 30-40% faster than levels
- Super-linear PSD sensor with <0.25% linearity error
- Bluetooth wireless with 100 ft. (30 m) range
- 3-point measuring base accommodates nearly any measuring increment
- Kit includes a set of straight-edge rulers for fast setups for plates up to 72 in. diagonal. Optional add-on straightedges are available for diagonals up to 126 in. (3.2m).
- Also includes corner & midpoint, straightedge-locating tools to position the straightedge so that the target is located directly on the measurement line.
- Plane6 Surface Plate Calibration Software corrects setup errors and quickly records data, producing calibration report with graph
- Plane6 software runs on most typical Windows® laptops/tablets running Win 8/10/11.
- Li-Po rechargeable batteries for laser/ target with 14+ hrs life

L-703SP Surface Plate Calibration System - Hardware Overview

This section describes the equipment and operation for calibrating surface plates using Hamar Laser's L-703SP Surface Plate Calibration Laser System. The system includes the laser, targets, fixtures, and software.

L-703S Spindle & Straightness Laser - Features and Setup

Figure 1 - L-703S Laser

- Operating range of 50 ft. (15 m).
- Pitch and yaw angular adjustments with a resolution of .00002 in/ft (1.6 µm/m) and adjustment range of ±0.36° (±.075 in/ft. or ± 6.26 mm/m).
- A .4995 in. (12.69 mm) mounting stud with the laser beam concentric to < .0003 in. (0.008 mm).
- Under good environmental conditions, it is accurate to .0015 in. (0.075 mm) in 50 ft. (15 m).
- Rechargeable Li-Ion battery with 20+ hours of battery life.

The L-703S is mounted directly in the A-703SP-LM Surface-Plate Mounting Fixture and aligned to the T-1297 Target located at the end of the line segment. This provides a straight reference line for checking the flatness of the line segment and the rest of the surface plate.

Applications include:

- Surface plate calibration
- Linear guideway straightness
- Flatness/straightness of large parts

L-703S Laser Control Panel and Functions

The I/O and Status LEDs

- *Battery Status LED* – green – normally it is off.
  - Blinks when the battery is low.
  - Solid green when the battery is charging. Turns off when the battery is fully charged.
- *I/O LED* – indicates the laser is turned on. This is also the mode indicator for the laser mode (see Laser Modes below).

The On/Off Button

Press the **I/O** button once to turn it on and press and *hold* for 3 seconds to turn it off. The I/O LED will illuminate when the power turns on.

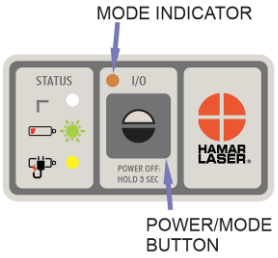


Figure 2 - L-703S Power Overlay

L-703S Laser Modes

There are 2 laser modes:

1. **Double-Blink Mode** (default) – this is used for the T-1295/T-1296/T-1297 Targets only. The I/O LED will blink twice and pause, blink twice and pause, and will do this continuously.
2. **Fixed (Continuous) Beam mode** – the laser beam is turned on continuously and does not blink. This is used for legacy targets using the R-358 Computer Interface or R-307/R-307V Readouts. The I/O LED will be continuously on (no blinking).

To change the mode, press the **I/O** power button once – do <u>not</u> press and hold, just press one time.

A/C Connector

The L-703S comes with a rechargeable battery. The connector is shown in Figure 3 To connect it, line up the red dot on the A/C adapter plug with the red line on the connector.

Figure 3 - The L-703S - Laser A/C Adapter Connector

L-703S Angular Adjustments

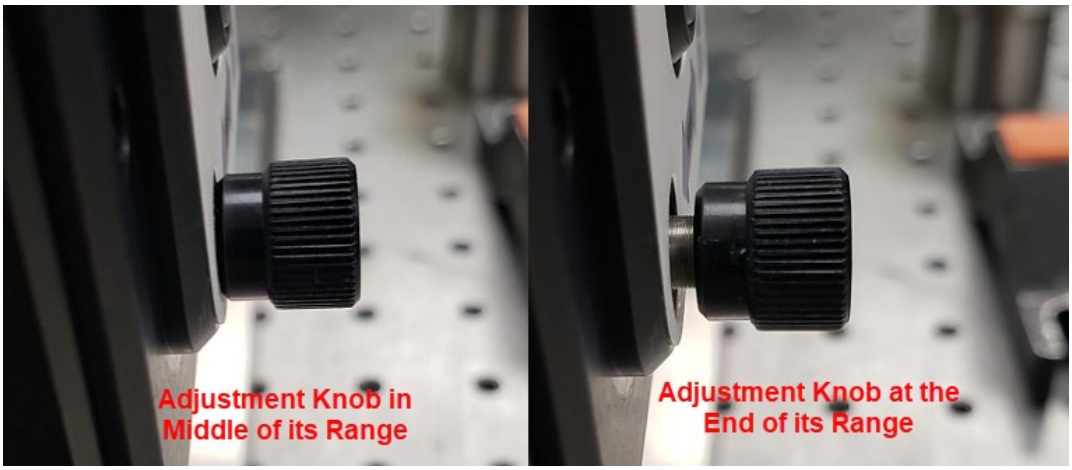
The L-703S comes with pitch (vertical) and yaw (horizontal) angular adjustments to adjust (tilt) the laser to align it to reference points or a rotation axis. The angular adjustments have a resolution of .00002 in/ft (0.0016 mm/m) and an adjustment range of ±0.36° (±.075 in/ft or ± 6.26 mm/m)

L-703 Specifications		
Beam Centering to Mount	.0003 in.	0.008 mm
Angular Range (slope)	±.08 in/ft.	6.6 mm/m
Angular Range (deg.)	±0.38 deg.	
Angular Resolution	.00002 in./ft.	0.0016 mm/m

Figure 4 - - L-703S Laser showing Pitch & Yaw Adjustments

L-703S Angular Adjustments – Returning Adjustments to the Center of their Range

To start an alignment, it is best to return the L-703S's angular adjustments to the middle of their range. The middle of the range is when the knob is flush with the overlay (see below). If the knob is unscrewed all the way, then knob will come out but this will not harm the mechanism, so just screw it back in. If the knob is screwed in, then it will also go into the face plate about .25 in. (10 mm).



L-703S Level Vials

When using the L-703S in machine tools, we typically will do measurements with the laser at the NORMal position (12:00) and then rotated with the spindle 180 degrees to the INverted position (6:00). There are level vials on the *side* of the laser to help you know if the laser is directly at 12:00 or 6:00. However, this is not typically used in surface plate calibration, so they are not used in this application.

To use the level, rotate the laser 90 degrees so that the control panel is on the side (i.e. at 3:00 or 9:00). Then slowly rotate the spindle until the bubble is centered in the circle. This indicates the laser is ready to be aligned to the rotation axis.

Figure 5 - L-703 Level Vial

L-703S Warmup Period

IMPORTANT!

We recommend that the use let the laser warm up for at least 30 minutes for the lower accuracy plate grades and for 40-45 minutes for the high accuracy grades. To warm it up, simply turn it on and let it run for the recommended time.

The warmup period allows the internal mounting hardware to thermally grow to a stable state, which reduces the variability in the measurement.

It is also very important to let the target and mounting hardware warm up to ambient temperature especially if they have been stored in an environment that is more than 10 degrees from the ambient temperature.

L-703SP Surface Plate Calibration System - Hardware Overview

The T-1297 3-Axis Wireless Spindle & Straightness Target

Hamar Laser's T-1297 3-Axis Wireless Spindle & Straightness Target is designed work with our L-703S Spindle & Straightness Laser. With Bluetooth communication and multiple measuring axes, the T-1297 target is a multi-purpose target that can be used for many different applications.

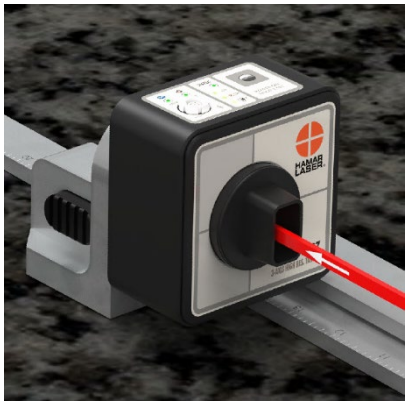


Figure 6 - T-1297 3-Axis Wireless Spindle &

- Offers 2 measurement modes:
  - ❖ *Center Mode* - 2-axis center measurement for use with the L-703S Spindle laser.
  - ❖ *Flatness (Scan) Mode* - single-axis flatness measurement for use with our series of auto-rotating lasers (L-730/L-740/ L-702SP) in Scan Mode. ***(Note – Scan Mode is <u>not</u> used with the L-703S Laser nor used for surface plate calibration.)***
- PSD (Position Sensing Detector) Size:
  - ❖ .39 x .39 in. (10x10 mm) PSD
- Resolution (2 axis & 1 axis): .00001 in. (0.00025 mm)
- Wireless communication via Bluetooth Class 1 radio with 100 ft. (30 m) of communication range.
- Accuracy error is < 0.25% of the measurement
- PSD concentric to the mounting stud to < .0003 in. (0.008 mm).
- The T-1297 is designed so the measuring plane of the target is right at the face plate of the mounting stud, so when used with the A-1297 High-Accuracy Flatness-Measuring Base, it achieves the highest accuracy possible.
- Accelerometer rotation axis (3rd axis) helps to orient the PSD sensor axes to the alignment axes of the spindle.
- Lithium polymer rechargeable battery with 14 hours of battery life.

How to Use the T-1297 Targets

The T-1297 Targets are designed for use with the L-703S in Double-Blink Mode (center/angular measurements) or Scanning Beam Mode (flatness measurements using one of our scanning laser plane lasers). The targets have a .4995 in. (12.69 mm) mounting stud for mounting spindles and fixtures, such as the A-1297 High-Accuracy Flatness Measuring Base.

Note – this section describes the full functions of the T-1297 Targets. For surface plate calibration applications, the L-703S Spindle Laser and the T-1297 are used <u>only</u> in Center Mode.

T-1297 Center Mode with the L-703S Spindle Laser

This is the default mode when the target is turned on and is what is used with the L-703S Spindle Laser and Plane6 Software. It is recommended while in Center Mode to use the light/dust shield, which is held in place with magnets. While in this mode, the values shown in Plane6 Software displays show the center (offset) values of the target's mounting stud relative to the laser beam. It follows the same sign convention as shown **on Page 39**, *Interpreting the + and – Signs in the Live Displays.*

T-1297 Scanning Laser Mode - Optional

For applications other than surface plate calibration, the T-1297 Targets can be converted to Scanning Mode and used with the auto-rotating laser planes in our L-702SP and any L-730/L-740 Series lasers. These lasers automatically rotate to create a laser plane, which can then be measured with the T-1297.

Note: The T-1297 in Scan Mode is <u>not</u> compatible with the L-703S Spindle Laser

To change the T-1297 target into Scanning Mode, make sure the laser is *turned off* or the laser beam is blocked. Then press and hold the Power Button (**see Figure 7**). The **ON-TGT** LED will blink instead of being continuously on, as it is when it's in **2-Axis Center Mode**. To return the T-1297 to ***2-Axis Center Mode*** power down the target and turn it back on.

Figure 7 - T-1295/1296 Control Panel

Note**: **Plane6 Software does <u>not</u> support Scan Mode. To use Scan Mode, you must purchase MultiTurn10 or Plane5 Software. Please see those manuals for more details.

T-1297 Target LEDs

The T-1297 LED's have several colors and actions to indicate certain functions:

Bluetooth LED Green – means the target is connected to the computer
Bluetooth LED Green/Yellow – alternating green/yellow means the target is communicating with Plane6 software
On Tgt LED Continuous Green – means the target is detecting the laser beam in Center Mode.
On Tgt LED Continuous Red – means the target is not detecting the laser beam in Center Mode.
On Tgt LED Blinking Green – means the target is detecting the laser scan plane in Scan Mode.
On Tgt LED Blinking Red – means the target is not detecting the laser scan plane in Scan Mode.
Battery LED Green – means the target is turned on.
Battery LED Yellow - means the target is charging. It will turn off when fully charged.
Battery LED Blinking Yellow – means the target needs to be charged.

Charging the T-1297

The T-1297 comes with a USB charging cable that plugs into the top of the target. Simply line up the red dot on the connector with the red dot on the female connector on the top of the target.

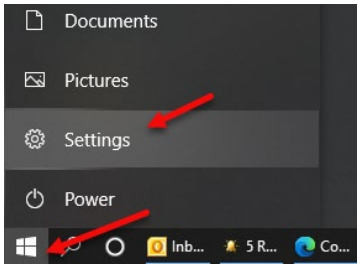
Please note:

1. ***The LED will flash for 0.25 seconds and turn off if the battery is fully charged.***
2. ***Charging the battery will generate heat and can cause thermal growth in the target, which could add additional uncertainty to the measurements. We recommend charging the target prior to starting the measurements. When the battery capacity gets low, it will also generate heat, so make sure to charge the battery when it gets below 20%.***

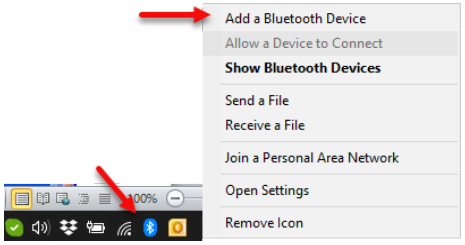
How to Pair the T-1297 Target's Bluetooth to a PC

For your computer to see the Bluetooth device, you need to turn it on.

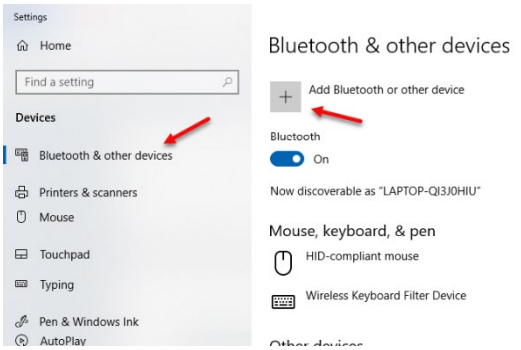
1. Tap on **Start** (the Microsoft Logo) > **Settings**.
2. Navigate to **Devices** and go to **Bluetooth**



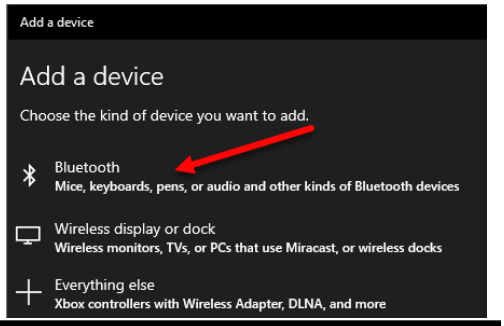
Or click on the **Bluetooth** icon in the system tray and click on Add a **Bluetooth Device**.

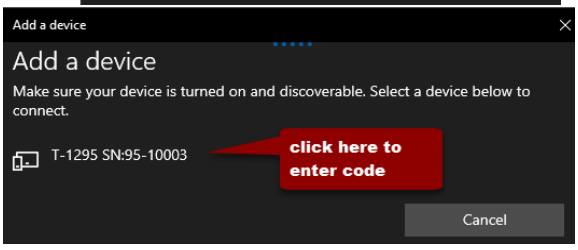


3. Make sure the Bluetooth toggle is in the **On** position. (You'll know it is working because you'll notice the message that reads "Your PC is searching for and can be discovered by Bluetooth devices.")
4. Click on **Add Bluetooth or other device**

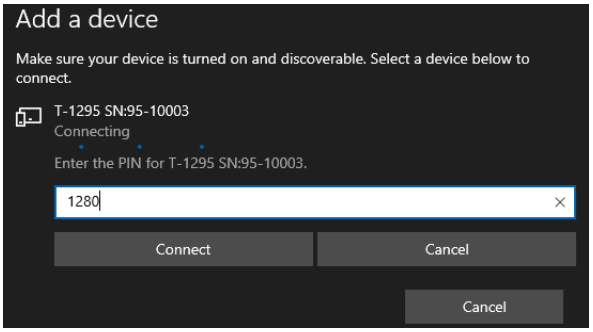


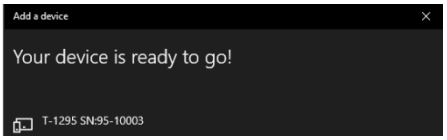
5. Select the device type you want to connect (usually you will select **Bluetooth**). You will see the devices listed under **Add a Device.**





6. Enter **1280** for the passcode when prompted and hit **Connect**. Your Target is now paired and ready to be used. Exit Settings window





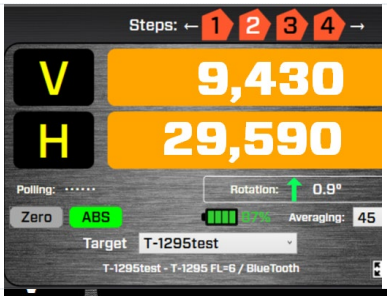
T-1297 USB Data Backup Communications Cable

The L-703SP's USB charging cable also functions as a data backup communications cable in case something happens to the Bluetooth connection. Here's how to connect it:

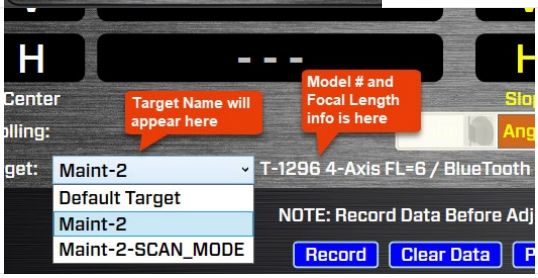
***Important Note**: To use the USB charging cable as a backup, you will need the Silicon Labs USB Driver installed on your computer **before** connecting the cable. Here is the download link. Here is more information on the driver.*

1. Connect the cable to the top of T-1297 Target just as you would do to charge it (see pg. 6).

2. Insert the USB cable into one of the USB ports on your PC.
3. If Plane6 is running already, then make sure you are in Step 2. Wait about 20 seconds and you should see target values in the display area.



4. If Plane6 is not running, then open the program, go to Step 2 and make sure you have the target selected in the dropdown box.
5. After a few seconds, you should see target values in the display area.



A-703SP-LM Surface-Plate Mounting Fixture

To accurately measure the flatness of surface plates, the L-703SP requires a stable mounting fixture to hold the laser and a special flatness-measuring base for the target to achieve the highest accuracy possible.

The A-703SP-LM is used to mount the L-703S (*see* **Figure 8**) on flat surfaces for measuring:

- Flatness measurements of surfaces, such as surface plates.
- Flatness, straightness & squareness measurements of machine tool axes.

To secure the laser in the A-703SP-LM, insert the mounting stud into the .4995 in. (12.7 mm) mounting hole in the fixture. Then use the thumb screw to tighten the mounting stud. Make sure to make it very tight to ensure a rigid mount and avoid laser drift issues.

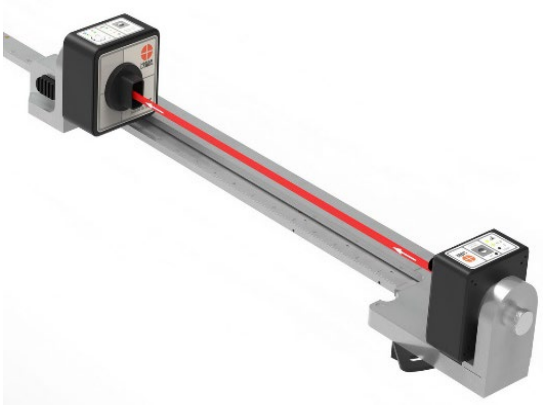


Figure 8 - A-703SP-LM Surface-Plate Mounting Fixture

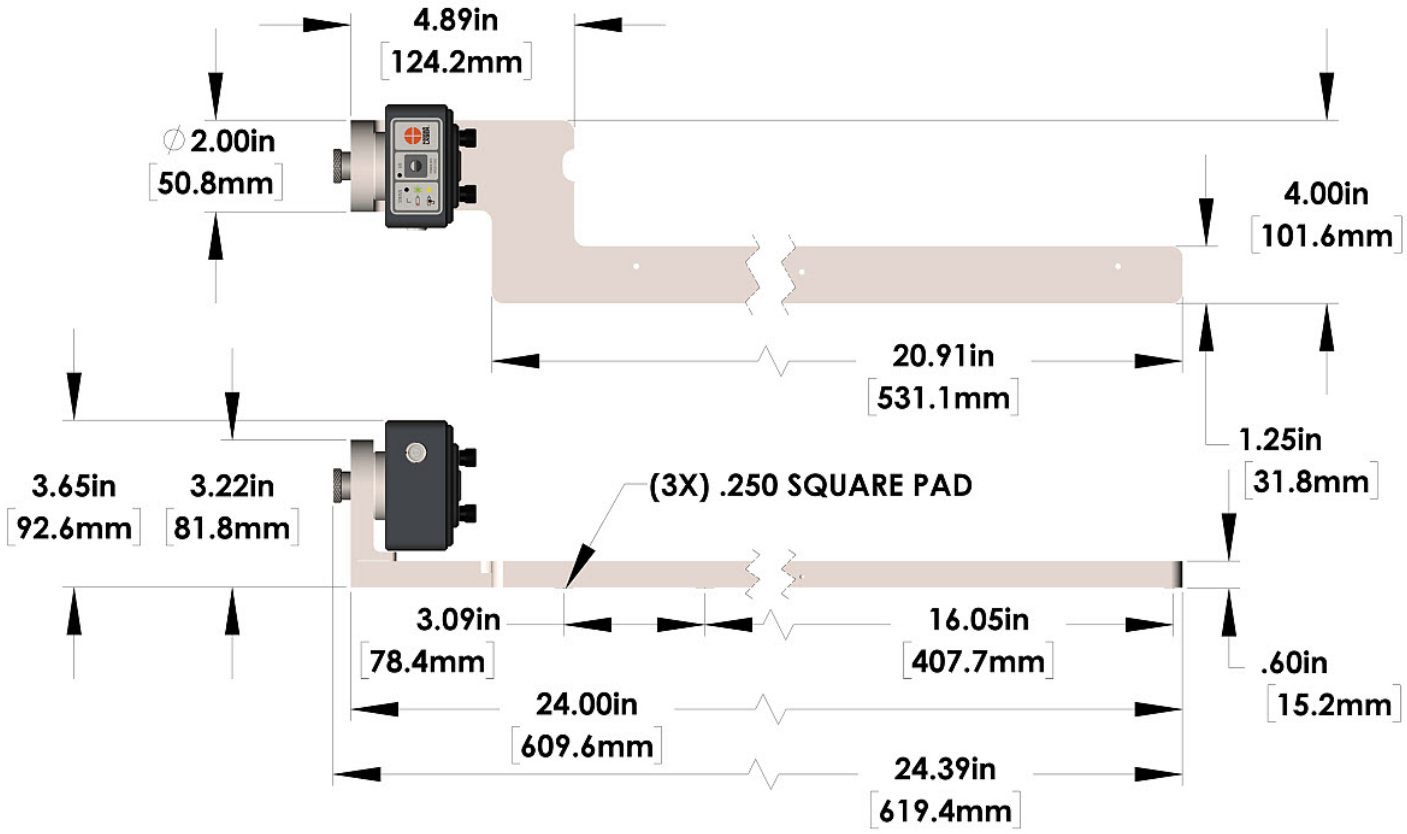


Figure 9 - A-703SP-LM Laser Mounting Fixture Dimensions

Please note *- for surface plates smaller than 24 inches (611 mm), there is a second mounting foot (pad) location that is approximately 10 inches (250 mm) from the back mounting foot, so the A-703SP-LM can be used on plates as small as 12x12 in.*

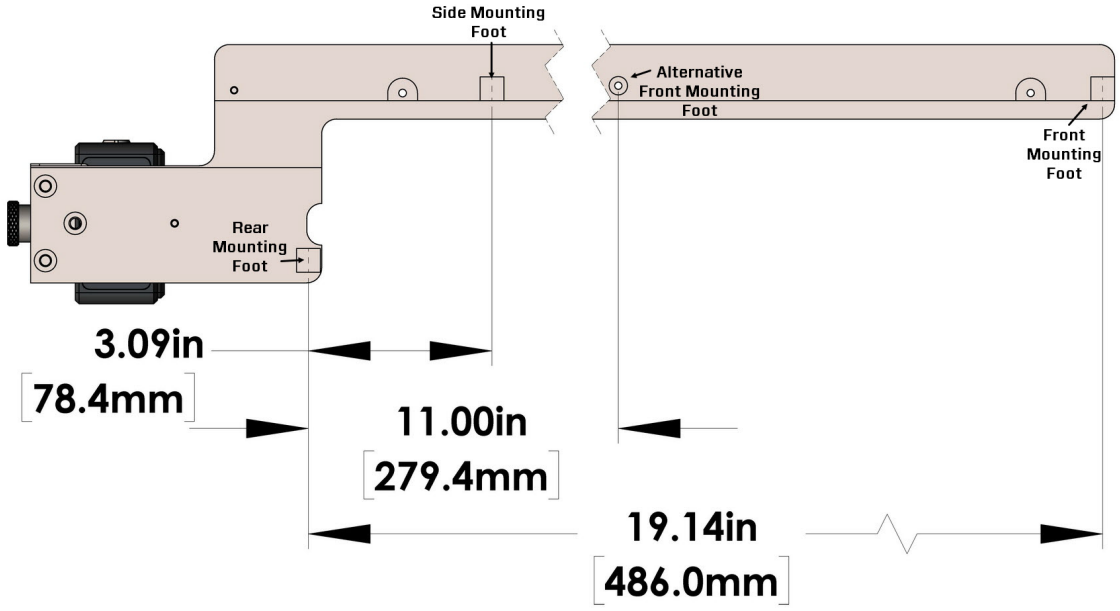


Figure 10 - A-703SP-LM Laser Mounting Fixture Dimensions - Bottom

Important Note when Handling the L-703SP-LM Laser Fixture

It is very important to note that wearing thin gloves to insulate the heat from your hands is an important good practice when handling the L-703SP-LM. When you hold the L-703SP-LM in your hand, it will growth thermally and this will happen remarkably fast! Keep in mind that a small micro change in the metal upright can cause an angular change in the mounting surface, tilting the laser, which can turn into a significant change in the measurement value when the target is located several feet away.

We also recommend waiting 30-45 seconds after setting down the fixture before taking data. This gives the fixture time to settle down and stabilize. Of course, if the plate being measured is a B-grade plate, then these precautions are less important and can be set aside in the interest of time.

Finally, do NOT touch the L-703SP-LM during the measurement of the line. This can cause the laser beam to move and add uncertainty to the measurement. If you touch it, wait 30 seconds for the movement to settle down and then record the point.

A-1297-SP High Accuracy, Flatness Measuring Base for T-1297 Target

A-1297-SP is used to mount the T-1297 Target (see **Figure 11**) to measure flatness of the plate for measuring:

- Flatness measurements of surfaces.
- Flatness, straightness & squareness measurements of machine tool axes.

Insert the T-1297 Target into the .4995 in. (12.7 mm) mounting hole, making sure to insert the alignment pin (see **Figure 11** and Step 4, starting on Page 40) into the smaller hole below the main hole. Make sure to tighten very tight to ensure a rigid mount and repeatability issues.

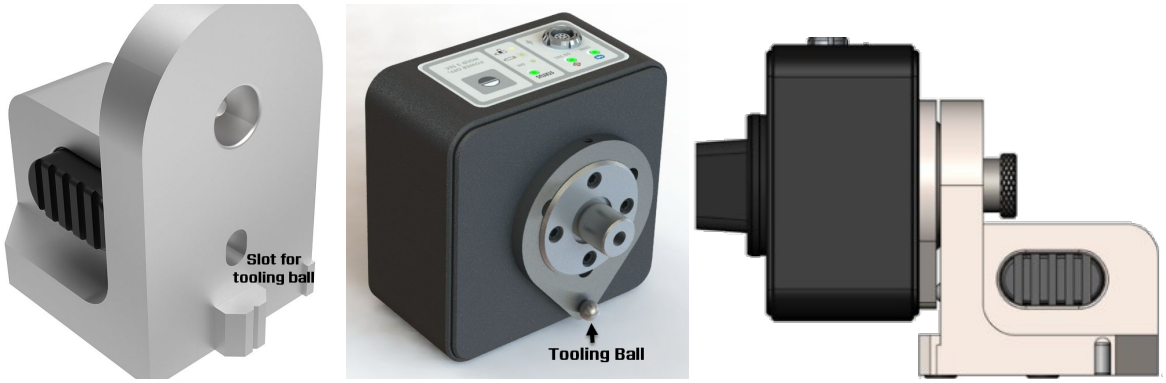


Figure 11 - - A-1297-SP High Accuracy, Flatness Measuring Base for T-1297 Target

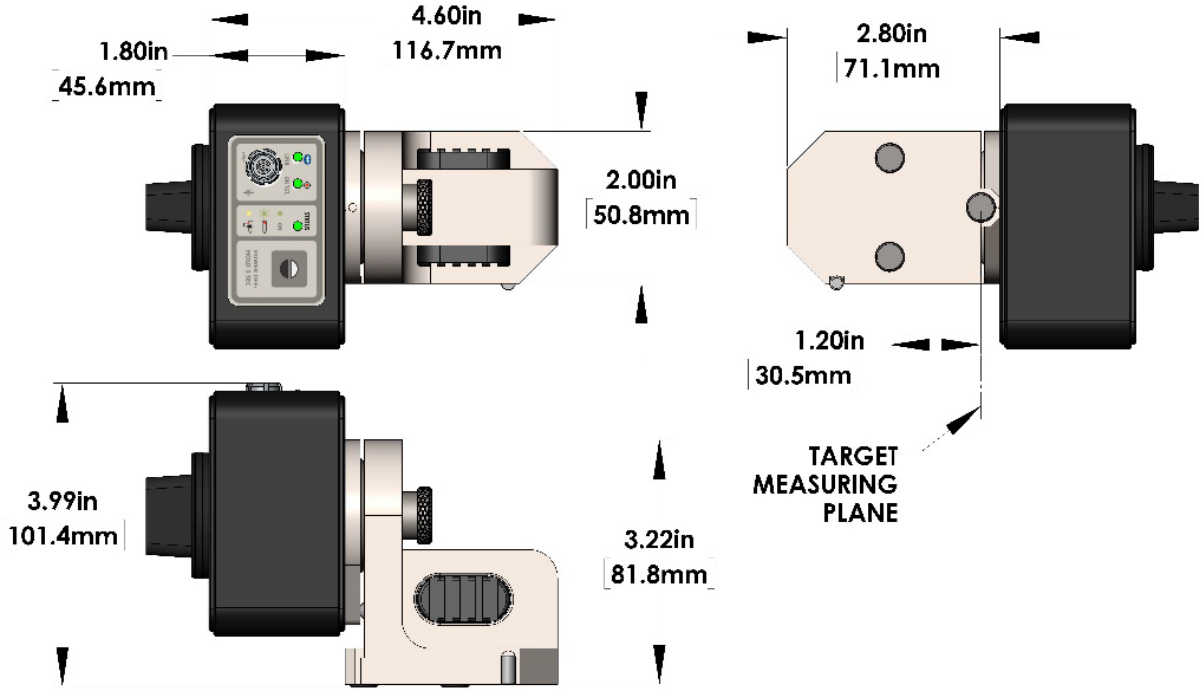


Figure 12 - A-1297-SP Measuring Base - Dimensions

A-703SP-SE-A/B/C/D Target Straight-Edges and Rulers

Used with the A-703SP-LM Surface-Plate Mounting Fixture (see ***Figure 8***) as a guide for the T-1297 Target to take flatness data for each line segment. They come in the following sizes:

- *A-703SP-SE-A Target Straight-Edge and Ruler – 18 in. (457 mm)*
- *A-703SP-SE-B Target Straight-Edge and Ruler – 26 in. (660 mm)*
- *A-703SP-SE-C Target Straight-Edge and Ruler – 36 in. (914 mm)*
- *A-703SP-SE-D Target Straight-Edge and Ruler – 54 in. (1,373 mm)*
- *A-703SP-SE-E Target Straight-Edge and Ruler – 72 in. (1,829 mm)*
- *A-703SP-SE-D-EXT-A 18 in. (457 mm) Target Straight-Edge Extension and Ruler for 72-90 in. (1.8-2.3 m) lengths*
- *A-703SP-SE-D-EXT-B 18 in. (457 mm) Target Straight-Edge Extension and Ruler for 90-108 in. (2.3-2.7 m) lengths*
- *A-703SP-SE-D-EXT-C 18 in. (457 mm) Target Straight-Edge Extension and Ruler for 108-126 in. (2.7-3.2 m) lengths*

For the 18-in add-on extensions, they must be assembled as shown in ***Figure*** 13 To assemble the pieces:

1. Screw in the mounting screws but leave them loose.
2. Place the scale side of each straightedge length down on the surface plate to align the straightedge pieces and make them straight.
3. Tighten the screws very tight to ensure the straightedge stays straight.
4. Add the GPR-RB Reinforcement Bar to the top of the straightedge to make it rigid. Do NOT overtighten the bolts. Just a light tightening is fine. Over-tightening may cause the straightedge to bow up, which can cause the rubber feet to fail to make contact with the surface plate.

   Note: If the rubber pads come off, use Loctite 496 Glue to reinstall them. Contact the sales office to get replacement rubber pads.

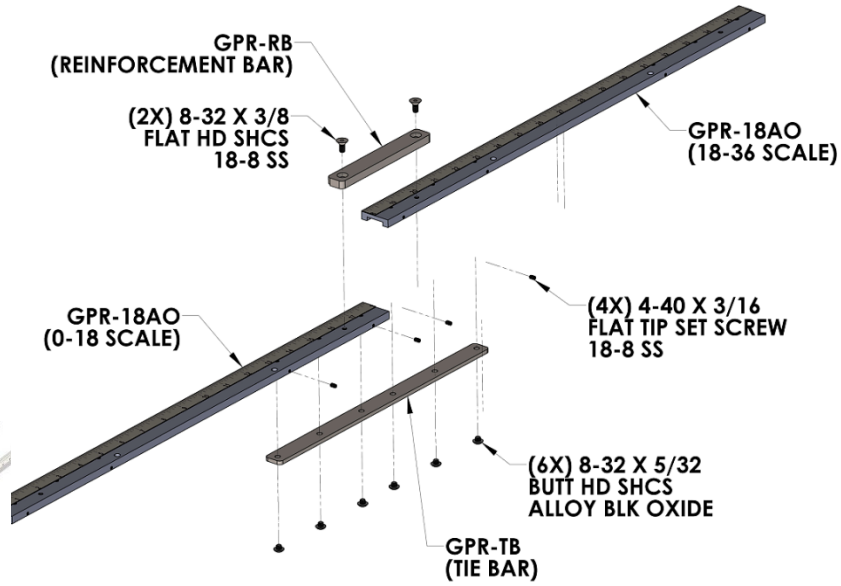


Figure 13 - A-703SP-SE-EXT-A/B Target Straight-Edge

Figure 14 - A-703SP-SE-A/B/C/D Target Straight-Edges and Rulers

Selecting Straightedge Length

To select the length of the straightedge, use the table below to see which length to use. It is recommended that you select the straight-edge length that is less than 1.5 times the Grid Line Dimension, which ensures the best stability for the bar. For example, for the 18x18 plate, use the 18 in. straightedge for the sides and midpoint segments and the 36 in. straightedge for the diagonals.

We recommend that you assemble the longer straightedges (see above) before starting the alignment checks. This allows you to easily swap in a longer or shorter bar as needed for each segment and speeds up the calibration process.

Here are some definitions for the table:

- *Plate Size* – this is the nominal dimensions of the plate from edge to edge.
- *Diag Bar Increments* – this is the total number of 18-in. increments needed for the straightedge.
- *Longest Bar* – this is the longest bar that is needed for the longest line segment (the diagonal).
- *Grid Line Dimensions* – this is the length of the plate side minus 2 x the border width. This represents the total length needed for the measurements for that line segment.
- *Diag Angle* – this is the angle of the diagonal relative to the edges and is generally not needed for a measurement but is for informational purposes.

Note - *if you use a straightedge that is too long for the plate, it will not be stable and may lead to errors.*

Plate Size			Diag Bar	Longest	Grid Line Dimensions [(Length/Width - (Border*2))]			
Width	Length	Diag	Increments	Bar	Width	Length	Diag	Diag Angle
12	12	17.0	1.0	18.0	9.0	9.0	12.7	45.0
12	18	21.6	1.0	18.0	9.0	15.0	17.5	31.0
18	18	25.5	2.0	36.0	15.0	15.0	21.2	45.0
18	24	30.0	2.0	36.0	15.0	21.0	25.8	35.5
24	24	33.9	2.0	36.0	21.0	21.0	29.7	45.0
24	36	43.3	3.0	54.0	21.0	33.0	39.1	32.5
24	48	53.7	3.0	54.0	21.0	45.0	49.7	25.0
36	36	50.9	3.0	54.0	33.0	33.0	46.7	45.0
36	48	60.0	4.0	72.0	33.0	45.0	55.8	36.3
36	60	70.0	4.0	72.0	33.0	57.0	65.9	30.1
36	72	80.5	5.0	90.0	33.0	69.0	76.5	25.6
48	48	67.9	4.0	72.0	45.0	45.0	63.6	45.0
48	60	76.8	5.0	90.0	45.0	57.0	72.6	38.3
48	72	86.5	5.0	90.0	45.0	69.0	82.4	33.1
48	96	107.3	6.0	108.0	45.0	93.0	103.3	25.8
48	120	129.2	8.0	144.0	45.0	117.0	125.4	21.0
60	120	134.2	8.0	144.0	57.0	117.0	130.1	26.0
72	96	120.0	7.0	126.0	69.0	93.0	115.8	36.6
72	144	161.0	9.0	162.0	69.0	141.0	157.0	26.1

A-703SP-SE-CLT Corner Locating Tools

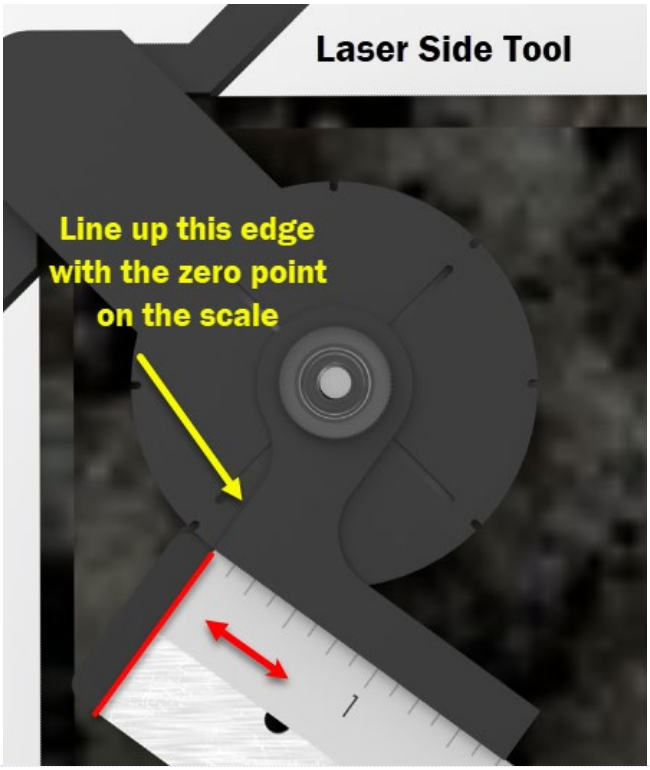
To set the straight edges at the proper spacing from the edge of the plate, we supply a set of A-703SP-SE-CLT corner locating tools to aid in the setup. They come in 3 sizes:

A-703SP-SE-CLT-1.5 Corner & Midpoint Straight-Edge Locating Tool - Set of 2 for 1.5 in. border
A-703SP-SE-CLT-2.0 Corner & Midpoint Straight-Edge Locating Tool - Set of 2 for 2.0 in. border
A-703SP-SE-CLT-2.5 Corner & Midpoint Straight-Edge Locating Tool - Set of 2 for 2.5 in. border

Select the right tool to match the desired border width. You must also set the border width in Plane6 Software Step 1 (see Page 30).

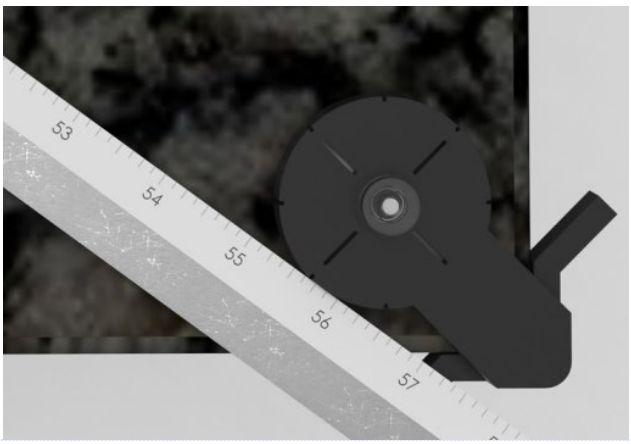
There are two types of locating tools: 1. The first type is used on the laser end of the straight edge, and 2. The second type is used on the target end of the scale.

The laser side has a rotary edge that is used to set the end of the straight edge at the correction dimension from the plate. You need to match the end of the rotary piece with the zero point on the straight edge.



The target-side tool does not have the rotary edge-setting tool.

When the straight edge is positioned in the correct location, you must remove the corner locating tools by sliding them off the plate.



Preparing for an Alignment

There are several preparations that need to be made before beginning a measurement or alignment process. Ensure that accurate records are kept for all procedures.

Cleaning the Plate

For accurate calibration results is highly important to clean the surface plate prior to starting the calibration check. Use approved surfaced plate cleaners and cloths to remove all dust and dirt (see ***Figure 15*** Relative Particle Sizes). If you are trying to calibrate a 36x36 in. plate to a Grade A spec, the flatness requirement is 300 µin. or 8 µm (microns). As you can see a few grains of dust (4 microns) on your plate and this eats up half of the Grade A tolerance and can significantly impact the flatness data! Run your hand over the plate to feel for dust and make sure it's ready to check the flatness. We also recommend using a cloth to wipe each measurement line before taking the data. Also, frequent wiping of the bottom of the target base is important to keep dust off of it.

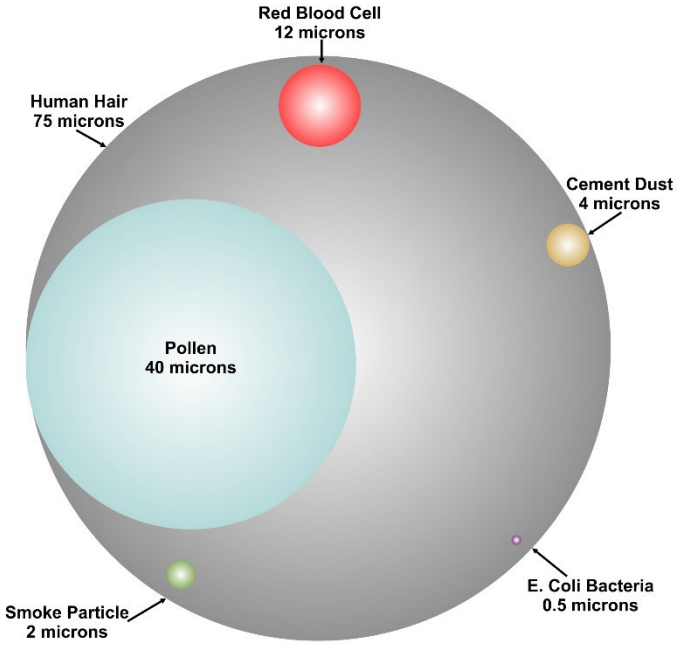


Figure 15 - Relative Particles Sizes

Maintenance and Cleaning of L-703SP & T-1297

The windows on the T-1297 target should be clean and free from dirt, thumbprints, and other smudges. Clean the window with alcohol wipes or a Q-tip soaked in alcohol. Always wipe in the same direction. Do **not** wipe back and forth.

The same applies to the L-703SP Laser Window. If you see a reflection on the lens window on the laser (**see *Figure*** 16), which means it is contaminated and needs to be cleaned.

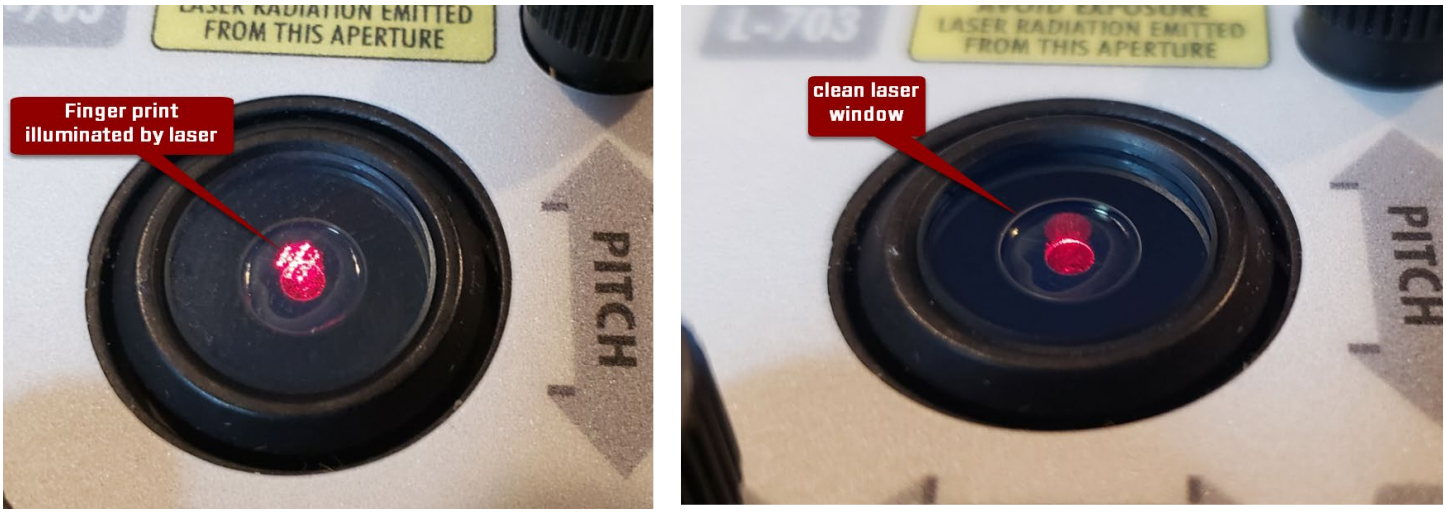


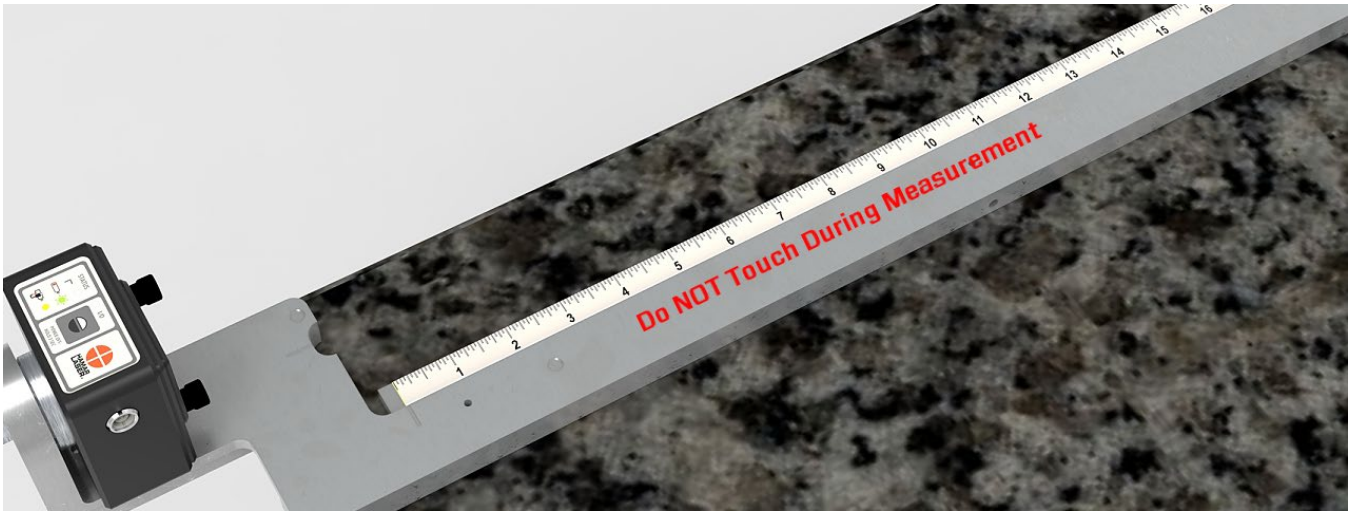
Figure 16 - Dirty vs. Clean Laser Window Example

Target Calibration

The T-1297 Targets are calibrated and the calibration factors are stored inside the target, so there is no need to upload calibration factors into Plane6.

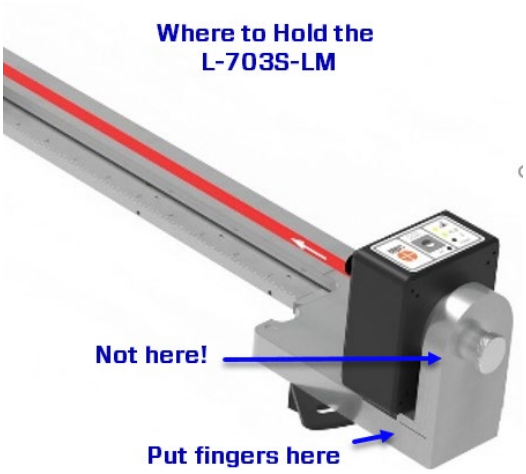
Important Tips for Taking Data with the L-703SP

1. Do Not Touch L-703S-LM During Measurement – After positioning the laser fixture and straightedge, it is VERY important to NOT touch the laser fixture during the measurement of any of the lines. This can cause the fixture to bend, which will move the laser beam and cause additional uncertainty into the measurement.



2. Wear gloves! - It is very important to note that wearing thin gloves to insulate the heat from your hands is an important good practice when handling the L-703SP-LM Laser Fixture. When you hold the L-703SP-LM in your hand, it will warm the metal, causing it to grow thermally, which will happen remarkably fast – in 1 second! This is due to a small micro growth in the metal upright, which can cause an angular change in the mounting surface, tilting the laser, which can turn into a significant change in the measurement value when the target is located several feet away.

3. Hold the L-703SP-LM Fixture at the Base – It is best practice to hold the L-703S-LM Fixture at the base of the upright. See the image. This will limit the amount of bending in the fixture when moving from line to line and the fixture will stabilize faster.



4. Pause before Taking Data - We recommend waiting between 30-45 seconds after setting down the fixture before taking data for a new measurement line. This gives the fixture time to settle down and stabilize. Of course, if the plate being measured is a B-grade plate, then these precautions are less important and, in the interest of time, can be set aside.

5. Wipe the Surface before Taking Data for Each Line Segment – Use the plate cleaning cloth to wipe the line segment before taking data for the line. This will capture any dust that has fallen on the plate while you have been taking data for the other lines.

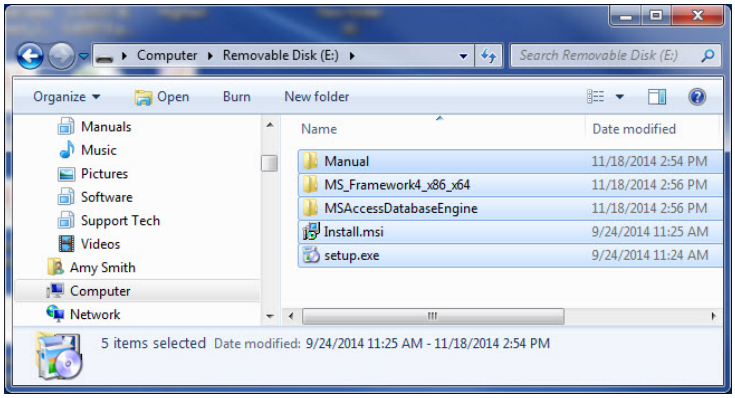
6. Hold Your Breath When Positioning the Target – This is not a joke! When recording data with the T-1297 Target, it is important to hold your breath while you are positioning the Target on the measurement point. This is because it is normal to exhale when bending over, and when you are lining up the target, you must bend over it to see the scale, causing you to exhale. Well, believe it or not, the warmth from your breath will create additional air turbulence and increase the variability in the measurements. We found in our testing that this can add more variability if you do not control your breathing!

Plane6 Surface Plate Calibration Software - System Requirements

- Physical memory (RAM): 8 GB recommended for Win10 & 11
- Processor: Intel Pentium4 or later version or AMD equivalent, 1.3 GHz minimum speed
- Available Hard Drive space: 20 GB minimum
- Video Resolution: 1366 x 768 minimum (32-bit color) with hardware acceleration and dedicated video memory.
- Windows 10/11 professional editions.

The following Microsoft Windows operating systems have *not* been tested and are not supported with Plane6:

- Windows 7 (All versions)
- Windows 8 (All versions)
- Windows XP (All versions)



Before installing Plane6, ensure that your computer has the latest Windows Service Pack and critical updates. To find security updates, visit **www.windowsupdates.com** .

In addition, to read this Plane6 Surface Plate Calibration manual PDF file on your laptop, it is necessary to install Adobe Reader/Acrobat or an equivalent PDF reader program. Adobe Reader can be downloaded for free from: Download Adobe Acrobat Reader: Free PDF viewer.

Installing Plane6

1. Insert the USB flash drive provided into the USB port on the laptop or tablet PC.
2. If your system is configured to do so, the AutoPlay window displays. Click **Open folder to view files**.
3. If the AutoPlay window does not display, click **Start>Run**. Click **Browse>My Computer** and select the USB flash drive.
   Note: *.NET 4.0 framework must be installed– see* **Page 58** *if you are unsure if this has been installed.*
4. Click **setup.exe** to begin the Plane6 installation.

Hamar Product Registration

After a Hamar product is installed and when the program is run for the first time, the user is prompted to enter the Product Registration Code (see **Figure 17**). To obtain the Product Registration Code, send the **PC ID Code** displayed on the screen to Hamar Laser Support (Support@hamarlaser.com). A Hamar representative will issue a Product Registration Code via email to complete the registration process **(see Figure 18)**.

Enter the Product Registration Code and click ***Register Product***. The product is now registered.

Figure 17 - Product Registration Screen

Figure 18 - Enter Product Registration Code

To begin using Plane6, double-click the Plane6 icon on your desktop or select the program from the Windows Start Menu. The initialization screen displays, providing the number of the current software version.

Creating a New Project File or Opening an Existing Project File

When creating a new project, Plane6 will create a folder with the filename entered here. It will then create a project file in the folder with a time stamp of when it was created. After saving a project, you can open the project file and save a new file for this project, which will save the information entered in Step 1 but will clear the data recorded in Step 2.

Project Selection Screen:

When Plane6 opens, the **Project Selection** screen displays the following:

Recent Projects **–** This will list the most recent projects that were saved.

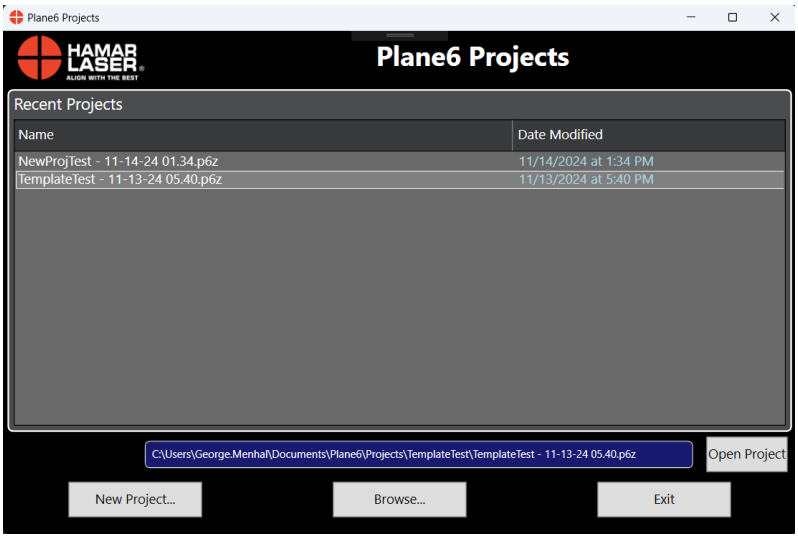
Open Project – select one of the recently saved projects and click ***Open Project*** to open the project. You can also double-click the filename to open it.

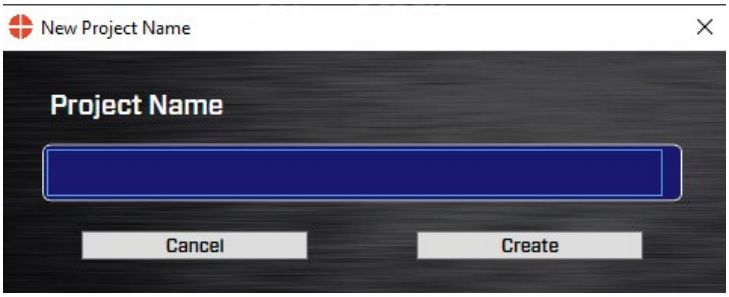
New Project – click here to enter a filename and create a new project folder and project filename within the folder.

Browse – Click here to open the Windows File Open dialog box and browse for a saved file, either from another folder or from a USB drive.

Exit Plane6 – this closes Plane6.

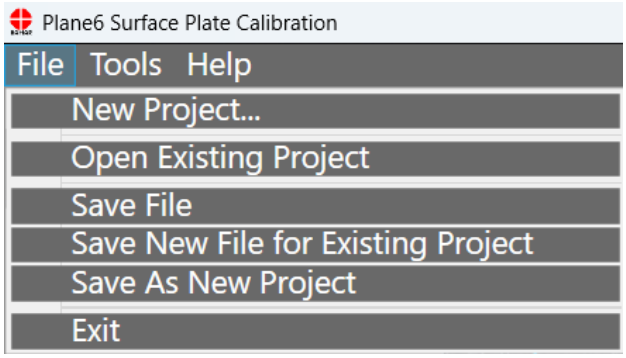
Note: *This screen can also be accessed by clicking* ***Open Project*** *from the* ***File*** *menu.*





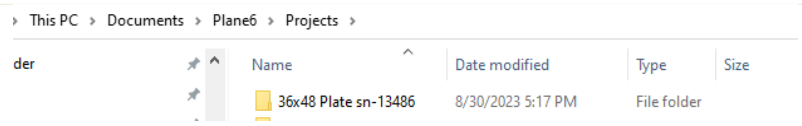
File Menu

New Project – see above
Open Existing Project – same as above
Save File – saves the project.
Save New File for Existing Project –allows you to save a project file of the same project name to the current working directory (folder). It keeps only the information entered in Step 1. All the data from Step 2 is erased.
Save As New Project –allows you to save a project file of a new name to a new folder. It keeps only the information entered in Step 1. All the data from Step 2 is erased.
Exit – exits Plane6, and if the project has not been saved, you will be prompted to save it.

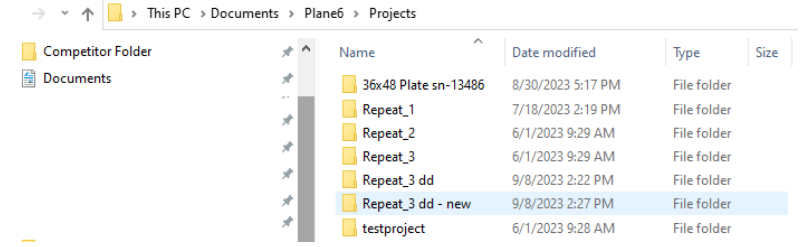


File Location

Files are saved in the *Documents/Plane6/Projects* folder.



Each project is saved into a dedicated folder in the Projects folder that you specified in the New File dialog box.

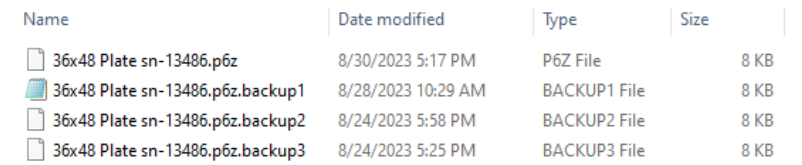


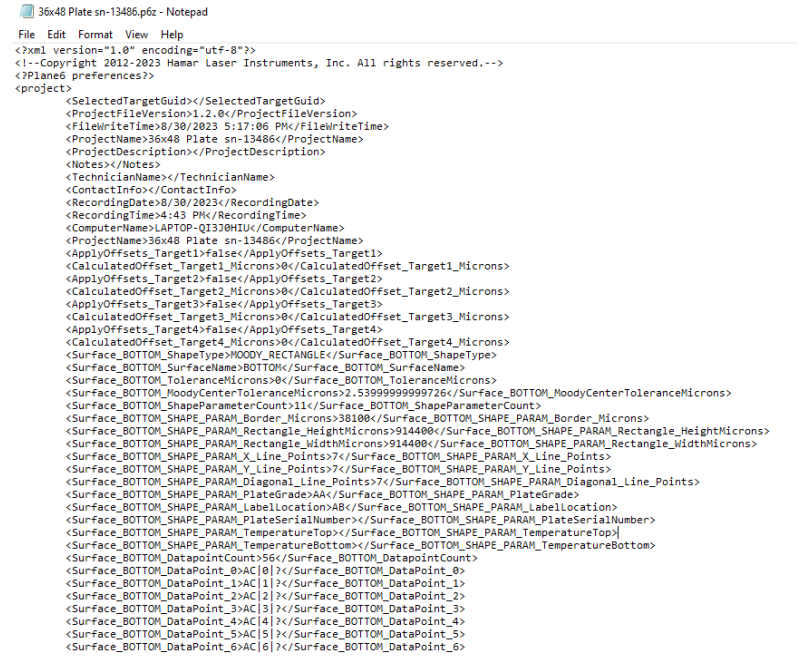
File Structure

In each Plane6 folder, there are 2 data files.

- The ***.*p6z* file contains all the data taken during the sesssion.
- The *. *p6z*.backup* are backup files recorded during each session you save data.

The data format for these files is XML but it can exported to a CSV file by clicking on the Tools menu. The file can be opened in Notepad and viewed there. All data is recorded in microns. Divide all values by 1000 to get millimeters.





Warning! Do not delete or modify the P6z files in these folders as Plane6 will be unable to open the project.

Converting Raw Data Values in CSV files to Inches or Millimeters

The values stored in the CSV file correspond to the units chosen in Preferences, either µin or µm.

- To get inches, divide the microinch value by 1,000,000:
- To get mm's, divide the micron value by 1000

Plane6 Software – Summary of Main Screens

Step 1: Set Up Plane6
Enter the horizontal and vertical dimension of the plate and the border width from the edge of the plate to the measuring line. Then select the number of points you want to measure for the horizontal, vertical and diagonal lines. Next select the plate grade enter the plate serial number and top and bottom temperature (if measured).

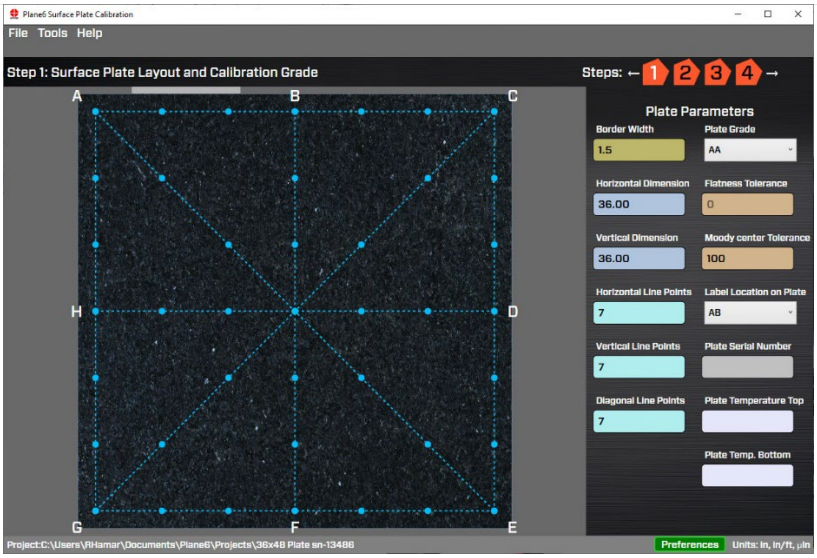


Figure 19 - Plane6 - Step 1 Dimensions & Tolerances

Step 2: Data Collection – Plate View
There are 2 data collection screens*: Plate View* and *Line View*.

Plate View - This is the main data recording screen. It features a 2-axis, real-time data display, the layout for the plate, the measurement points and distances. It guides the user through the sequence of data taking for the 8 line segments in the Moody Method for calibrating surface plates.

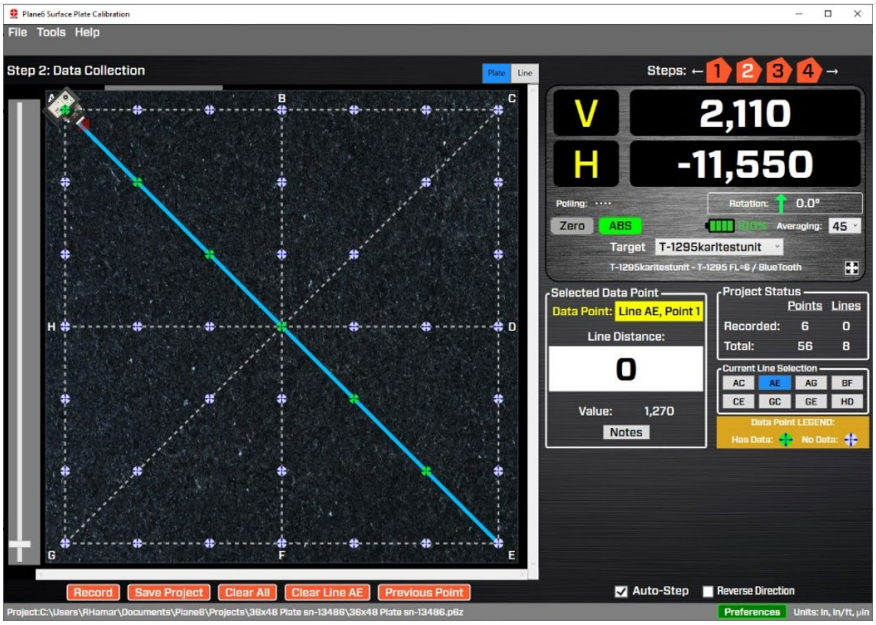


Figure 20 - Plane6 - Step 2: Data Collection

Step 2 Data Collection – Line View

For situations where the plate has failed calibration and needs to be resurfaced (lapped), a second data-taking method has been developed, called *Line View*. It is an optional feature and requires an additional license.

Just as with *Plate View*, *Line View* features a 2-axis, real-time data display and enables the recording of line flatness data for each of the 8 individual line segments in the Moody Method and features the ability to chart the flatness of up to 5 line revisions at once.

Step 3: Results -
After recording the data, click on Step 3 to view the overall flatness results and whether it is in tolerance or out. You can also view the data for each line segment and a 3d graph of the alignment.

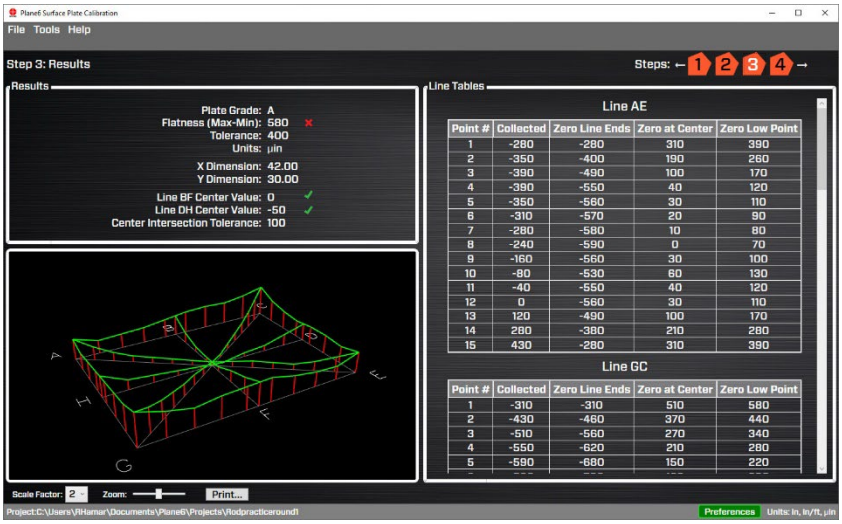


Figure 21 - Plane6 - Step 3: Results

Step 4: 3D Graph
In Step 4, you can view an adjustable, 3D graph of the alignment. Rotate and zoom in to see the results for each line segment plotted on the graph.

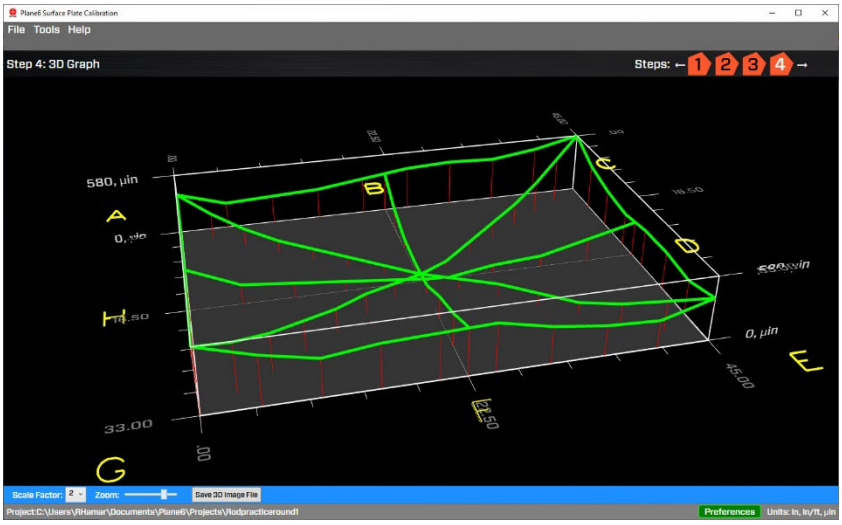
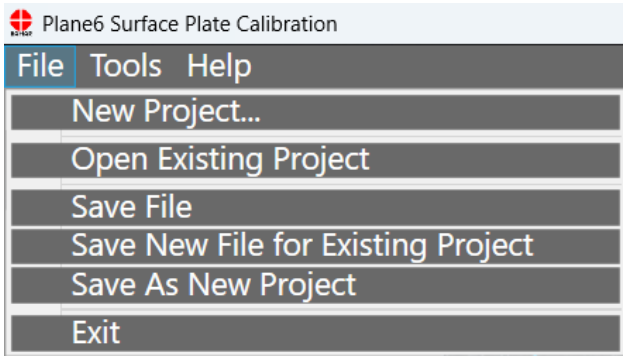


Figure 22 - Plane6 - Step 4: 3D Graph

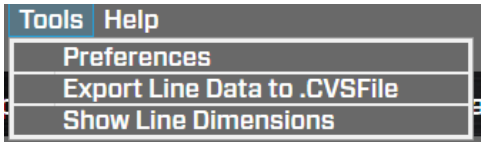
Plane6 Screens - File Menus

File Menu

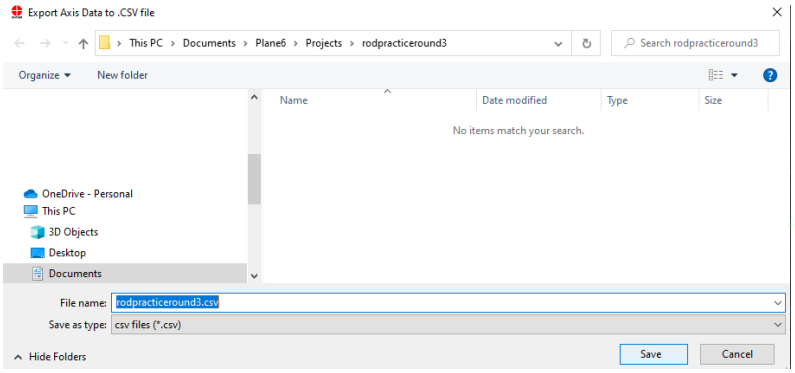
New Project – see above
Open Existing Project – same as above
Save File – saves the project.
Save New File for Existing Project –allows you to save a project file of the same project name to the current working directory. It keeps only the information entered in Step 1. All the data from Step 2 is erased.
Save As New Project –allows you to save a project file of a new name to a new folder. It keeps only the information entered in Step 1. All the data from Step 2 is erased.
Exit – exits Plane6 and if the project has not been saved, it will prompt you to save it.



The Tools Menu
Preferences - Opens the Preferences window to change units, resolution, decimals, target type, etc. See more details below.



Export Line Data to CSV File – Exports data in a CSV format to easy importing into Excel. The CSV file is saved in the same folder as the main project file. After clicking on this item, you will be prompted to enter a filename for the project. It uses the existing filename by default. After saving the file, use Excel to open the file and the data will be in there. The file contains the raw data from the table and does not display the results.



Show Line Dimensions – Opens a window showing the number of measurement points, the line distance for each point on the line segment for the horizontal, vertical and diagonal lines.

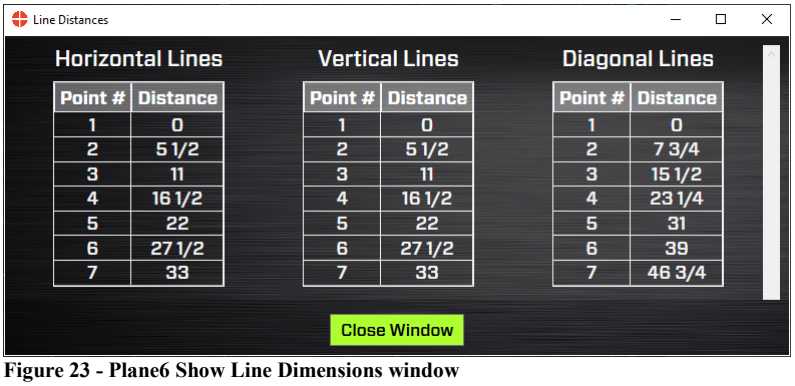


Figure 23 - Plane6 Show Line Dimensions window

The Help Menu.

User Manual - Opens a PDF of the manual.

About This Program - Usual info about the program.

Navigating Plane6 with the Status Bar

Software Steps

In the upper right part of all the screens is the Navigation Bar. It lists the number of steps in the software along with arrows to move to the left or the right. You can either click the arrow to move back or forward to the previous or next step or click on any step to go straight to the page.

Plane6 Screens - Preferences

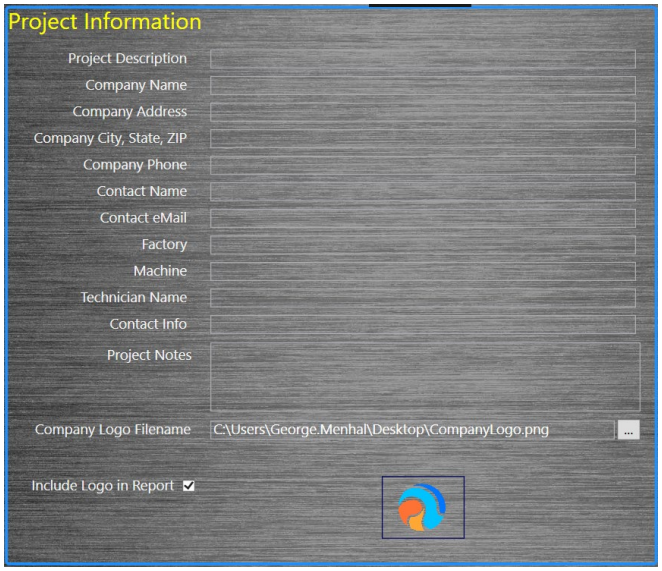
Click **Preferences** to open a window to change Plane6 settings. You can also click on the Preferences button in the lower right side of each screen in Plane6.

Note: *If you are installing the software yourself, you will need to go to* ***Enter Target Info*** *(see* **Page 28***) and follow the procedure to enter the target serial number and calibration factors.*

Navigation – Use the Navigation button to go to a particular section in Preferences. You can also use the scroll bar to move the scrollable section up and down.

Project Information

Enter a project description, company contact information and notes that will be displayed in the reports here. You can also add a custom logo to the report. Click on the ellipse (3 dots) to the right of *Company Logo Filename* to upload the image into Plane6.

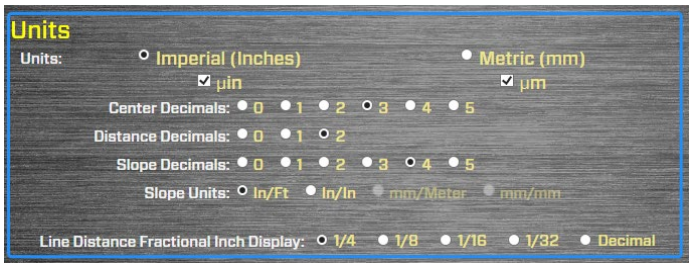


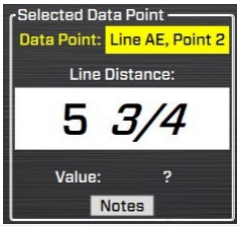
Units

Select **Imperial** (in.) or **Metric** (mm) and units for the project. Check on the ***µin*** checkbox to see the units in *microinches*, or ***µm*** to see the units in *microns*.

If you prefer normal digits, then select the number of digits to show in the display.

For the line dimensions, you can also select the fraction rounding increment and Plane6 will round the fraction up or down to the selected value. For example, if "1/4" is selected and the next point dimension is 5 3/16, then Plane6 will display 5 1/4 as the dimension for the next





point. You can also choose a decimal in the display.

Targets

Target settings

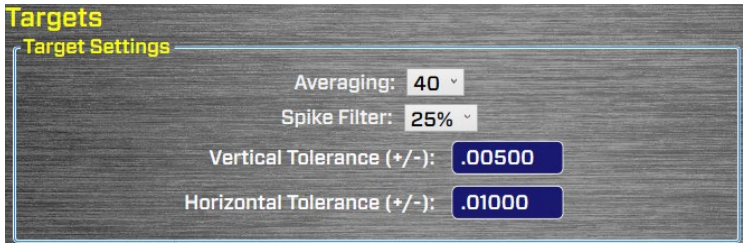
Averaging – This controls the amount of sampling the software does for both the live data display and for recording each value. If the Averaging value is set to 40, then Plan6 will record 40 values and average them, applying a spike filter to reduce noise in the measurement. The data updates at a rate of 14-15 readings per second, so for 40 samples, the data display should update in about 3 seconds.

Spike Filter – This is the amount of data points that are filtered out of a set of recorded data after sorting them from high to low. The default is 40%, or ±20% off each end of the sorted data, meaning the highest 20% of the values and the lowest 20% of the values are removed. Then, the rest of the data points are averaged into a single recorded value.

Vertical & Horizontal Tolerance (±) – this is a display tolerance for Step 2 that changes the display background color to orange if these tolerances are exceeded. The recommended values (default) are:

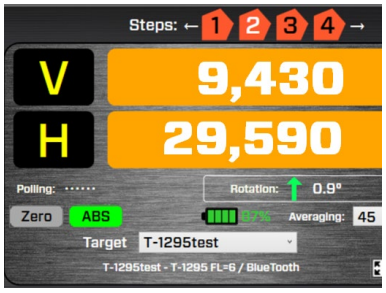
Vertical: ± .005 in. (5,000 µin.)
Horizontal: ± .010 in. (10,000 µin.)
Vertical: ± 0.13 mm (127 µm)
Horizontal: ± 0.25 mm (250 µm)

If the display values are higher than these, the values will start to become slightly less accurate. If you are working on a B-grade plate, then these values can be exceeded without an issue.



Calculation of 1 data point with 10 Samples Using Spike Filter

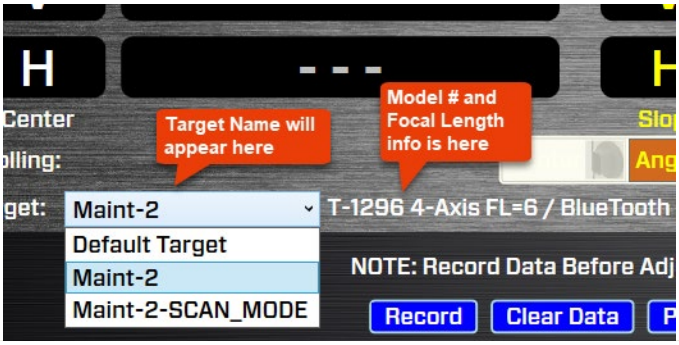
	40% Filter									
Num Points to delete (.4*10)	4									
Point	1	2	3	4	5	6	7	8	9	10
Recorded Values	210	250	220	200	210	250	210	220	210	240
Sort Low to High	200	210	210	210	210	220	220	240	250	250
Delete 2 hi & 2 Lo Points	~~200~~	~~210~~	210	210	210	220	220	240	~~250~~	~~250~~
Ave the remaining values:	218.33									
Rounded Recorded Value	220									



Defined Targets

This is a list of T-1297 Targets (or other similar targets) that have been set up in Plane6.

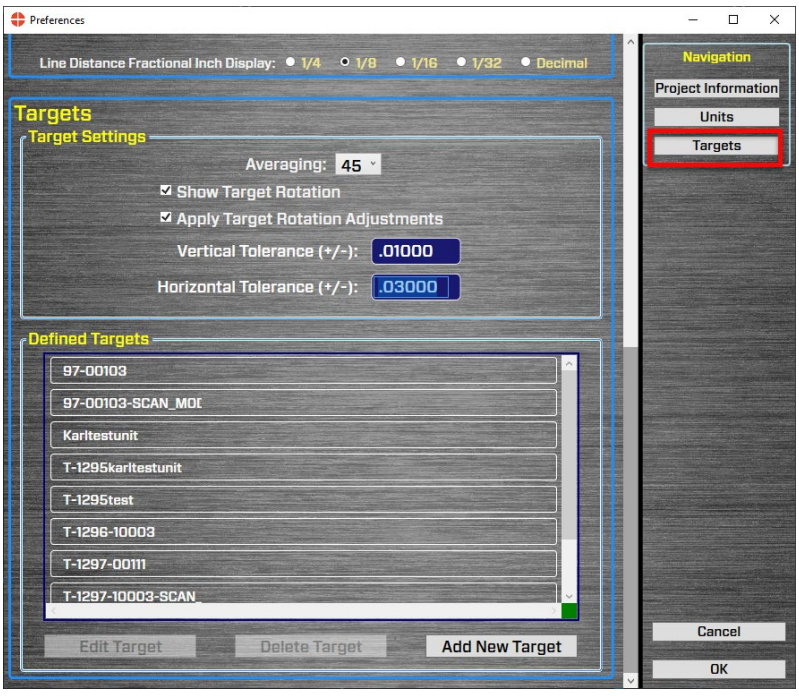
This list will show up in the dropdown menu in Step 2.



Targets – Setup Procedure

When you buy a new system and laptop from HLI, the target setup is already pre-configured into Plane 6. However, if you are installing Plane6 on your laptop, then you must follow this procedure to set up the target.

1. Click the **Target** button.



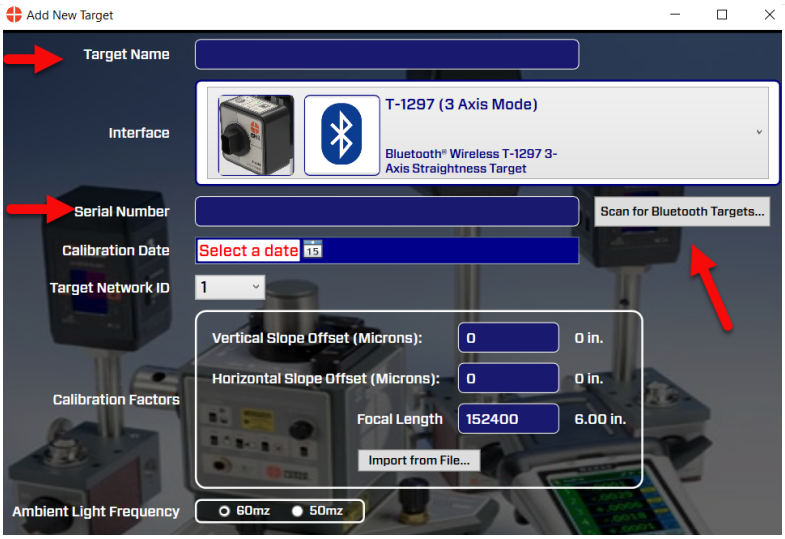
2. Click **Add New Target** to specify and set up a target type and computer interface if needed. There will be a dropdown list of target types supported by Plane6. Pick the T-1297 target type by clicking on it.

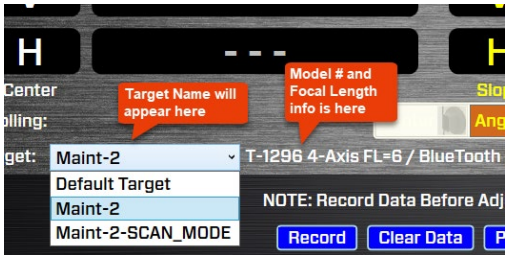
3. **Select Target Type – *T-1297 Targets 3-Axis Mode***

   To choose the T-1297 targets, select the target number with "*3-Axis Mode*". Do <u>not</u> select "*Scan Mode*".

   Note - *the Scan Mode will automatically be added as a target type for each T-1297 selected. Scan Mode is needed with the L-702SP or L-730/740 Series Lasers for a different application.*

4. **Target Name**. Enter a "nick name" for the target. This name will show up in the Target area on the data displays. The target part number and focal length are automatically displayed by Plane6.



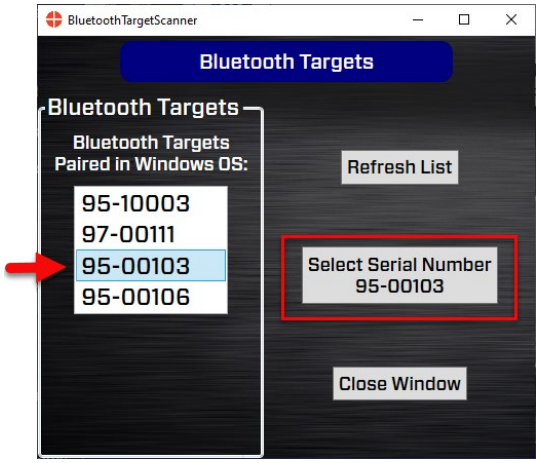


5. **Serial Number** and **Calibration Date** – enter the serial number and calibration date (supplied with the system)

6. **Scan for Bluetooth Targets** - You will need to pair the targets with the laptop - see **Page 7,** *How to Pair the T-1297 Target's Bluetooth to a PC.*

   After pairing, click on **Scan for Bluetooth Targets** to see if your target has been paired with your PC. Paired targets will display in the window (shown right). If your target is not displayed, it will need to be paired.

   If it shows up in the list, then click on the serial number and click on **Select Serial Number XXXX** to select the paired target. Then click on **Close Window.**



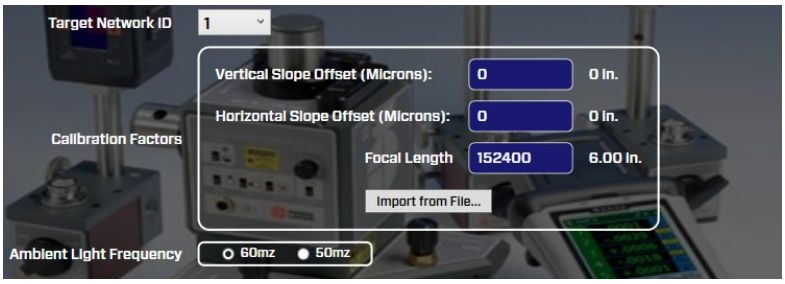
7. **Target Network ID**

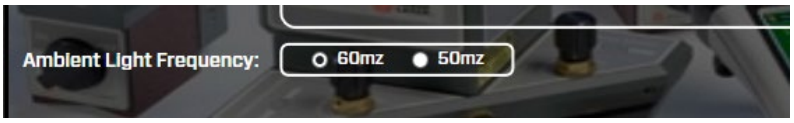
   This is needed for our A-1519/1520 Scanning targets and is not used in this application.

8. **Calibration Factors - Vertical and Horizontal Slope Offsets and Focal Length.** These are correction factors that are used for another application and are not needed for surface plate calibration.

9. **Ambient Light Frequency** – The T-1297 Targets utilize an ambient light correction feature that improves accuracy. This requires that the target be set to the existing electrical frequency. Normally the U.S. is 60 Hz and Asia/Europe is 50 Hz

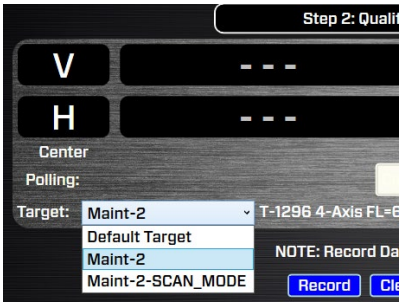
   Note – *the target must be turned on and be paired with the PC to change the frequency. Normally this is set at the factory to match the country it is being shipped to.*

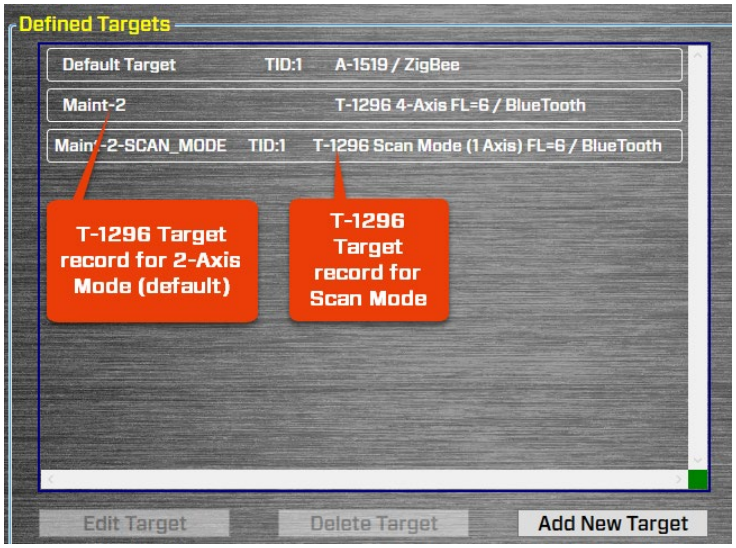




10. **Defined Targets** - You can set up multiple targets if desired. The target names and modes will appear in the **Defined Targets** area.

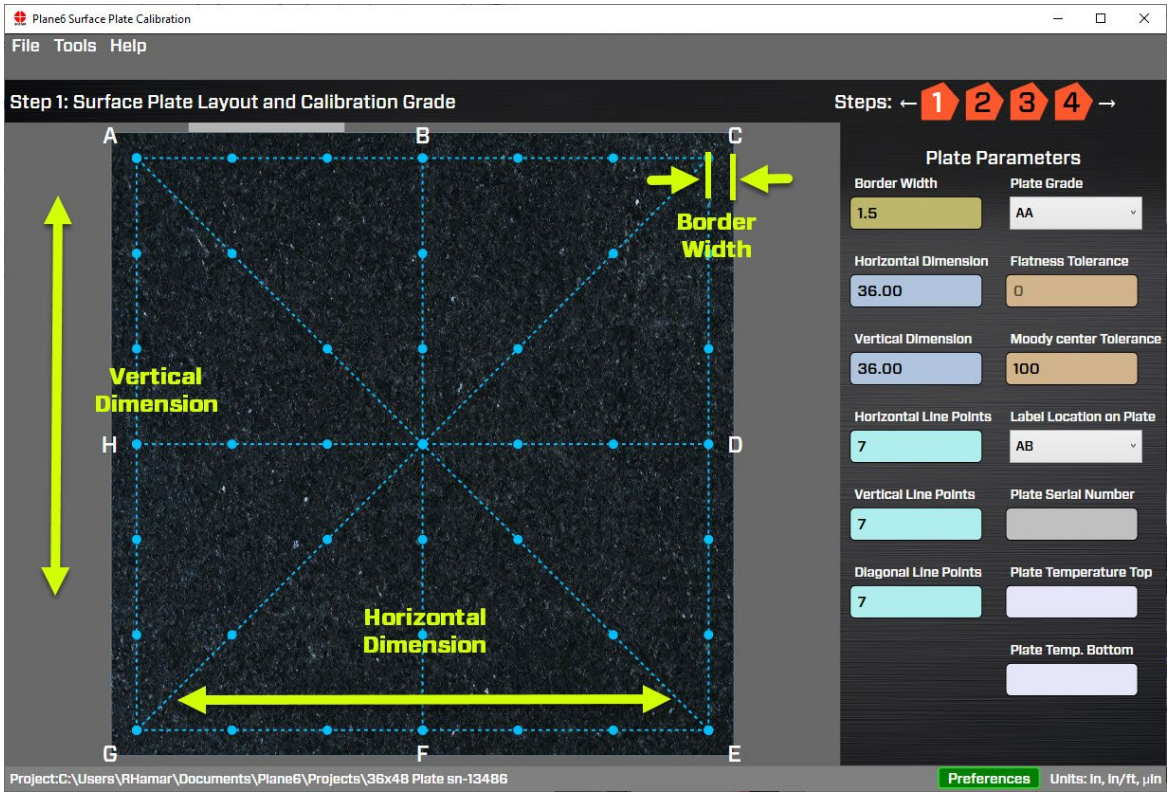
    To select a target go to **Step 2** and choose from the ***Target*** dropdown list where up to 10 target setups may be stored.





Plane6 Screens - Step 1: Dimensions and Tolerances

Enter the horizontal and vertical dimension of the plate and the border width from the edge of the plate to the measuring line. Then select the number of points you want to measure for the horizontal, vertical and diagonal lines. Next select the plate grade enter the plate serial number and top and bottom temperature (if measured).



Border Width: Width of the margin between the physical outside edges of the plate and the measurement area. The ANSE spec typically calls for 1.5 in. (33.1 mm) borders pacing.

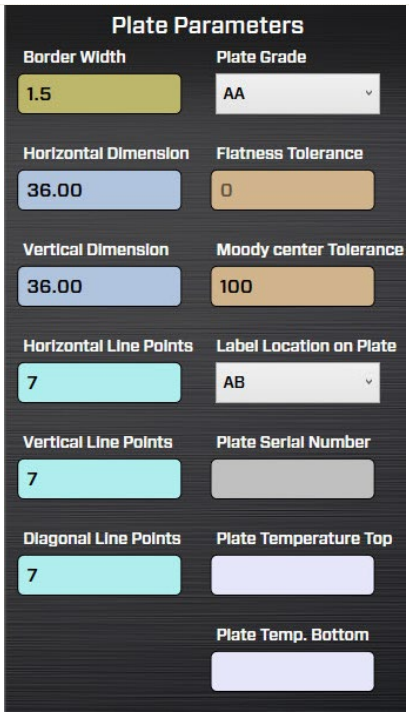
Horizontal Dimension: Outside horizontal dimension of the physical plate in inches or mm's.

Vertical Dimension: Outside vertical dimension of the physical plate in inches or mm's.

Horizontal/Vertical/Diagonal Line Points: The number of points to be recorded for each of the line types.

Plate Grade: AA, A, B or Custom. The *Flatness Tolerance* is set automatically based on ANSE B89.3.7.2013 standard. If *Custom* is selected, the *Flatness Tolerance* can be manually set.

Flatness Tolerance: This is enabled if *Custom* is selected under *Plate Grade.* This is the overall flatness tolerance for the plate. It is the difference between the highest and lowest measured point. Enter the value and click on any other part of the screen for Plane6 to accept it.

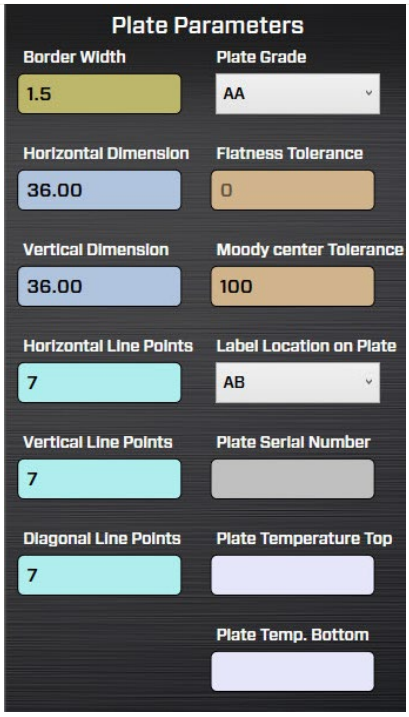


Moody Center Tolerance: As per *Moody Method* procedure, this is the maximum allowed deviation between the intersecting diagonal lines after all point adjustments have been made. If this tolerance is exceeded, it suggests that measurement errors were made, and it suggested that the data be retaken.

Plate Serial Number: Enter the plate's serial number for the report.

Label Location on Plate: Location of the manufacturer's label applied to the plate. The letters correspond to the letters on the plate graphic A…H points as shown above. *AB* means the plate is located between A & B on the plate.

Plate Temperature Top/Bottom: Temperatures for the top and bottom of the plate (if measured) as the flatness data was recorded.



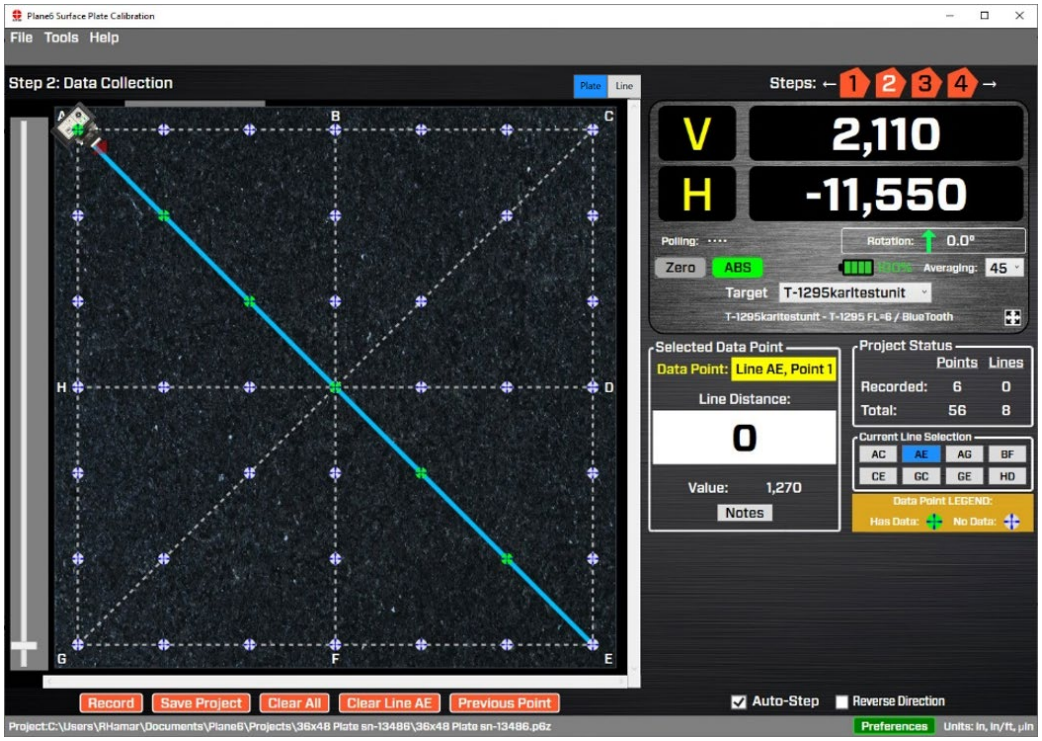
Plane6 Screens - Step 2: Data Collection – Plate and Lapping Line Views

Step 2: Data Collection – Plate View

In *Step 2: Data Collection – Plate View*, the flatness data is recorded for each line segment on the plate. The screen uses a predetermined sequence for recording each line segment that minimizes the time to record the plate data. When setting up the laser, the A-703LM Laser Fixture and L-703S Laser should be placed at the point where the target icon is located and be pointed in the direction of the arrow (see more information below under L-703SP - How It Works *Page 40*).

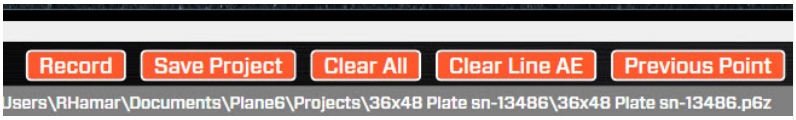
Plane6 will also highlight blue, the line segment that it is ready to record. In addition, it will show the point number and ruler dimension for that point. After a data point is recorded, the point-location icon will turn green, indicating it has recorded data, the target icon will move to the next point and the *Selected Data Point* display will show the ruler dimension for the next point to record.

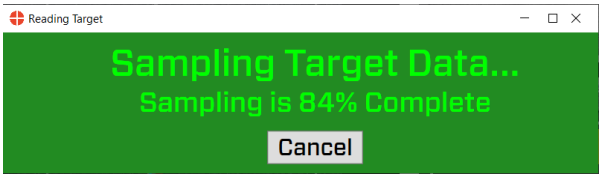
After recording the last point for a given line segment, Plane6 will move the target icon to the next recommended line segment and highlight it in blue.



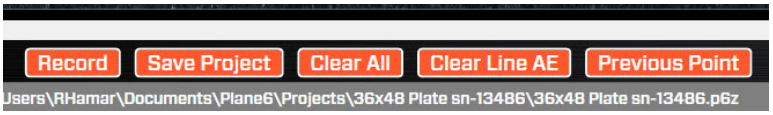
What the Buttons Do

Record – click **Record** or press the spacebar to record the data point. After pressing **Record**, a window will open and display how many samples are being recorded and will close after the sampling is done. The number of samples is changed by changing the *Averaging* in the display area – see below.
Note*: when first hitting record, Plane 6 pauses for 2 seconds to let the readings settle. Also, if the laser is blocked during sampling, Plane6 will automatically restart the data-taking.*





Save Project **–** click here to save the data already recorded.



Clear All – this clears <u>all</u> the data from <u>all</u> the line segments recorded for the plate.

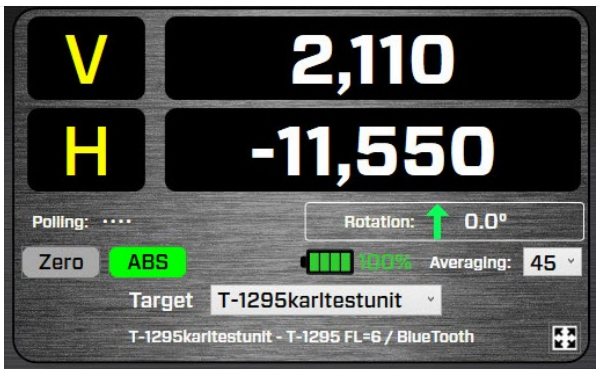
Clear Line XX – this clears <u>all</u> the data from the line segment currently selected.

Previous Point – this moves the target icon (cursor) to the previously recorded point to re-record it.

Zero – Click here to zero the display. This is generally **<u>not</u>** needed to record the data but may be useful when sampling small areas of the plate.

ABS – Click here to return the data display to the absolute (raw) value display from the target. This is a measure of how far from the PSD sensor's center the laser beam is located.

Normally ABS Mode is used for recording data.



Averaging – enter values from 1 to 200 and this will change the number of samples Plane6 uses to average for each of the values shown in the data displays.

This also changes the amount of sampling the software takes when recording a data point. A value of 45 means that Plane6 will record 45 target values, average them and record the averaged value as the data value for that point.

Note: *The higher the averaging value, the more noise fluctuations will be dampened out, but also the slower the response time for movements in the laser position. The data updates at ~13 readings per second, so with an averaging value of 26, the data takes about 2 seconds to update after the laser beam position has started moving.*

The recommended starting value for most small-to-medium plates in good environmental conditions is 10 (~2 seconds per point) for A & B grades. If doing AA grade, then up the sampling to 40 (4-5 seconds per point).

Target Battery Icon – displays the estimated remaining battery life of the target. It updates continuously.

Target – this is the dropdown list of all the targets that have been set up in *Preferences* to allow you to change the target if using your laptop with a different set of laser/target. This is normally not changed unless you are switching laptops and laser/target kits. See page **Targets - Setup Procedure** on Page **Error! Bookmark not defined.** to add to this list.

Plane6 Screens: Step 2 – Data Collection – *Lapping Line View*™

Click on the *Line* tab button to go to ***Step 2: Data Collection – Lapping Line View***, flatness data is recorded for a single line segment, with up to 5 line revisions stored for each line segment at one time.

You can select any line segment from the **Plate View** and Plane6 will bring in the values from that segment. This allows you to focus on the line segment that has the biggest flatness error when resurfacing the plate.

Grid R – These are the raw values, which are currently recorded for the selected line points either from the plate data or for newly recorded line values.

Grid C – These are the corrected values (end point adjusted to zero), which are automatically calculated once all **Grid R** values are recorded for a given line segment.

L is short for "Line Revision", so **L1** is for "Line Revision 1," etc.

L1 R is short for "Line Revision 1, Raw Values"

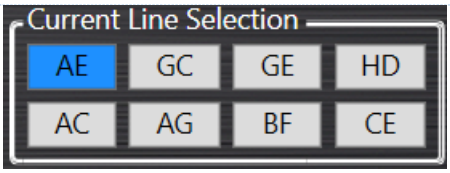
L1 C is short for "Line Revision 1, Corrected Values."

Once corrected values have been generated for a line segment, the flatness of each line revision will be plotted in the **Line Chart** at the bottom of the screen. The color of each line in the **Line Chart** corresponds to the color of each line revision, as shown on the far-left side of the data grid. ***Note*** *- the original data imported from the Plate View Data Grid is also plotted in the graph and uses a white line*.

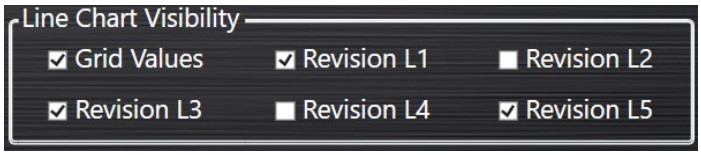
Each individual point in the **Line View** Data Grid can be selected with a left-mouse click and is highlighted by a filled gray background. The

information shown in the **Selected Data Point** display corresponds to the selected data point within the Line View Data Grid.

You can change the line segment by using the **Current Line Selection** control, which features a dedicated button for each individual line segment. By clicking on a new line segment, Plane6 will bring into the Data Grid the values it recorded in **Plate View** for that segment.



The **Line Chart Visibility** control can be used to toggle the visibility of the plotted line points for all Grid C, L1 C, L2 C, L3 C, L4 C, and L5 C values within the Line Chart control.



What the Buttons Do

Record – click **Record** or press the spacebar to record the data from the target. After displaying the value in the grid, the cursor will jump to the next oi

New – click **New** to find the next available grid line to record a new set of data for the line. **New** works in ascending order, meaning it searches for the first available data point in L1, then proceeds to check for any available data points in L2, L3, L4, and L5.

Clear Line – click **Clear Line** to erase all previously recorded data point values for a single line revision. **Clear Line** works in descending order, meaning it first clears all recorded data point values for L5, then proceeds to clear all recorded data point values for L4, L3, L2, and L1.

Step 2: Data Collection - Line View

GE		Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7
Grid R		1,170	1,180	1,200	1,200	1,170	1,180	1,210
Grid C		0	0	20	10	-30	-20	0
L1	R	690	700	720	670	690	690	700
	C	0	10	30	-30	-10	-10	0
L2	R	1,620	1,580	1,650	1,610	1,620	1,580	1,590
	C	0	-30	40	10	20	-10	0
L3	R	1,570	1,550	1,530	1,530	1,560	1,560	1,530
	C	0	-20	-30	-20	10	20	0
L4	R	1,430	1,410	1,420	1,400	1,410	1,440	1,420
	C	0	-20	0	-30	-10	10	0
L5	R	1,450	1,420	1,450	1,380	1,430	1,420	1,440
	C	0	-30	0	-60	-20	-30	0

Clear All – click **Clear All** to erase all previously recorded data point values for all line revisions, including L1, L2, L3, L4, and L5.

Dump To Grid – click **Dump To Grid** to replace all previously recorded Grid R values with the data point values assigned to the currently-selected line revision. This will "dump" the data into the **Plate View** data grid updating the old data with the newly recorded data. You can then go back to Step 3 to see how this affects the overall flatness data.

Plane6 Screens - Step 3: Results

When all the data is collected, click on Step 3 icon to bring you to **Step 3: Results**. This shows the Moody Method calculations to get the overall flatness results.

The results are summarized in the *Results* Table. The plate-grade tolerance, chosen from Step 1, is applied to the data and a red X or green checkmark is displayed to indicate if the overall flatness is in or out of tolerance.

A graph is also shown, giving a snapshot of the flatness data. A more dynamic graphic of the flatness is shown in **Step 4: Graph**.

The data tables for each line segment are also shown, along with the various values needed to calculate the overall flatness. The **Zero Low Point** column is the corrected flatness value for that line segment. The zero point is the lowest value of all the sets of data.

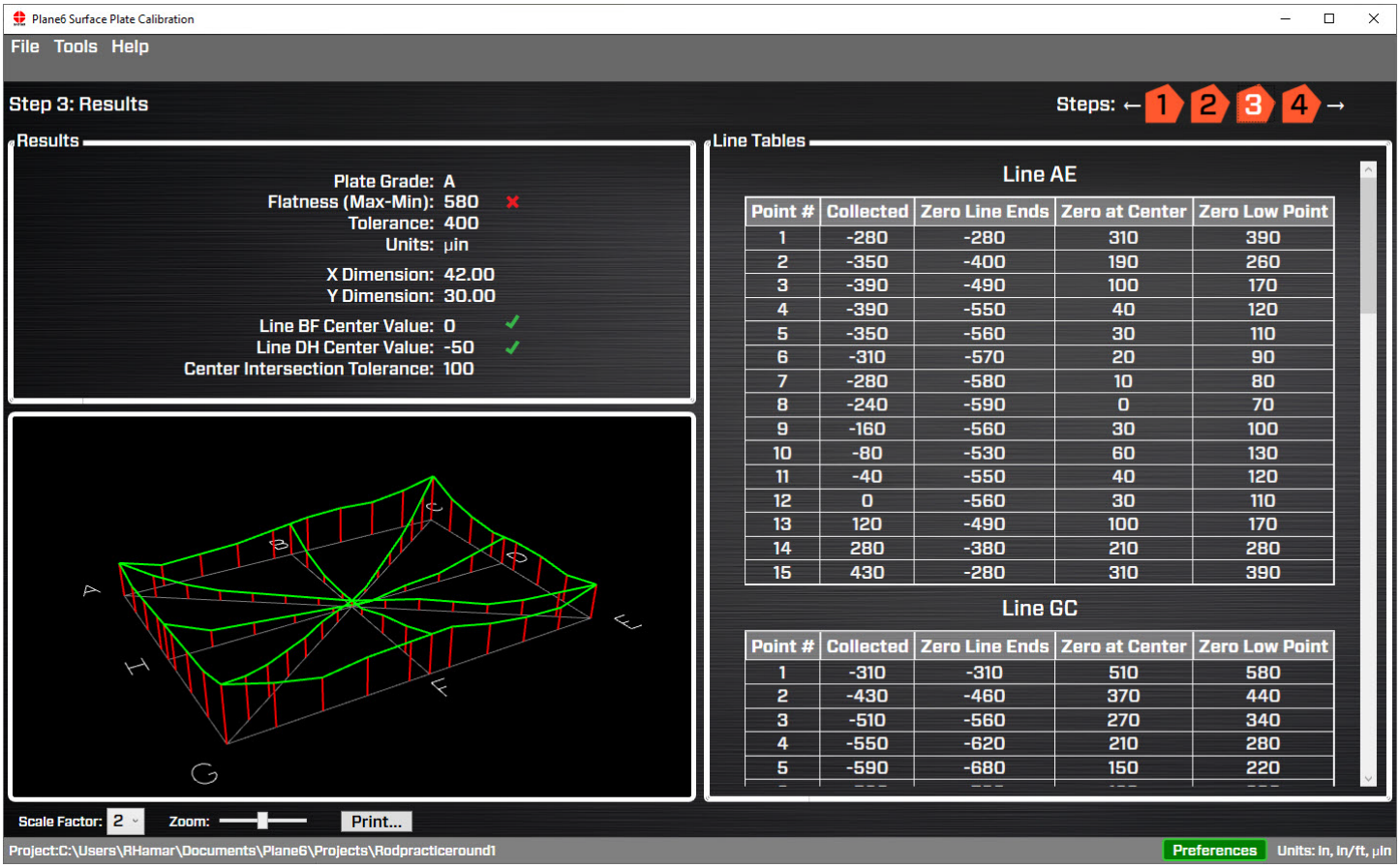


Figure 24 - Plane6 Step 3: Results

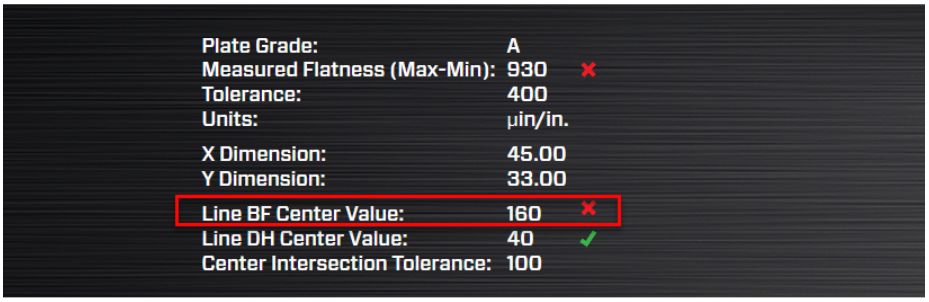
Center-Line Tolerance Check

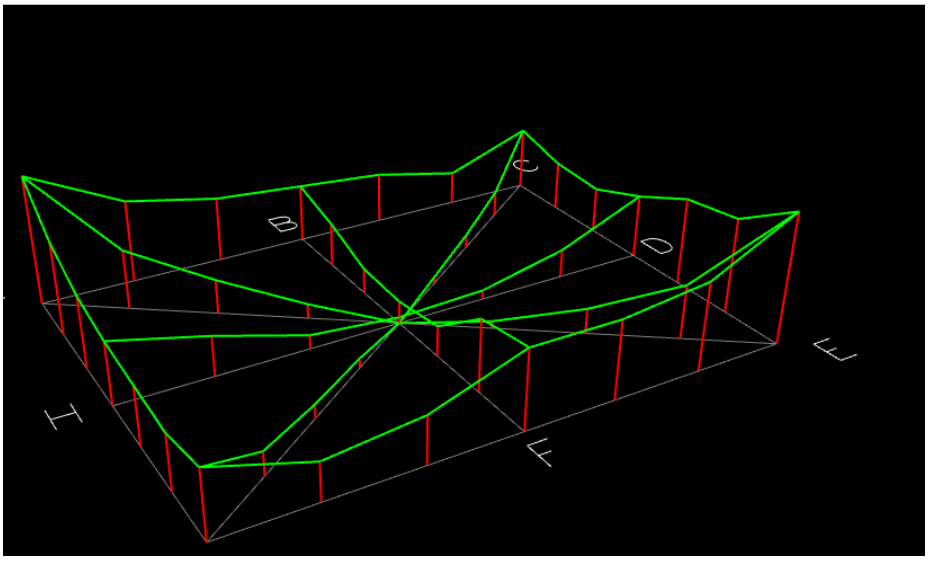
Check to make sure both center-line value tolerance checks are in tolerance. This means it's a good set of data.

However, if the center value check is out of tolerance, then the B89-3-7_2013 Surface-Plate Standard recommends that the data be retaken. You can either retake the entire plate data or you can first try to retake the data for the line segment that is out of tolerance. In the example below, you would retake the BF line data. As long as this data is taken within a reasonable amount of time from the time the overall plate data was recorded, then this is a valid way to try to correct the out-of-tolerance condition.

Procedure to retake a line segment.

1. Open the saved file if it's not already opened.
2. Go to Step 2 and select the line segment that is out of tolerance.
3. Setup the laser, laser fixture, straightedge and target, as detailed above, for the line segment you want to re-shoot.
4. Click on **Clear Line XX** button at the bottom of the screen (in this case, the button will say **Clear Line BF**).
5. Retake the data for the line.
6. Go to Step 3 to see if the results are now in tolerance.
7. Save file.





Plane6 Screens - Step 4: Graph

To see a more comprehensive graph of the flatness results, click on Step 4: Graph. This takes you to a user-adjustable graph where you can rotate the graph, zoom in and out and adjust the graph to study the results.

To rotate the graph, use a mouse to click and drag left/right or up/down. To make the elevation of the graph lines larger, click on **Scale Factor**. To zoom in/out on the whole image, slide the bar under **Zoom** or use the scroll.

You can also save the graph as a JPG file by hitting the **Save 3D Image File** button at the bottom of the screen. This saves the screen to a JPG file on your hard drive.

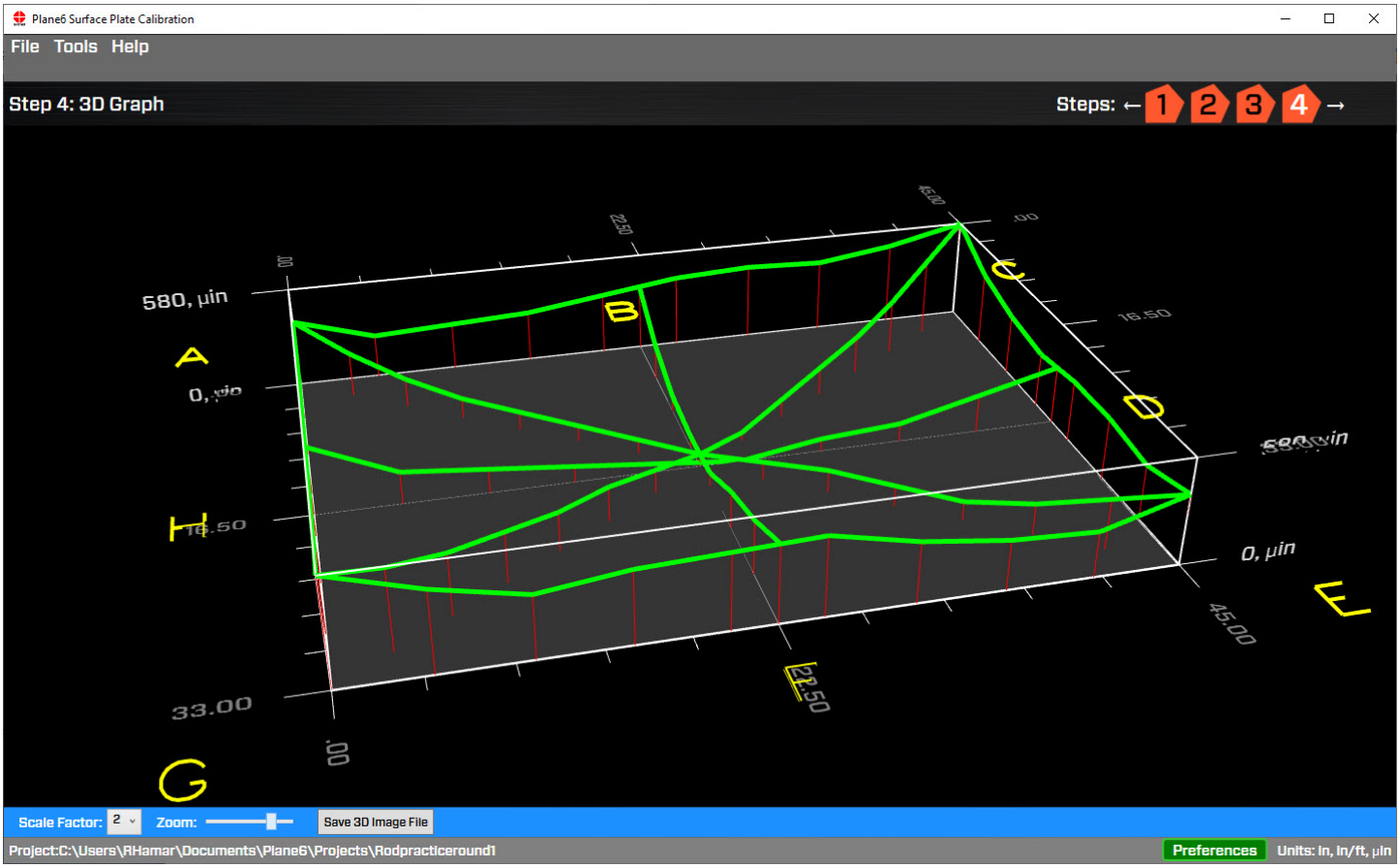
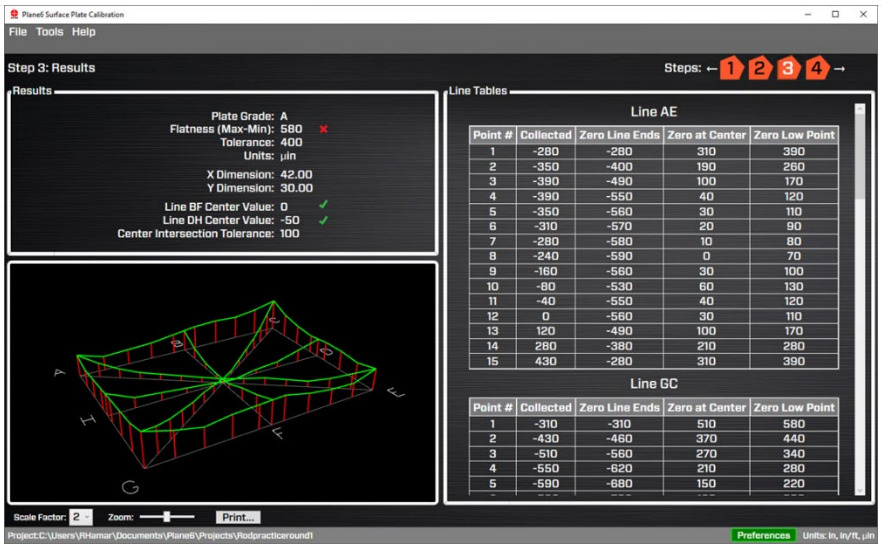


Figure 25 - Plane6 Step 4: Graph

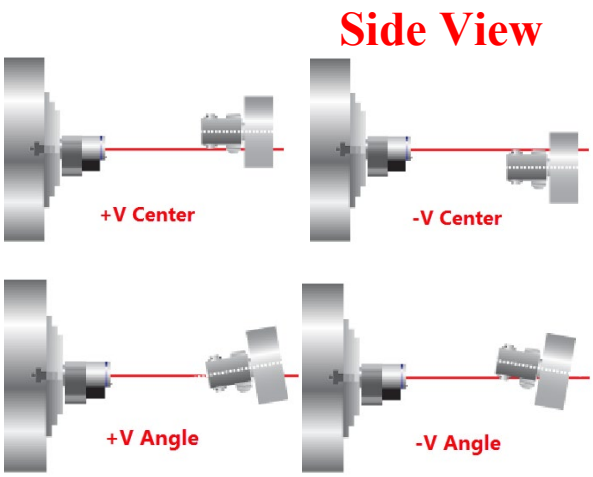
Interpreting the Plus and Minus Signs in the Live Displays

The signs of the data displays indicate the position (high/low or left/right) of the target is relative to the laser beam. See the interpretation below.



Vertical Axis

A **+V** *center* value indicates the target is higher than the laser beam.
A **+V** *angular* value indicates the back of the target is *higher* than the front of the target.
A **–V** *center* value indicates the target is lower than the laser beam.
A **-V** *angular* value indicates the back of the target is *lower* than the front of the target.



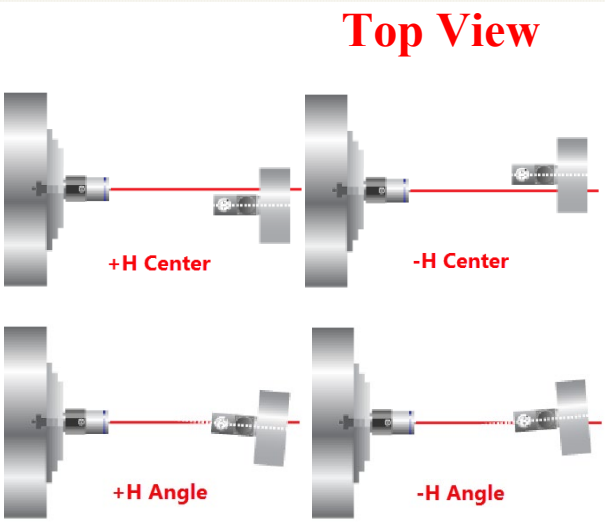
Horizontal Axis

A **+H** *center* value indicates the target is to the right of the laser beam when looking from the laser *into* the T-261 target.

A **+H** *angular* value indicates the back of the target is to the *right* of the front of the target when looking from the laser *into* the T-261 target.

A **–H** *center* value indicates the target is to the *left* of the laser beam when looking from the laser *into* the T-261 target.

A -H *angular* value means the back of the target is to the *left* of the front of the target when looking from the laser *into* the T-261 target.

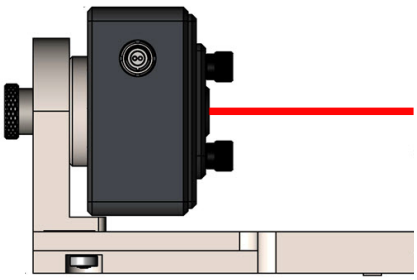


L-703SP - How It Works
Step-by-Step Surface Plate Calibration Procedure

Step 1 – Assemble Laser and Laser Mount

Insert the L-703S Laser into the L-703SP-LM Laser Mounting Fixture and tighten the thumb screw very tight and make sure to keep the top of the laser level. Turn on the laser and make sure it is in *Double-Blink Mode* (See Page 2 of the manual). The LED will blink twice and pause, blink twice and pause, etc. when in *Double-Blink Mode*.

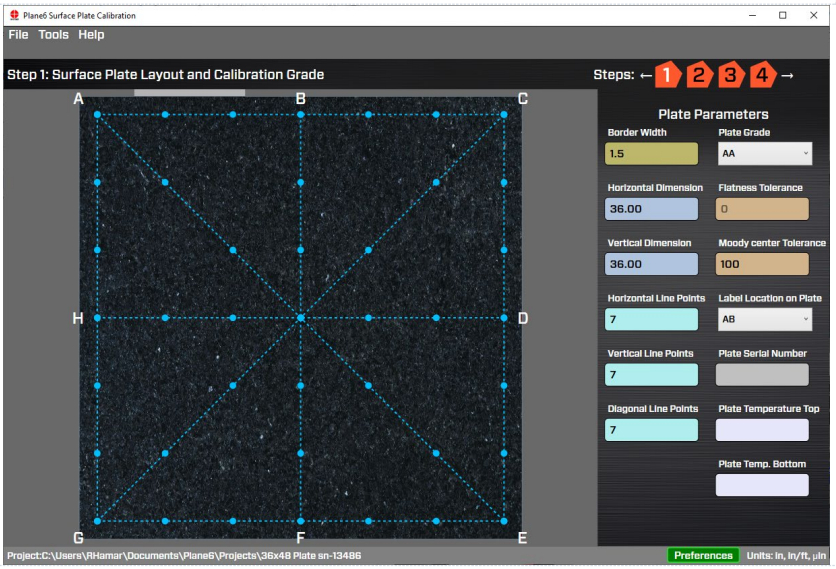
***Note**: we recommend a 30-minute warmup period for the laser and target.*



Step 2 – Plate Setup

These parameters need to be entered:

- the plate border size (default is 1.5 in. 37 mm). See Step 2 to determine what border to use.
- the plate grade,
- the plate size in X & Y,
- the number of points to measure for the horizontal, vertical and diagonal line segments,
- pick the label location,
- the plate serial number,
- the temperature for the top and bottom of the plate and,
- the alignment tolerance.

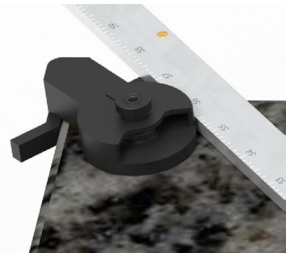


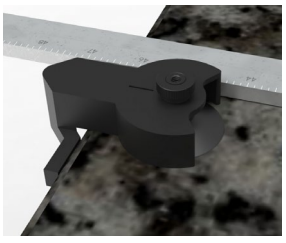
Step 3 – Use Corner/Mid-Point Locating Tool to Mark Mid Points

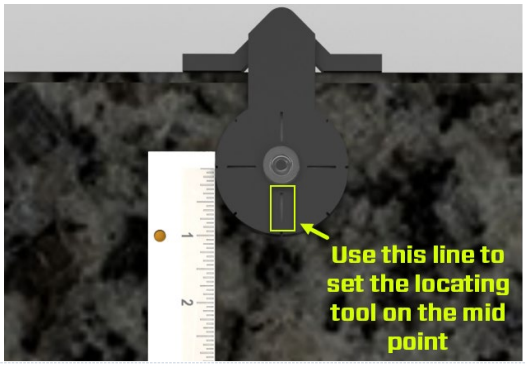
A corner-locating tool is supplied to create the proper border width and help align the straightedge to the line segment on the plate, speeding up the process.

***Note** – We supply a 1.5 in. and 2.0 in. corner tool, but we can make up different sizes if desired (2.5 in. or 3.0 in.). Enter the border-width value for the tool in Border Width in Plane6 Step 1.*

a. Use a tape measure to mark the midpoint for each perimeter segment line, using the locating tool to show you where to make the mark.
b. Do this for all 4 outside line segments.



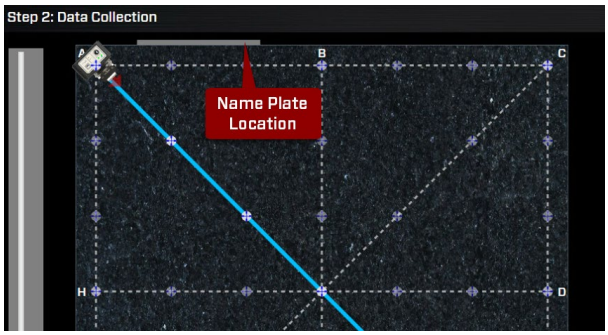


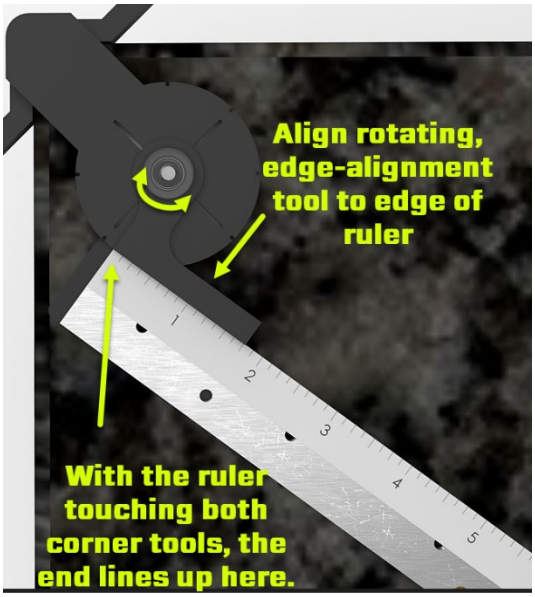


Step 4 – Place Straightedge on the Diagonal Segment

Plane6 preselects the line sequence that you will measure. This can be overridden but this sequence was selected to minimize the time it takes take all the data. To measure the diagonal:

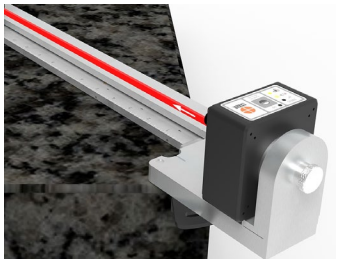
a. Locate the first diagonal segment as recommended by Plate6, using the plate label location to orient yourself (see screen below).
b. Place the side of the straightedge with the ruler so it is touching the corner locator. See image. In general, you always want the *scale side* of the ruler to be touching the locator tool.
c. Position the <u>end</u> of the straightedge to line up with the line on the rotating-edge-alignment tool – see image.
d. Now, the straightedge is located next to the line segment that you need to measure so that when the target is put down against the straightedge, it is directly over the line segment.

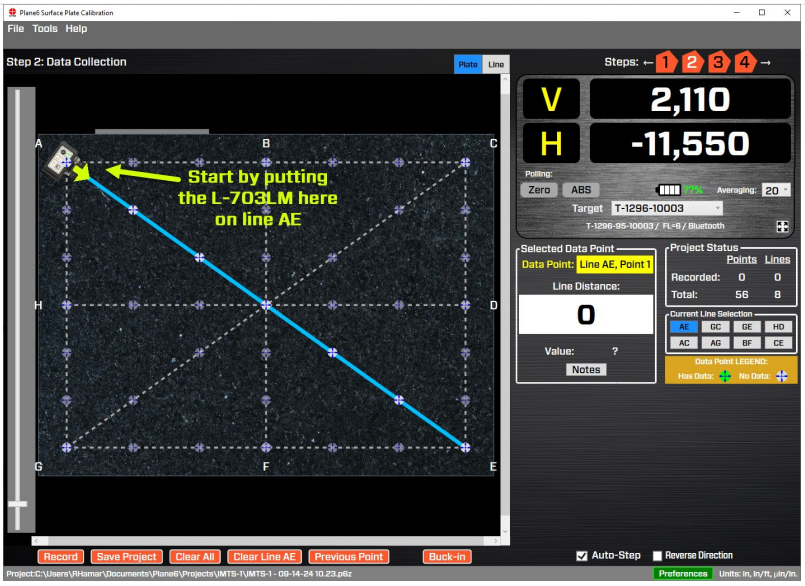




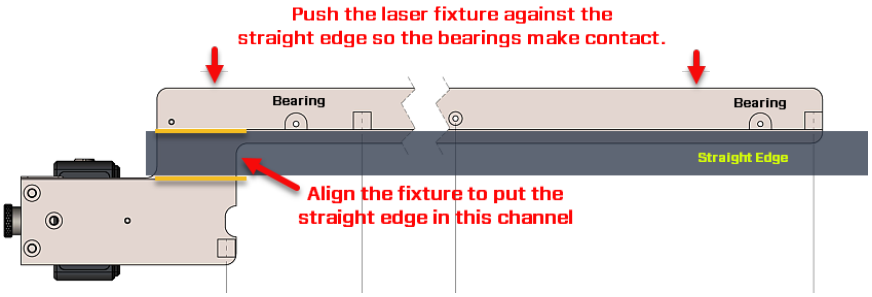
Step 4a –Place L-703SP-LM + L-703S on top of the straightedge

a. Find the correct corner on which to place the A-703SP-LM from the Step 2 Measure Screen, keeping track of the name plate location. Normally this is on line AE.

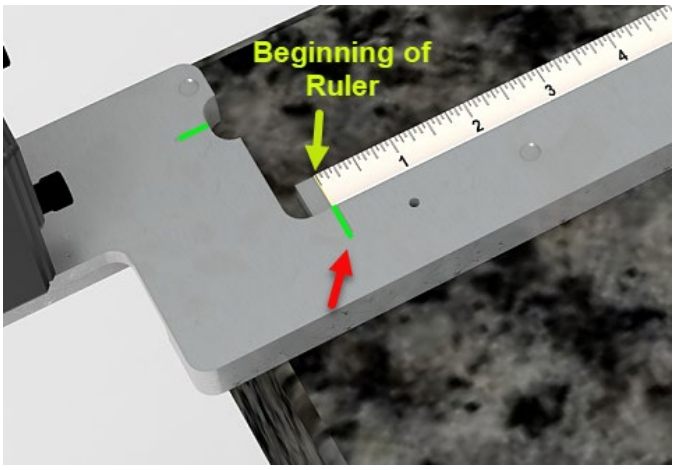




b. Place the A-703SP-LM on top of the straightedge, aligning the channel (cutout) on the bottom to the straightedge, making sure to put pressure on the straight edge to prevent it from sliding. Then, holding down the straightedge, slide the laser fixture against the straightedge to make it parallel to the straightedge and line segment. You can squeeze them together so the bearings on the bottom of the laser fixture makes contact with the straightedge.



***Note**: When putting the A-703SP-LM on the straightedge make sure to line up the green mark on the fixture with the beginning of the ruler scale.*

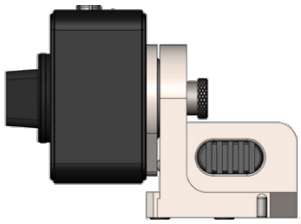


Step 5 – Assemble the T-1297 Target and A-1297-SP Measuring Base

Now assemble the T-1297 Target into the A-1297-SP Precision Measuring base. Notice that the T-1297 has an alignment ball. This should be inserted into the slot on the A-1297-SP to align the target to the A-1297-SP base's measuring feet. Tighten the thumb screw very tight.

Turn on the T-1297 and use *Center Mode*.

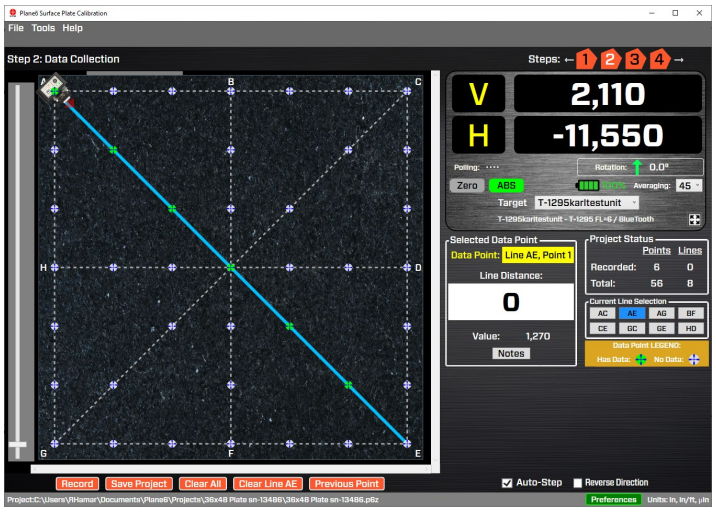
***Note** – do <u>not</u> use Scanning Mode as outlined on page 6. When you turn on the T-1297 it defaults to Center Mode. If you see the On TGT LED on top of the target blinking in red, then this means it has been set to Scan Mode. Press and hold the power button to turn it off and then turn it back on again to put it back into Center Mode.*

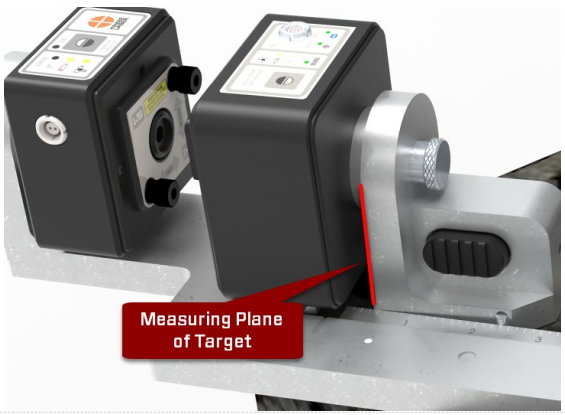


Step 5a – Place T-1297 Target & Base on the Plate

Place the T-1297 Target and Base on the plate near the laser, *gently* push it against the straightedge, and line up the *Measuring Plane* of the base with the zero point on the scale (see image). Check to make sure the that the **H Axis** value is less than 10,000 µin. (250 µm), which it normally is.

Zero the display by clicking **Zero.**



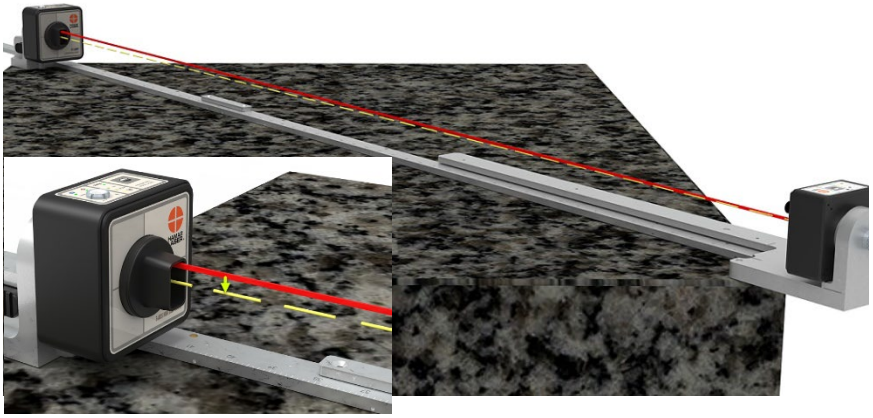


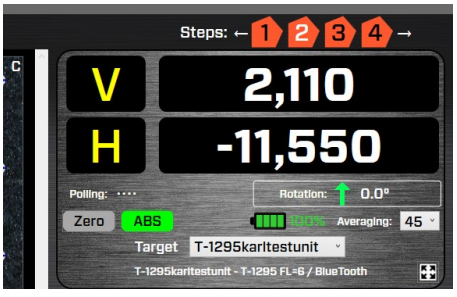
Step 5b – Move the T-1297 Target & Base to the Far End of Straightedge

a. Move the T-1297 Target + Base to the *far* end of the straightedge and gently push it against the straightedge.
b. Adjust the H (yaw) and V (pitch) axis adjustments on the L-703S laser to tilt the laser beam until the values are less than:

H Axis: ±7,000
V Axis: ±3,000

This aligns the laser beam to the straightedge and puts it on the most accurate part of the PSD sensor.

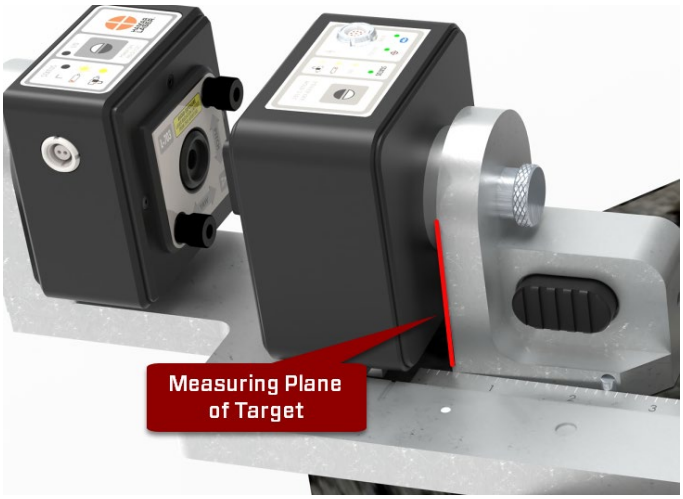


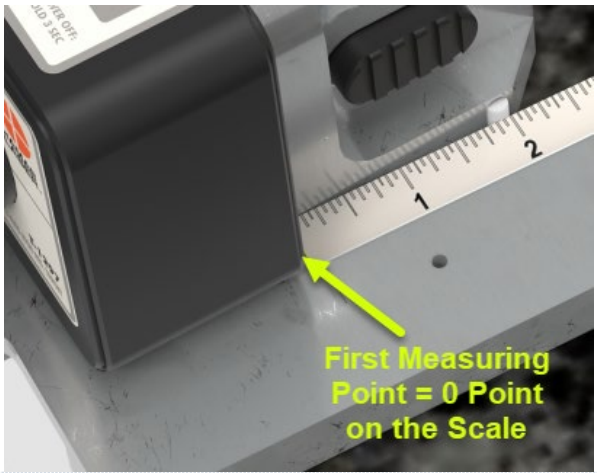


Step 5c – Move the T-1297 back to Near Position and Start Recording

Move the T-1297 Target back to the near point and click **ABS** button (next to the **Zero** button). Then click **Record** to record the first data point. When positioning the target, line up the *Measuring Plane* (front edge of target base mounting surface) with the ruler dimension before hitting **Record**. In this case it should be on the zero (0) point on the ruler.

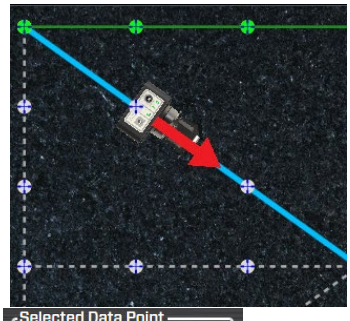
Note *– for the zero point, there is a stop on the ruler to let you know you're at the right point.*

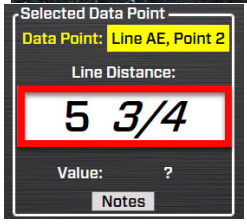


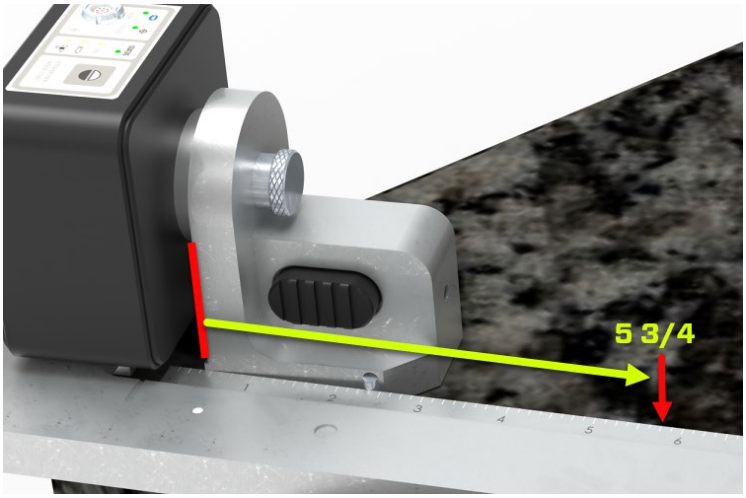


Step 6 – Move to Next Point and Continue Recording

Move to the next point by looking at the *Line Distance* display in **Plane6 Step 2** to tell you where to position the target. Click **Record**. Continue recording until all the points are taken.





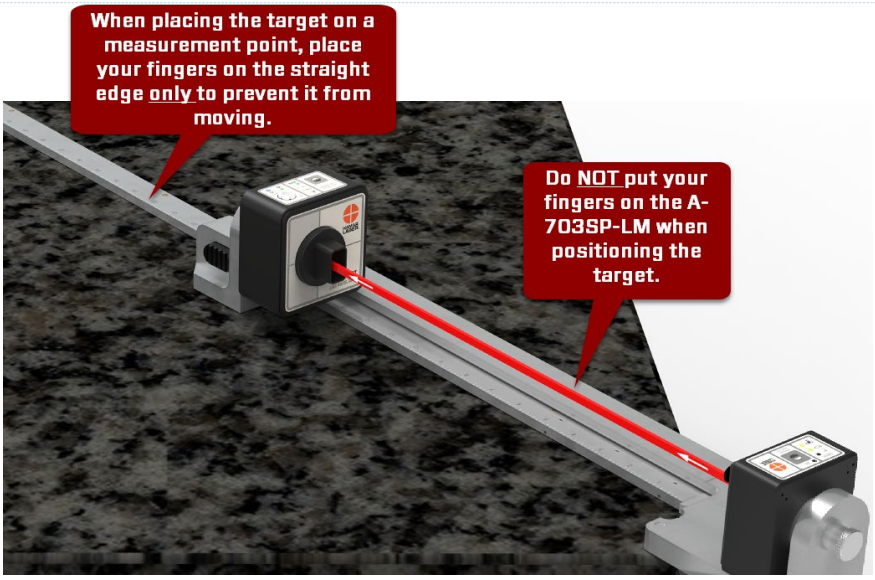


Step 6a – Note: Moving the Target when Taking Data

Note *- when moving the target to the next point, it is important to only hold the straightedge to prevent it from moving. There are rubber feet on the bottom to help it from sliding, so light pressure on the straightedge will keep it from moving.*

However, DO NOT TOUCH THE L-703SP-LM laser fixture since it does not have rubber feet and can be moved easily. Moving the fixture can cause the laser beam to move, causing measurement errors.

If the A-703SP-LM moves, we strongly recommend repositioning it, making sure it is properly touching the straightedge, clearing the data for the line segment, and re-recording the data for the line segment.

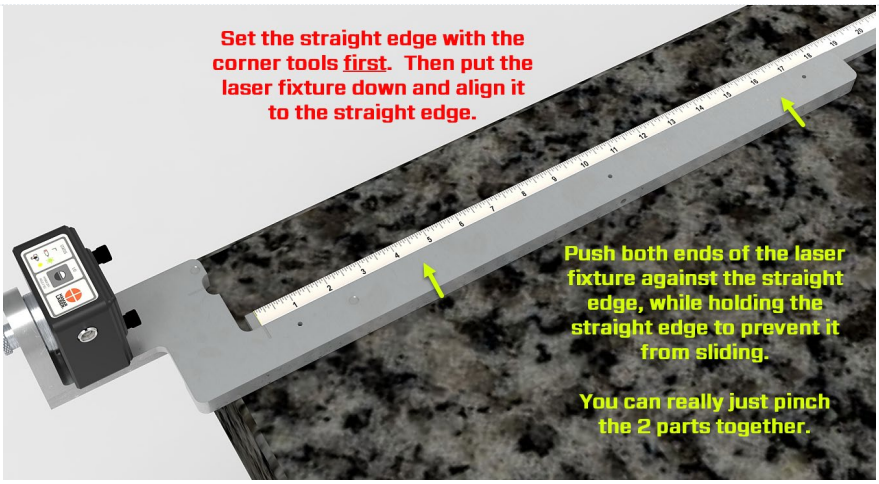


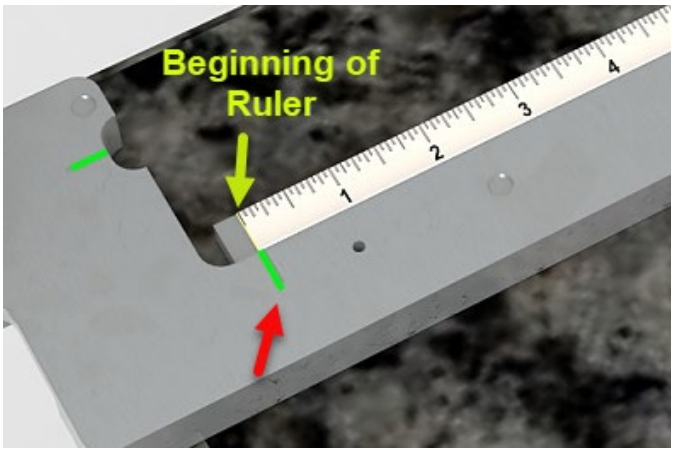
Step 6b - Note on Moving the Straightedge for a New Line Segment

When moving the A-703SP-LM Laser Mount and A-703SP-SE Straightedge to the next line, follow these basic steps:

a. Place the straightedge on the line using the corner locating tool to position it correctly, as shown above in Step 2.
b. Place the laser mount over the straightedge (see above) and slide it so it hits the straightedge at both ends. You can "pinch" them together to make contact but try to keep the straightedge from moving.
c. Make sure to line up the start of the scale with the mark on laser fixture.
d. Once the laser fixture is in place, do NOT touch it when taking data. This is because even small movements of the laser fixture could cause the laser to move, especially at the far end of the line, which would require restarting the data taking for the line segment.
e. You can put your hand on the straightedge to help prevent it from sliding.

Note*: if you change the straightedge to a different length, we recommend you redo the laser Buckin as noted in Step 4. A different straightedge will have a different straightness profile, so the laser will need to*



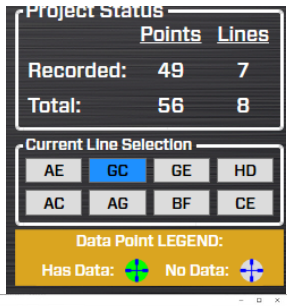


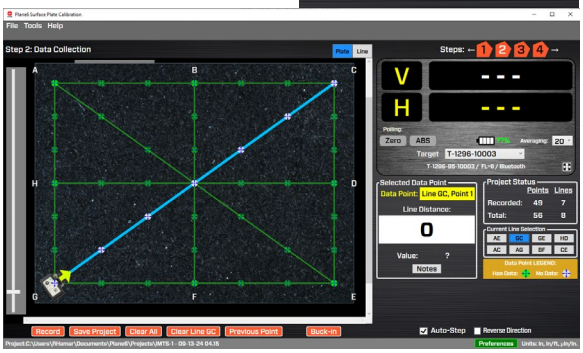
be adjusted to be parallel to the new straightedge.

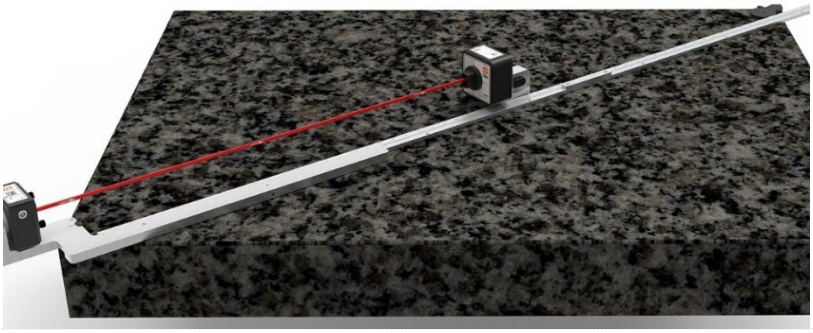
Step 7 – Move Laser to Second Diagonal and Record Data

a. Plane6 automatically moves the recording line segment to next line as shown in the *Current Line Selection* table, which is GC.
b. First, take off the L-703SP-LM Laser Mount and set it aside.
c. Then move the straightedge to the second diagonal using the corner locator tools to position the straightedge. *Note - the location of the target icon is where to put the laser fixture.* Again, make sure the straightedge is to the right of the corner locating tools and aligned with the mark as shown above.
d. Place the L-703SP-LM Laser Mount on the straightedge as shown Step 3a above. Place the target at the near position and you are ready to record.

***Note** - you do <u>not</u> need to re-adjust the laser beam since you are using the same straightedge, which means the alignment of the laser to the straightedge should hold its position, so after positioning it and the L-703SP-LM, you can start recording.*



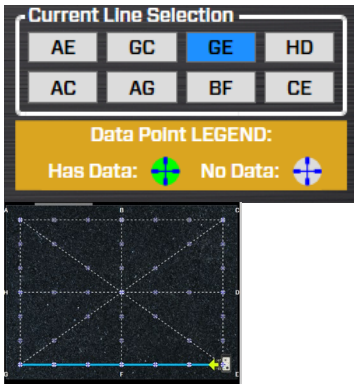


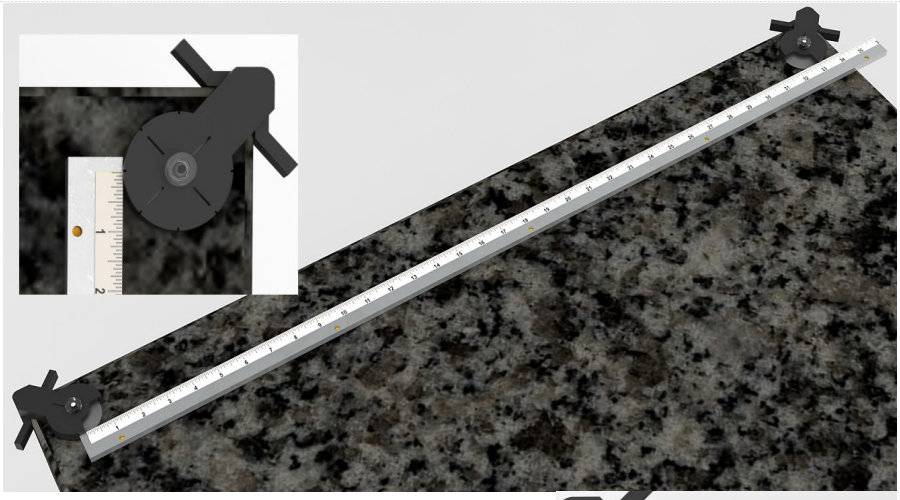


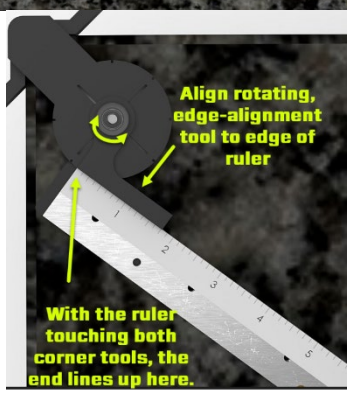
Step 8a – Move Laser and Straightedge to Outside Edge and Record Data

Now we move to next line segment, an outside edge, as shown in the *Current Line Selection* table (see below), usually Line GE. Pay attention to which edge to record, as shown in Step 2. Also pay attention to which end of the line to put the L-703SP-LM Laser Fixture. For line GE, it will be the right side of the line – see below.

Find the straightedge that best matches the length of that side of the plate. See Step 2 for instructions on lining up the straightedge to the corner locating tool.

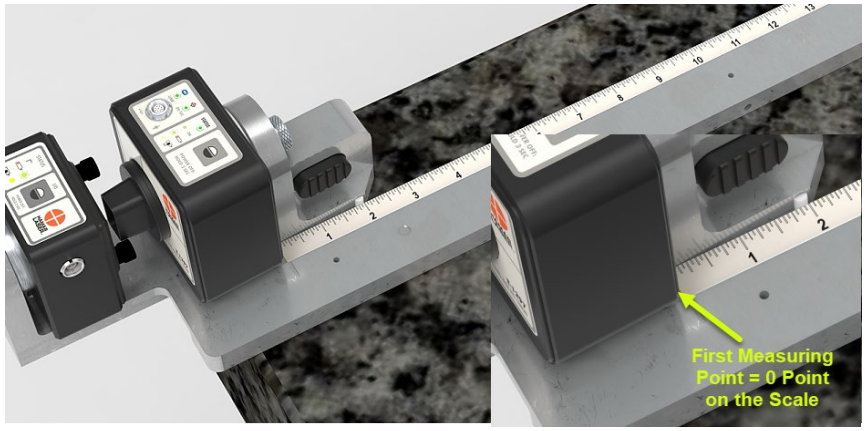






Note *– we recommend that the extra length of the straightedge be no longer than 1/3 of the edge of the plate. This is to ensure that the straightedge does not move around when you are taking data. This can happen because as the straightedge gets longer relative to the plate edge, it tends to want to fall off the plate.*

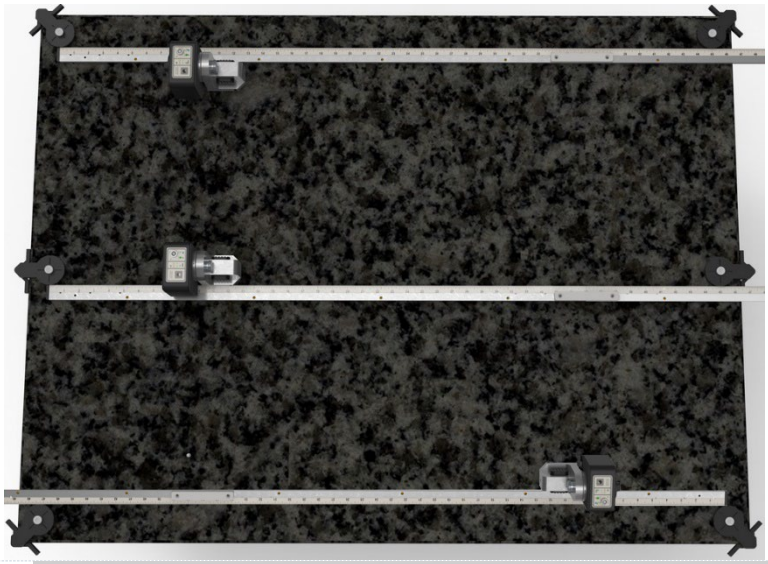
Again, when using the corner edge tool, always put the scale side touching the tool.



Place the L-703SP-LM Laser Mount on the straightedge as shown Step 3a above. Place the target at the near position and you are ready to record.

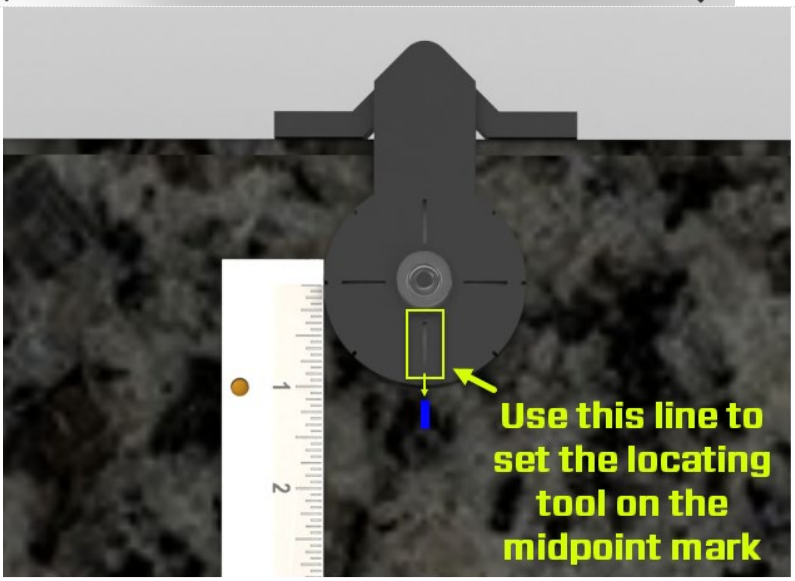
Step 8b - Record Second Outside Edge of Plate

Locate the second outside edge recommended by Plane6, usually Line HD and repeat the process in Step 7a

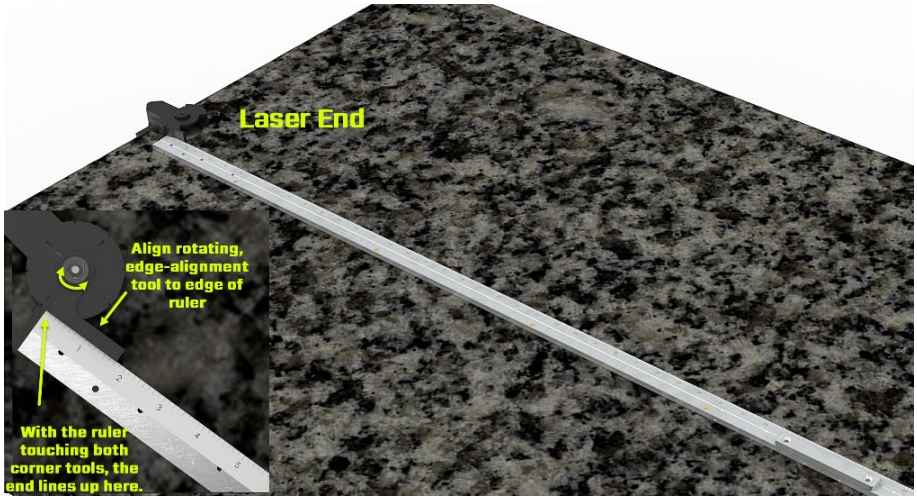


Step 9 – Record Mid-Point Line Segments

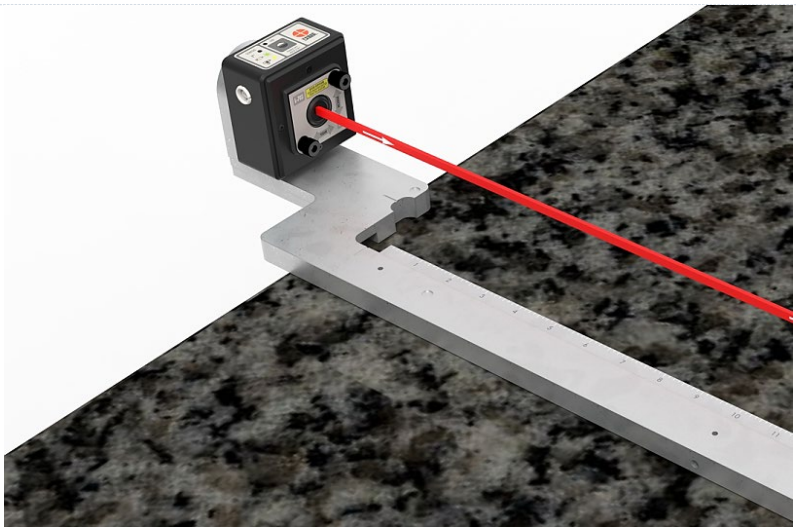
Using the mark made by the Mid-Point Marking Tool (see Step 1), position the Corner Locating Tool on the midpoint of the outside edges and align the mark on the locating tool with the mark on the plate.



Position the straightedge with the *scale side* touching the Corner Locating Tool and position the zero point on the scale with the rotary edge on the locating tool.

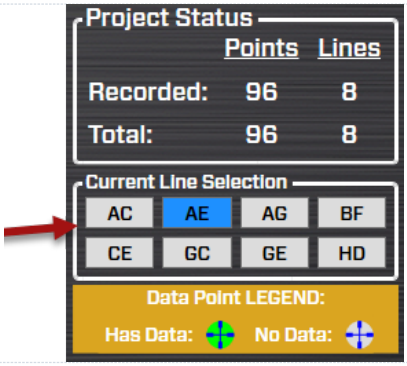


As before, place the A-703SP-LM fixture on the side recommended by Plane6 and place the target in the near position and hit Record. Continue taking data for the whole segment.



Step 10 - Record the Rest of the Line Segments

Record the rest of the line segments, following the recommended sequence from Plane6.

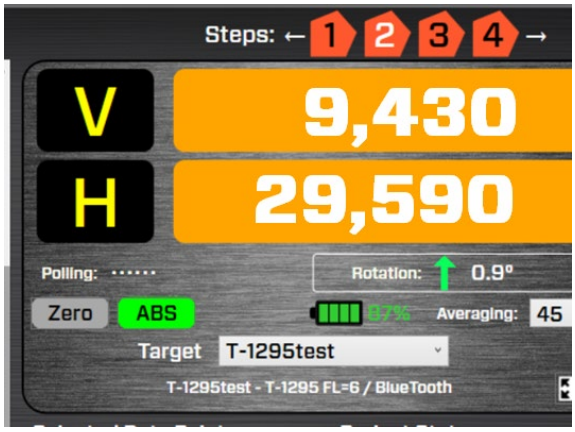


Notes on taking data:

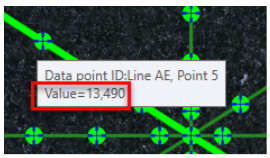
1. **Display Value Tolerance** - Pay attention to the H axis value. If the value gets higher than 10,000 µin. (760 µm), then the Plane6 data display will turn orange indicating that this is too far off center in the horizontal axis. This may mean the laser fixture moved. Check to make sure the laser fixture is still against the straightedge. If not, then move them together again.

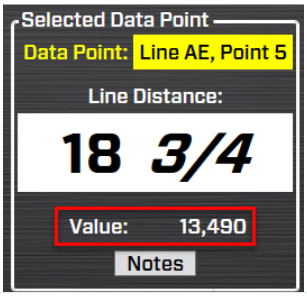
   Move the target to the end of the straightedge and see if the orange color disappears. If so, this means it's back in spec. Then hit **Clear Line XX** to restart the data taking for the line segment.

   If it's still orange, you can simply adjust the H axis until it's less than 10,000. Then hit **Clear Line XX** and retake the data for that line.



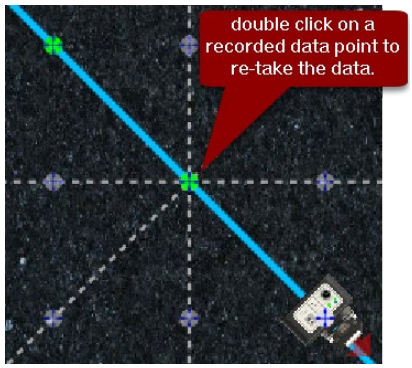
2. **Checking Recorded Data Points** - You can always check data values for a given point by hovering over it and seeing the



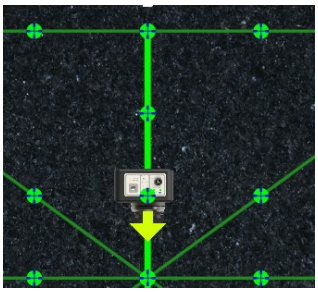


values or by clicking on it and seeing the values in the table.

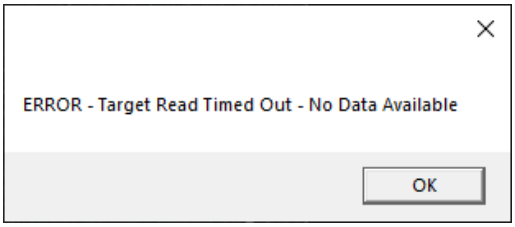
3. **Retaking a Data Point -** You can also click on a point and retake the data point if you think it is wrong.

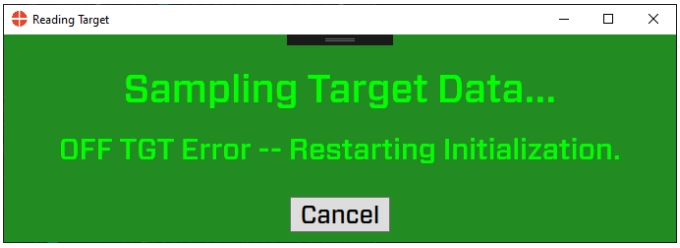


4. **Manually Picking Data Points** - You can turn off *Auto Step* if you want to move the target icon manually. First click on the line segment you want and then click on the point you want to record. The target icon should be over the point indicating it's ready to take data.



5. **Reversing Direction on a Line Segment** - You can also hit *Reverse Direction* to change the direction of a line if you need to.
6. **Data Time-Outs**
   There are two issues that can cause the data recording to restart:
   a. The data buffer does not get enough samples for the averaging in the time allotted, so it will "timeout" (T/O). For example, if the Avg is set to 40 and the buffer only has 25 samples and the time has exceeded 4 seconds, you will see the timeout message. The formula for the T/O T/O = (Avg/2)/13 subject to a minimum of 3 seconds. So, for 40 avg, the T/O is 40/2 = 20/13 = 1.5 but that is less than the minimum sot the T/O is 3 secs.

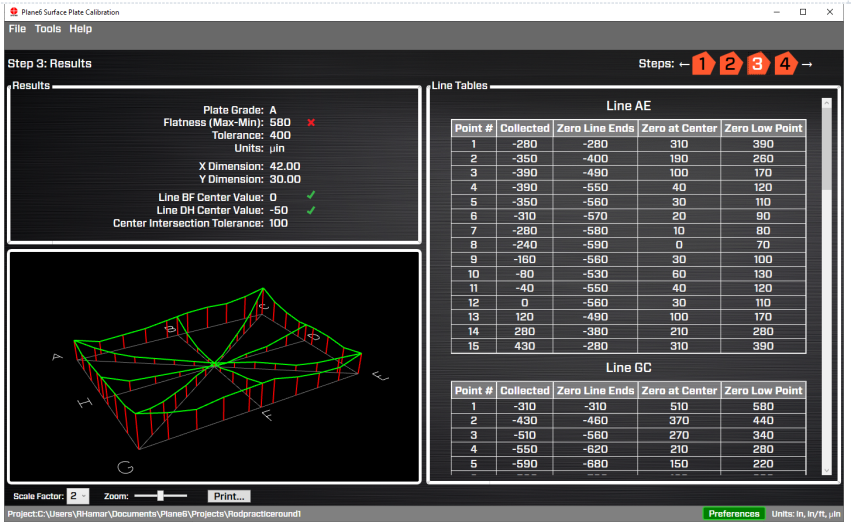




   b. The software receives an "Off TGT" message from the target. This will trigger the software to "flush the buffer" and restart the data taking routine. This is to avoid potential bad data being recorded as the laser beam is being partially blocked.

Plane6 will automatically retake the data unless **Cancel** is clicked.

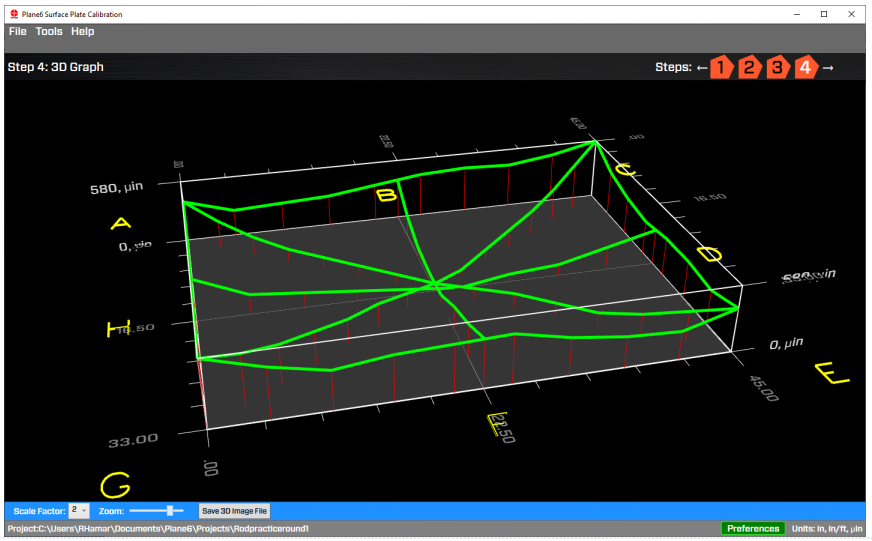
Step 9 – Review Results in Step 3 Results



There is also an additional check for the center point elevation difference as is directed in the B89 Standard. The tolerance is also displayed. According to the standard, if the center check is out of tolerance, it is recommended that the data be re-recorded. You may be able to retake one of the 2 center line segments to get it in tolerance. See page 35 ***Centerline Tolerance Check*** for a procedure to retake a line data.

Plane 6 also displays the data tables for each line segment. This is all displayed in the report.

Step 10 – Review Graphical Results in Step 4 3D Graph



L-703SP - How It Works – Step 2 - Line View
Performing a Flatness Quick-Check on a Line Segment after Lapping

One of the annoying parts of using electronic levels when re-surfacing a surface plate is you have to shoot the entire plate for flatness to see how the lapping process is going. This is a waste of time! With the L-703SP Surface Plate Calibration Systems, you can do quick checks of a single line segment in about 3-5 minutes to see how much the flatness error has been reduced. Typically, you'll pick the line segment with the highest flatness error and focus on it as you lap the plate.

To aid this process, we developed a second data-taking module called **Line View**. With **Line View**, you can select any line segment, which will bring the values from the plate data into the *Live View* data grid. You can then resurface the plate, clean it and measure the line to see how much improvement there is. You can record up to 5 sets of line data for each segment. You can also select more segments if you need to work on them, too.

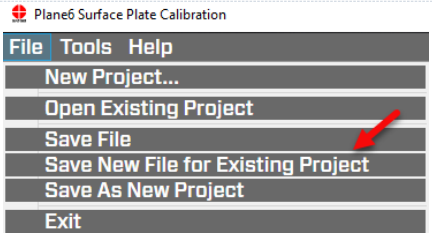
Here is the procedure.

Note *- you don't really need to clean the entire plate but just the area that you will measure.*

Step 1 – Open Calibration File

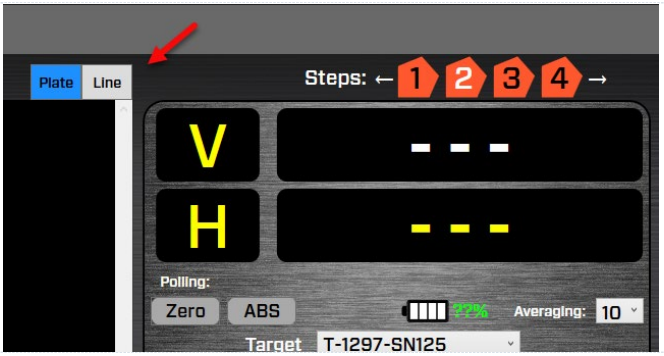
If it is not already open, then open the calibration file for the plate you want to lap.

Note *– Since you will be recording new data for one or more line segments, it's good practice to protect the existing saved data by clicking on* ***Save New File for Existing Project*** *or* ***Save As New Project****.*



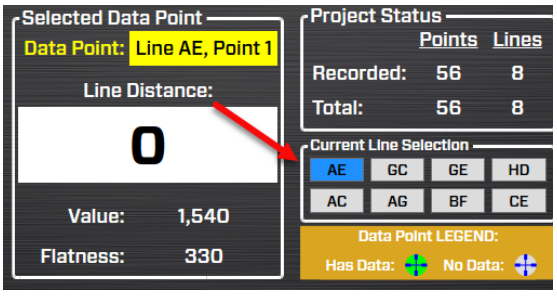
Step 2 – Open Step 2 and Select Line Checker Tab

Go to Step 2 and click on the **Line Tab** at the top of the screen to open the screen.



Step 3 - Select Line Segment & Set Up A-703SP-LM Laser Fixture

Select the line segment you want to measure by clicking on the segment letters in the **Current Line Selection** box. Then, select the matching length for the A-703SP-SE Straightedge ruler.

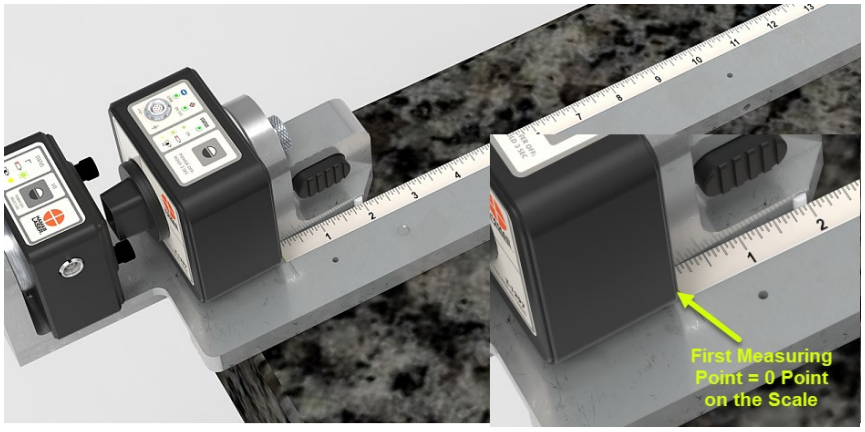


Use the corner/midpoint locating tool to set up the straightedge as shown above on pages 35, 41 or 42.

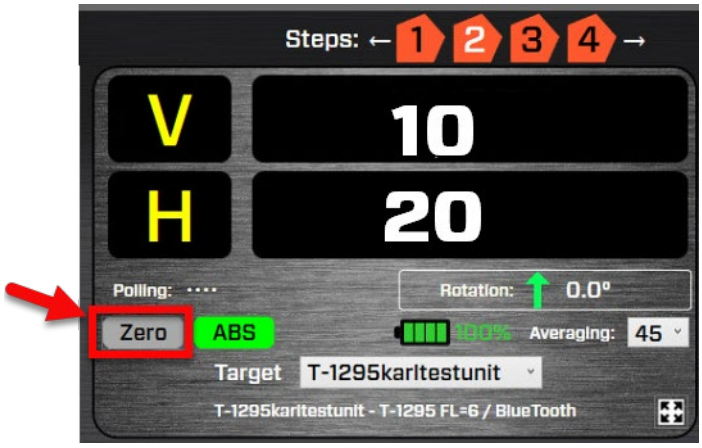
Then, place the L-703SP-LM Laser Fixture on the straightedge, as shown above.

Step 4 - Set Up Laser Line

Before taking data, it's a good idea to make sure the laser is still reasonably parallel to the A-703SP-LM Laser Mount. Bring the T-1297 Target and A-1297-SP Target-Measuring Base to the first measuring point as you did above. Zero the display by clicking on the **Zero** button.



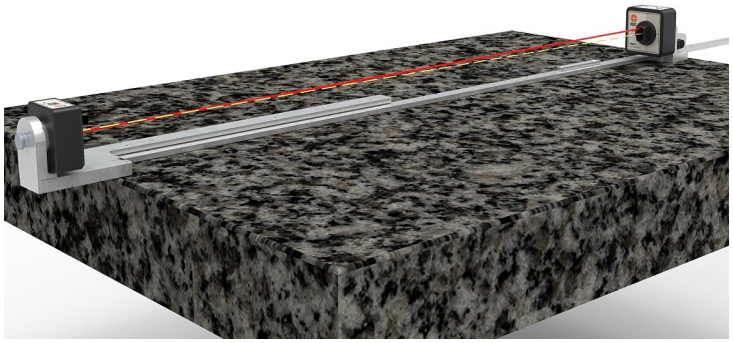
Note *- Due the extremely high resolution, it's expected that the value won't be exactly zero due to some measurement noise, but they will be close.*



Step 5 - Move Target to Far Point and Adjust Laser's Pitch/Yaw

Move T-1297/A-1297-SP Base to the far end of the straightedge. Adjust the Pitch and Yaw knobs on the laser until you get to around 2,000 µin (50 µm) for the V axis and 5,000 µin (125 µm) for the H axis.

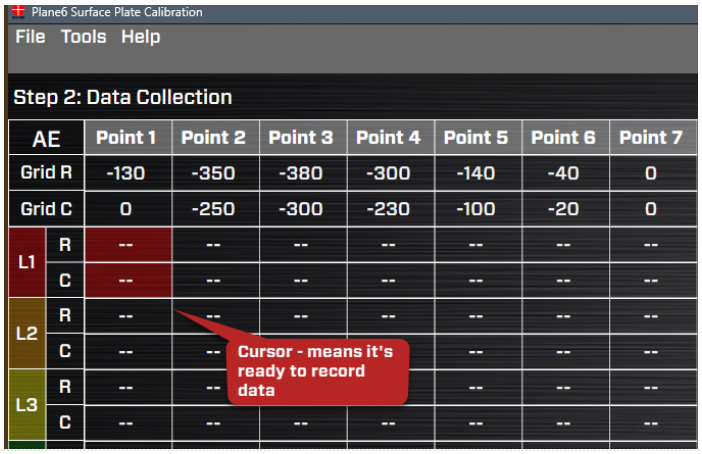
Go back to Point #1 and check to see if you have the nearly same values as when you zeroed it. If not, re-zero the target and repeat this process until you get the far point relative to the near point to within 2,000 µin (50 µm) for the V axis and 5,000 µin (125 µm) for the H axis.



Note *– As discussed above, once the laser is aligned to the straightedge, you won't need to check the alignment again unless you use a different straightedge.*

Step 6 – Select the Line Segment

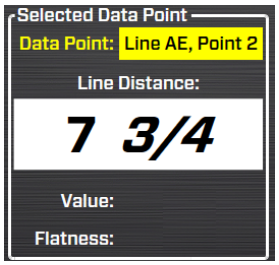
Click on the *New* button, which will enable the first empty row in the grid to record data. A "cursor" (the box will be highlighted) will appear at the first point in the row, which means it's ready to take data.



AE		Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7
Grid R		-130	-350	-380	-300	-140	-40	0
Grid C		0	-250	-300	-230	-100	-20	0
L1	R	--	--	--	--	--	--	--
	C	--	--	--	--	--	--	--
L2	R	--	--	--	--	--	--	--
	C	--	--	--	--	--	--	--
L3	R	--	--	--	--	--	--	--
	C	--	--	--	--	--	--	--

Step 7 – Record the Values

Place the target on the zero point on the scale. Click **Record** to record the value. Move the target to the next point on the scale, by looking at the **Select Data Point** display to find the location on the measuring scale. Click **Record** and continue to record data until all the points are taken.



Step 8 – View Results

When you're done recording the values for AE, you'll see the raw data (R) in row L1. You will also see the corrected data (C), where the endpoints are zeroed and the max value represents the overall flatness error for the segment. In the example to the right, the max value is 240 µin.

The data is plotted in the graph below, along with the plot for the original data set. The plots are color-coded to match the Row color.

Step 9 – Continue to Lap and Record Data

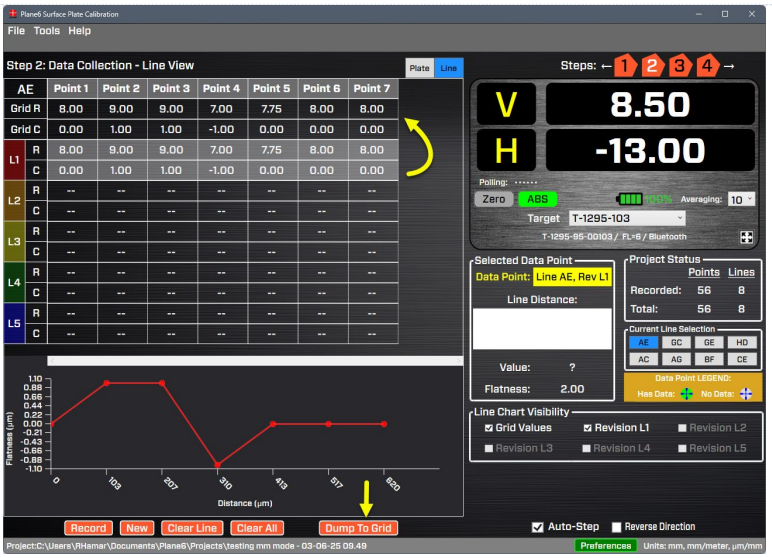
If the first run at lapping the plate did not help the plate to pass calibration, then you can lap it again and then record a new set of line data for a given line segment.

To record a second set of data, click on the **New** button, which will enable the next available row to record data. Then, as before, click on *Record* to record the data. You will notice the data will start filling into the second row, L2. When you're done, as before, it will calculate the corrections and display the results in row *C*. The graph will also show the line graph for the new set of data.

Step 10 – Add New Data back into Plate Data

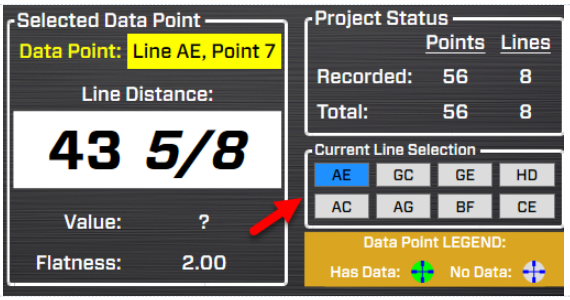
If you are satisfied with the results, you can pick another segment to work on, or you can use **Dump to Grid**, which will automatically upload the new data into the Grid Line in **Line View** and then into the **Plate View** data set. Then, you can see how that new line of data affected the overall flatness of the plate.

To use **Dump to Grid**, you must first click on the row (click on L1, L2, etc.) to highlight it and then click on **Dump to Grid**. You will notice the white graph disappears as this was the "old" data and has now been replaced by the set of data that you selected.



Step 11 – Record Values for Other Line Segments

By clicking on another line segment in the **Current Line Selection** box, you can take data for that segment by following the steps above.

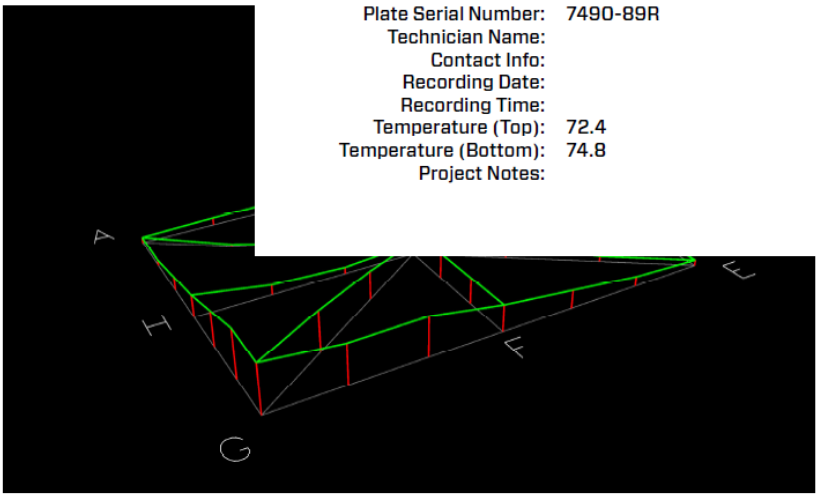


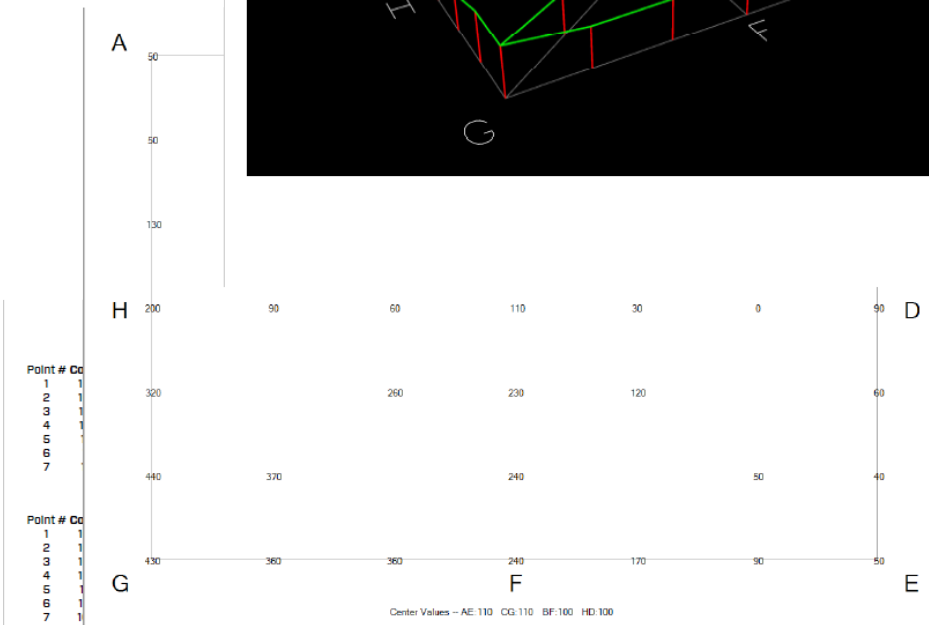
Plane6 Sample Report

HAMAR LASER ALIGN WITH THE BEST

Plane6
Repeat_3 Results

Plate Grade:	B	
Flatness (Max-Min):	440	X
Tolerance:	200	
Units:	µin	
X Dimension:	39.13	
Y Dimension:	27.13	
Line BF Center Value:	-10	✓
Line DH Center Value:	-10	✓
Center Intersection Tolerance:	100	
Plate Serial Number:	7490-89R	
Technician Name:		
Contact Info:		
Recording Date:		
Recording Time:		
Temperature (Top):	72.4	
Temperature (Bottom):	74.8	
Project Notes:		





Point # Co

1	1		
2	1		
3	1		
4	1		
5	1		
6			
7			

Point # Co

1	1		
2	1		
3	1		
4	1		
5	1		
6	1		
7	1		

Point # Co

1	1		
2	1		
3	1		
4	10,790	90	200
5	10,870	210	320
6	10,940	320	440
7	10,910	320	430

4	10,750	-30	90
5	10,870	-50	60
6	10,980	-70	40
7	11,140	-60	50

Line HD

Point #	Collected	Ends to Outer Center	Zero Low Point
1	10,750	90	200
2	10,630	-20	90
3	10,590	-50	60
4	10,630	-10	100
5	10,550	-80	30
6	10,510	-110	0
7	10,590	-30	90

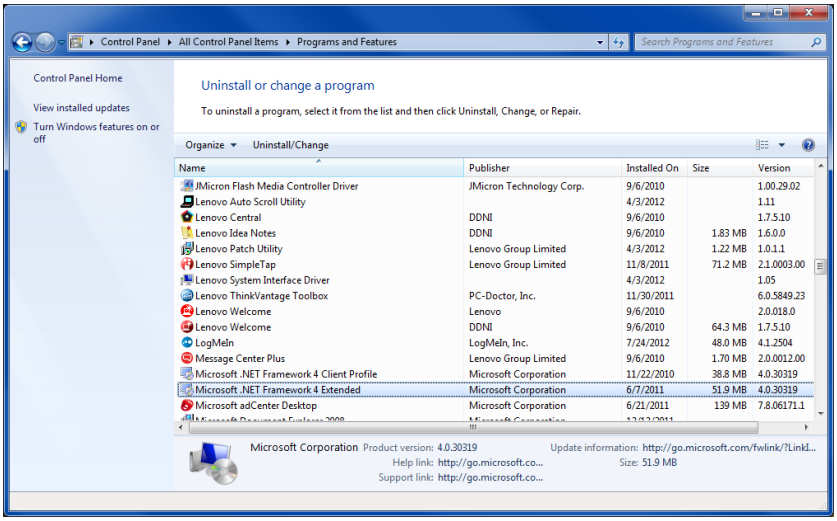
Line BF

Point #	Zero Line Ends	Ends to Outer Center	Zero Low Point
1	10,710	50	160
2	10,630	-60	50
3	10,670	-50	60
4	10,750	-10	100
5	10,910	120	230
6	10,940	120	240
7	10,980	130	240

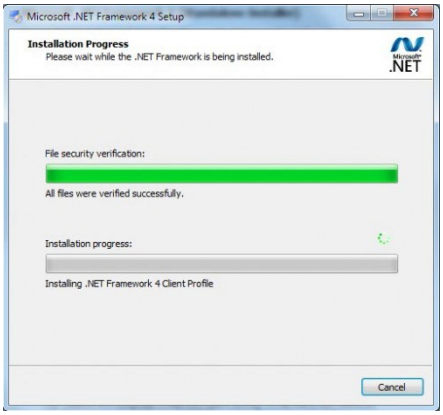
Appendix A – Installing Additional Microsoft Software

Installing Microsoft .NET Framework 4

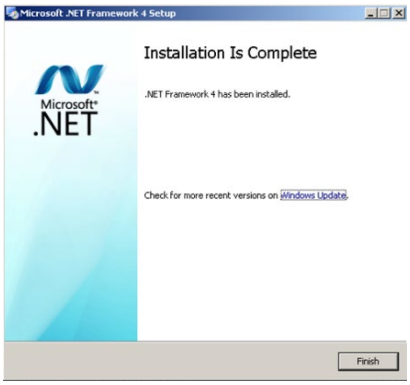
You must have Microsoft .NET Framework installed before installing the Plane6 software. If you are unsure whether you have Microsoft .NET Framework 4 installed on your computer, open the Control Panel. Window 7 users, select **Programs and Features**. Scroll down the list of installed software to locate Microsoft .NET Framework 4. If the program is not installed, follow the instructions below. Windows 10 & Windows 11, Microsoft .Net is preinstalled and user should not need to install. Follow steps below if .Net is missing from computer.



1. To install Microsoft .NET Framework 4, locate the folder **MS_Framework_4_X86_X64** on the Plane6 installation USB drive. Open the folder and double-click **DOTNETFX40_FULL_X86_X64** to begin the installation. Follow the on-screen prompts to complete.



2. When the installation is complete, click **Finish** to close the installation program.



Appendix B – ANSI B89.3.7.2013 Standard Tolerance Table

Plane6 Software uses the tolerances for the standard plate sizes shown in Figure 29 below from the ANSI B89.3.7.2013 Standard for Granite Surface Plates.

For non-standard sizes, we use the formula from the standard:

"Flatness tolerance for surface plates, whose sizes are not listed in Table 1, is obtained from the following formula:

*Overall flatness tolerance (μm) = 1 + 1.6*D²*
Overall flatness tolerance (μin.) = 40 + D²/25

Where,

D = diagonal or diameter of the plate

The calculated flatness tolerance for grade AA is rounded up to the nearest 0.5-μm or 25-μin. increment. The tolerance of grades A and B plates are 2 and 4 times, respectively, those for grade AA."

Table 1 Common Sizes and Flatness Tolerances

Common Sizes				Tolerance											
				Grade AA				Grade A				Grade B			
Rectangular Surface Plates				Local Variation in Flatness (Using Repeat Reading Gage)		Overall Flatness		Local Variation in Flatness (Using Repeat Reading Gage)		Overall Flatness		Local Variation in Flatness (Using Repeat Reading Gage)		Overall Flatness	
U.S. Customary Size, in.		Metric Size, mm		U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm
Width	Length	Width	Length												
12	12	300	300	35	0.9	50	1.3	60	1.5	100	2.5	110	2.8	200	5
12	18	300	450	35	0.9	50	1.3	60	1.5	100	2.5	110	2.8	200	5
18	18	450	450	35	0.9	50	1.3	60	1.5	100	2.5	110	2.8	200	5
18	24	450	600	35	0.9	80	2.0	60	1.5	160	4.0	110	2.8	320	8
24	24	600	600	45	1.2	80	2.0	70	1.8	160	4.0	120	3.0	320	8
24	36	600	900	45	1.2	100	2.5	70	1.8	200	5.0	120	3.0	400	10
24	48	600	1 200	45	1.2	150	4.0	70	1.8	300	8.0	120	3.0	600	16
30	48	750	1 200	45	1.2	180	4.5	70	1.8	360	9.0	120	3.0	720	18
36	36	900	900	45	1.2	150	4.0	70	1.8	300	8.0	120	3.0	600	16
36	48	900	1 200	45	1.2	200	5.0	70	1.8	400	10.0	120	3.0	800	20
36	60	900	1 500	60	1.5	250	6.5	80	2.0	500	13.0	160	4.0	1,000	26
36	72	900	1 800	60	1.5	300	7.5	80	2.0	600	15.0	160	4.0	1,200	30
48	48	1 200	1 200	60	1.5	200	5.0	80	2.0	400	10.0	160	4.0	800	20
48	60	1 200	1 500	60	1.5	300	7.5	80	2.0	600	15.0	160	4.0	1,200	30
48	72	1 200	1 800	60	1.5	350	9.0	80	2.0	700	18.0	160	4.0	1,400	36
48	96	1 200	2 400	75	1.9	500	13.0	100	2.5	1,000	26.0	200	5.0	2,000	52
48	120	1 200	3 000	90	2.3	700	18.0	120	3.0	1,400	36.0	240	6.0	2,800	72
60	120	1 500	3 000	90	2.3	750	19.0	120	3.0	1,500	38.0	240	6.0	3,000	76
72	96	1 800	2 400	90	2.3	600	15.0	120	3.0	1,200	30.0	240	6.0	2,400	60
72	144	1 800	3 600	100	2.5	1,100	28.0	140	3.5	2,200	56.0	280	7.0	4,400	112

Round Surface Plates Diameter		Round Surface Plates Local Variation in Flatness (Using Repeat Reading Gage)		Overall Flatness		Round Surface Plates Local Variation in Flatness (Using Repeat Reading Gage)		Overall Flatness		Round Surface Plates Local Variation in Flatness (Using Repeat Reading Gage)		Overall Flatness	
U.S. Customary Size, in.	Metric Size, mm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm	U.S. Size, μin.	Metric Size, μm
12	300	35	0.9	50	1.3	60	1.5	100	2.5	110	2.8	200	5
18	450	35	0.9	50	1.3	60	1.5	100	2.5	110	2.8	200	5
24	600	35	0.9	80	2.0	60	1.5	160	4.0	110	2.8	320	8
36	900	45	1.2	100	2.5	70	1.8	200	5.0	120	3.0	400	10
48	1 200	45	1.2	120	3.0	70	1.8	240	6.0	120	3.0	500	12

GENERAL NOTES:
(a) Dimensions of length and width for common sizes are nominal dimensions only. The tolerances in this Table apply to sizes within ±5% of the nominal sizes listed. For guidance on recommended tolerances on sizes outside the listed common sizes, see para. 4.3.4.1. For flatness tolerances on surface plates not covered explicitly by this Standard, it is recommended that the manufacturer and buyer agree on the expected tolerance before a contract is concluded.
(b) For granite reference flats smaller than the sizes listed above (commonly known as "toolmakers' flats"), consult the manufacturer for tolerances supplied.

ASME B89.3.7-2013

Figure 26 - ANSI B89.3.7.2013 Flatness Tolerance Table