

VERMONT PHOTONICS

SurfaceView™

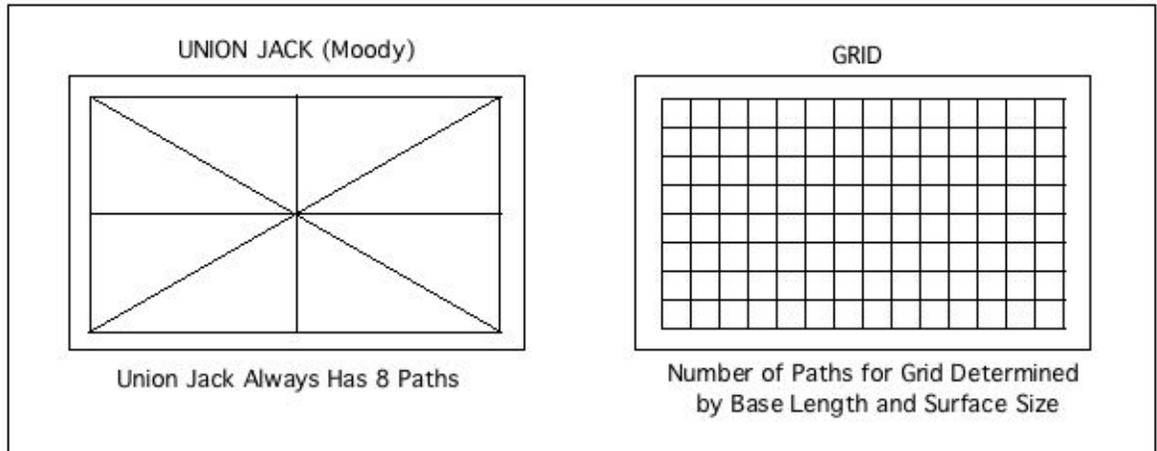
Möller Metrology Division

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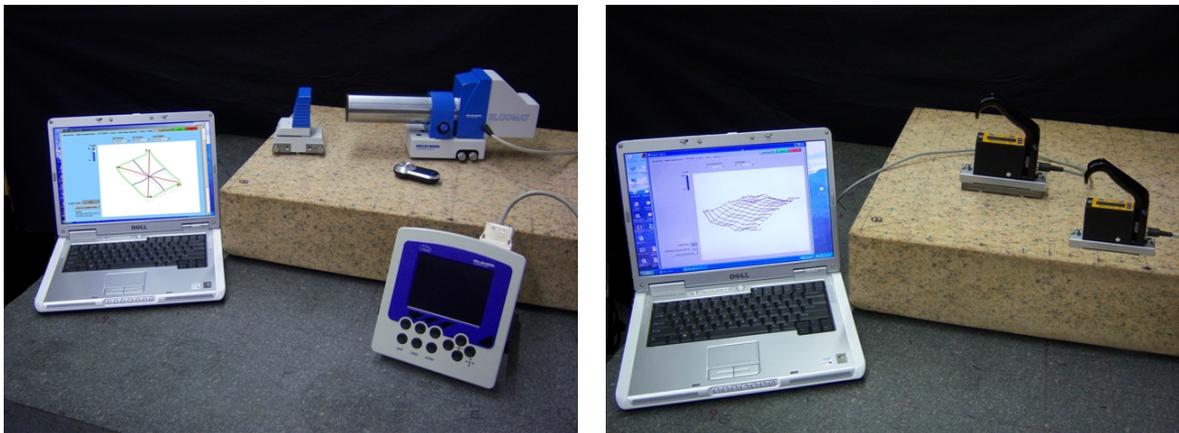
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Overview

SurfaceView is the industry leading, easy to use, and easy to interpret software for the calibration of granite surface plates. Granite surface plates are used in industrial settings as a reference standard flat plane for measuring and assembly purposes. Most often these surface plates are calibrated using the Union Jack Method (also called the Moody Method), but can also be calibrated using the Grid Method. SurfaceView is available for both calibration methods. The software for each method is sold separately, but both are covered in this manual.



Instruments typically used to make the measurements are autocollimators (electronic or visual) and electronic levels.



Within the program, the screen is arranged with page titles across the top so that the user can enter all the organizational information about the job on one page, all the data about the table on another page, and view all the results on individual pages. On a given page the user can employ standard methods to navigate the fields, i.e. using the "tab" key or "carriage return" key on the keyboard will step through the various data entry fields (Note that the "Enter" key on the numerical keypad at the bottom right of the keyboard will NOT work).

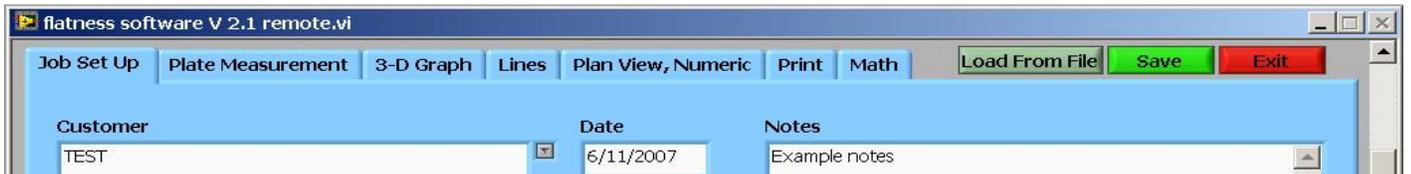
SurfaceView is only available for Windows™ 2000 or later (not tested with Vista). Your monitor resolution must be 1024 x 768 pixels or larger.

Conventions used in this manual.

This Manual is formatted to make it easier to read. When referring to a specific screen item it has the following format:

Tabs such as ***Job Set Up***, ***Plate Measurement***, ***3-D Graph***, ***Lines*** etc. (bold, italic, underline)

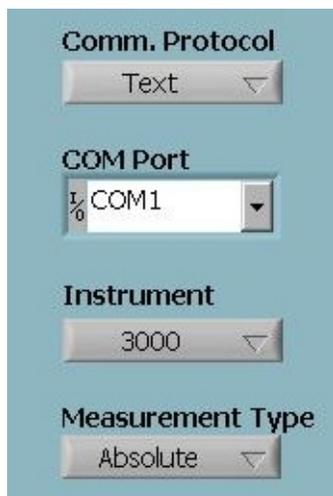
Buttons such as ***Load From File***, ***Save***, ***Exit*** etc. (bold, italic)



Data Entry Fields such as **Customer**, **Date**, **Notes**, etc.

and

Pop-up Lists such as **Comm. Protocol**, etc. (bold)



Numerical Readouts & Graphs (italic)

SurfaceView Union Jack

Getting Started

SurfaceView comes with three example data sets. This is a good place to start finding your way around the software. The user can load the examples and start changing some values to see how the software reacts, use the various Help screens, and try the Administrator functions. The example data can be loaded into the software using **Load From File** in the top-right corner of the screen. The files are located in the SurfaceView Data folder (default location C:\Program Files\SurfaceView\Union Jack\SurfaceView Data). The three data files are called AA-Example.dat, Table-Example.dat, and Moody-Example.dat. *Be careful not to save the examples with the same name after they have been changed.*

If you have data from a previously measured table then entering that data into the software as described below is also a good option. Be sure to use **Save** after you have entered all the data so you can access it again without retyping it (see User Access in ADMINISTRATOR FUNCTIONS below).

- AA-Example.dat (AA-Example.gdat for SurfaceView Grid) is an example of a 24 x 36 inch granite surface plate measured to virtually all the requirements of Federal Specification GGG-P-463c. The table was manufactured as a Grade AA Laboratory surface plate, the maximum flatness tolerance for this grade is 100 μ m. An adjustable base length sled was required to measure this table to the requirements of Federal Specification GGG-P-463c. Note that the base lengths used are specified to very high precision to meet all the requirements of Federal Specification GGG-P-463c. The example for SurfaceView Grid is the same area of the surface, but there are no federal specifications for the grid measurement.
- Table-Example.dat (Table-Example.gdat for SurfaceView Grid) is an example of a portion of a granite table measured using a fixed base length of 100 mm and the Union Jack pattern laid out in 3-4-5 right triangles (see below). This table was not manufactured to be a precision surface plate and the flatness is poor.
- Moody-Example.dat (no corresponding example for SurfaceView Grid) is an example of the data from the Moody article below. Moody defines the his "North" side differently than Federal Specification GGG-P-463c and takes the measurements in a different direction than SurfaceView Union Jack on some of his paths. Also, Moody's paths begin 1 base length in from the edge of the surface plate on all sides. Note that the results on **Plan View** are nearly identical to those of Moody.

SurfaceView Union Jack was designed to follow the procedures and requirements described in the following two documents:

Federal Specification; Plate, Surface, (Granite) GGG-P-463c

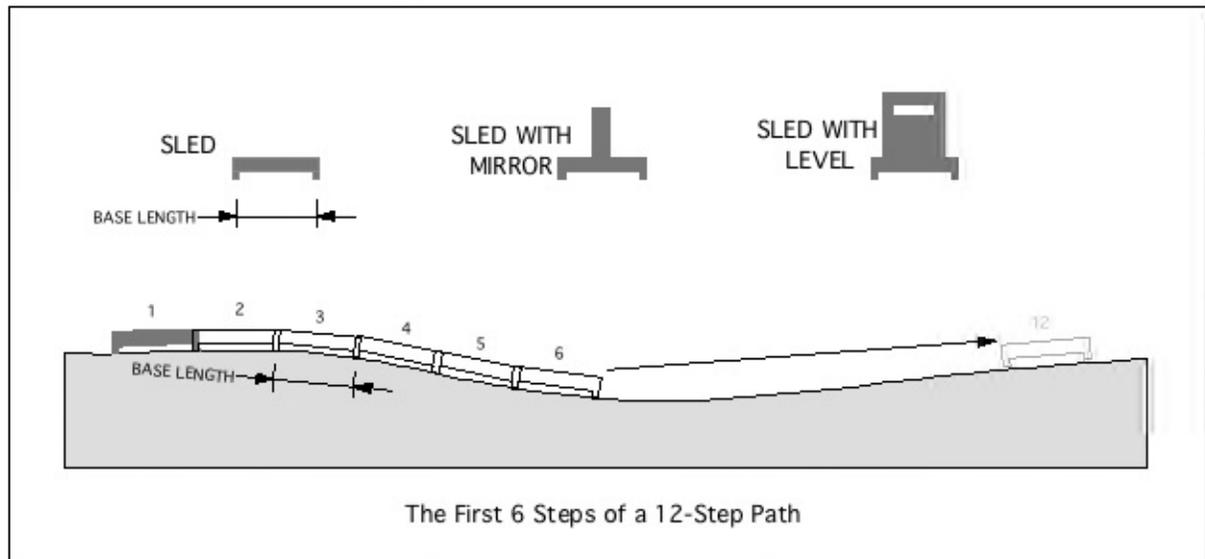
J. C. Moody, How to Calibrate Surface Plates in the Plant. The Tool Engineer. October 1955

Both documents can be obtained from the Vermont Photonics website here:

www.vermontphotonics.com/SurfaceView

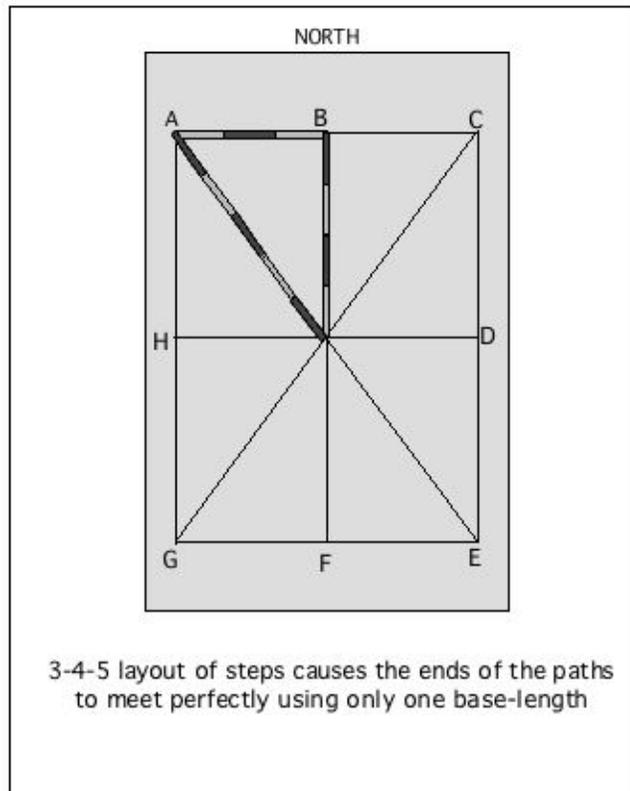
SurfaceView Union Jack makes it easy for the measurement to conform to Federal Specification GGG-P-463c for Granite Surface Plates. The software gives recommendations for how a surface plate should be measured based on that specification. The software assumes that the individual making the

measurement has been properly trained in the method. SurfaceView Union Jack is also flexible enough to allow the user to change any of the fields to any value desired for different types of measurements (e.g. Table-Example.dat).



Often it is necessary to have a sled with an adjustable base length in order to meet the requirements of Federal Specification GGG-P-463c. The software makes suggestions that conform to Federal Specification GGG-P-463c, but these can be over-written by the user if the proper tools are not available, or simply because the user has a historical reason for making the measurement differently. In this case the software will warn the user that Federal Specification GGG-P-463c is not being followed (see ***Plate Measurement***) but will still calculate a result for the surface. If there is a flaw in the measurement system used, or with the technique used by an individual, the software will still calculate a result that will appear correct, but may not conform to *any* established standard of measurement.

In practice, it is often only desirable to check the flatness of a portion of a surface plate rather than calibrate the entire table as required under Federal Specification GGG-P-463c (see ***Plate Measurement***). In that case some technicians choose to lay out the pattern of sled stations as 3-4-5 right triangles. This guarantees that the feet of the sled will meet at the corners perfectly without using a different base length for the diagonal paths.



In order to meet the requirements of Federal Specification GGG-P-463c, the path must be less than a defined distance from the edge of the table on all sides, which is not possible in the layout above. Paths AC and GE are further from the edge than allowed by Federal Specification GGG-P-463c. An adjustable base length sled is likely to be necessary to conform to Federal Specification GGG-P-463c. See [How to Lay Out Measurement Stations](#) in SurfaceView Grid section of this manual for tips on how to lay out the measurement pattern.

Notice that with a layout such as above, or one using an adjustable base length sled, there is an even number of measurements on each path, as required by Federal Specification GGG-P-463c: AC, HD, GE=6 (3+3); AE,CG=10 (5+5); and AG,BF,CE=8 (4+4). Be aware that Federal Specification GGG-P-463c requires an even number of steps in each path, and minimum of 6 steps in each path. See example Table-Example.dat for a measurement layout in 3-4-5 format.

In the event that the user decides to use path lengths and base lengths that do not conform to Federal Specification GGG-P-463c, the software will collect the data and calculate the surface profile, giving a warning on-screen that the layout is not conforming to Federal Specification GGG-P-463c, but this warning WILL NOT appear on any printed reports (see Sample Report at the back of this manual). It is the sole responsibility of the user to determine if the data is in compliance with the requirements of Federal Specification GGG-P-463c.

Description of User Interface

The following sections describe the function of each button, data entry field, selector, etc. on all the screens of the software.

Load From File

Allows the user to load data that has been previously saved. This is handy for comparing a surface plate that has been calibrated in the past to its current condition or to print a report long after the measurement was made. The data must be a SurfaceView data file with a .dat file extension (.gdat for SurfaceView Grid).

Save

Saves the currently displayed data to a SurfaceView data file with a .dat file extension (.gdat for SurfaceView Grid). The default save location is C:\, however the default path is an administrator function that can be changed while in Administrator Mode (see Administrator Functions).

Exit

Exits and closes SurfaceView without saving any information. Be sure to press **Save** before exiting if you would like to save the data.

Job Set Up

Union Jack V 2.7.vi

Job Set Up | Plate Measurement | 3-D Graph | Lines | Plan View, Numeric | Print | Math | Load From File | Save | Exit

Customer: J. Doe | Date: 6/11/2008

Serial #: AA123456 | Admin Login

Job Name: Calibration - Grade AA

Inspector: CFG & AOD

Instrument: Electronic Level

File Name: AA-Example.DAT

Allow Odd Number of Steps?
(If checked, the data may not conform to Federal Spec. GGG-P-463c)

Employ Adjustable Base Length?
(May be required for strict compliance with Federal Spec. GGG-P-463c)

Use 1st Step Verification?

New Job*

*New Job clears all unsaved data on all pages.
To Save, use green button at upper right.

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Admin Login

Notes

This example is a measurement of a Grade AA Granite Surface Plate. It was measured to virtually all the requirements of Federal Specification GGG-P-463c. An adjustable base length sled was required.

The flatness tolerance is calculated to be higher than the maximum acceptable for this size and grade surface plate. However, the accuracy of the calculated surface profile is limited by the 0.2 arcsec resolution of the electronic level used to make the measurements. Higher accuracy is likely required to measure a surface plate of this quality.

ELCOMAT Set Up

Plus/Minus on?
(If checked, the data will not conform to Federal Spec. GGG-P-463c)

Lines will be graphed Like this:

This screen is the starting place for a new measurement. The data file will be saved as the text in **File Name** with ".dat" appended to the end (".gdat" for SurfaceView Grid). **File Name** can be edited by the user.

Fields can be filled in or left blank as necessary for each users needs. All of these fields are saved with the data, but not all will be printed in the report (see Sample Report at the back of this manual, and **Print**).

- **Customer**

Enter the name of the owner of the plate or an internal designation (e.g. Production Dept. or Assembly Dept. or Inventory) or anything else. There is a drop down list of customers that can be populated in Admin Mode for repeated measurements for the same customer.

- **Serial #**

The manufacturer's identification number for the surface plate being measured. This should be on a sticker affixed to the short side of the surface plate closest to the single support. Some manufacturers may not have the location of the sticker configured this way.

- **Job Name**

This could be an internal designation (e.g. a numerical code) or a description of the surface plate manufacturing process (e.g. Final Smoothing, Resurfacing, etc.) or anything else.

- **Inspector**

The name, initials, or employee ID number of the person actually taking the measurements of the surface plate. There is a drop down list of inspectors that can be populated in Admin Mode. This will appear on the printed report as "Inspector:" when **Traceability Reference** is selected on **Print**.

- **Instrument**

A unique identifier for the instrument (e.g. ELCOMAT 3000) used to make the measurements. The drop down list of instruments can be populated in Admin Mode. In the event that you have multiple identical instruments, then a serial number from the instrument might be used. Note that this value will be used when **Traceability Reference** is selected for the printed report (see **Print**).

- **File Name**

The software takes **Serial #** and appends **Date** with .dat on the end as the default file name. For example: "XXX_YYMMDD.dat", where XXX was entered in **Serial #**. The user can edit **File Name** as desired with the keyboard.

- **Allow Odd Number of Steps?**

If checked the software can recommend an odd number of steps to be taken on all paths, but this violates Federal Specification GGG-P-463c. If not checked, the software will calculate an even number of steps for each path as is required by Federal Specification GGG-P-463c.

- **Employ Adjustable Base Length**

Check this field if you have a sled on which the center-to-center spacing of the feet can be accurately changed AND you intend to change it to conform to Federal Specification GGG-P-463c. If you do not employ an adjustable base length sled, it will be difficult to comply with Federal Specification GGG-P-463c in most cases. Example data AA-Example.dat shows a table measured using an adjustable base length sled, example data Table-Example.dat shows a portion of a table measured where the only available base length was 100mm.

- **Use 1st Step Verification**

If checked a window will pop up on completion of each path asking the operator to move the sled to the first step and record the first step in the path again. The software then compares the original reading with this second reading and tells the operator if the difference is within the acceptable limit. The limit is set by the user when the window appears when this box is first selected. A large difference between the first measurement and the verification measurement may indicate that there is a problem with the data collected caused by dirt on the sled, movement of the surface under test, or a problem with the measuring instrument.

- **New Job**

Clears everything from all screens of the program, unsaved data will be lost.

- **Date**

Today's date in MM/DD/YYYY format. This can be edited by the user. Note that the default for **File Name** includes the date in YYMMDD format.

- **Notes**

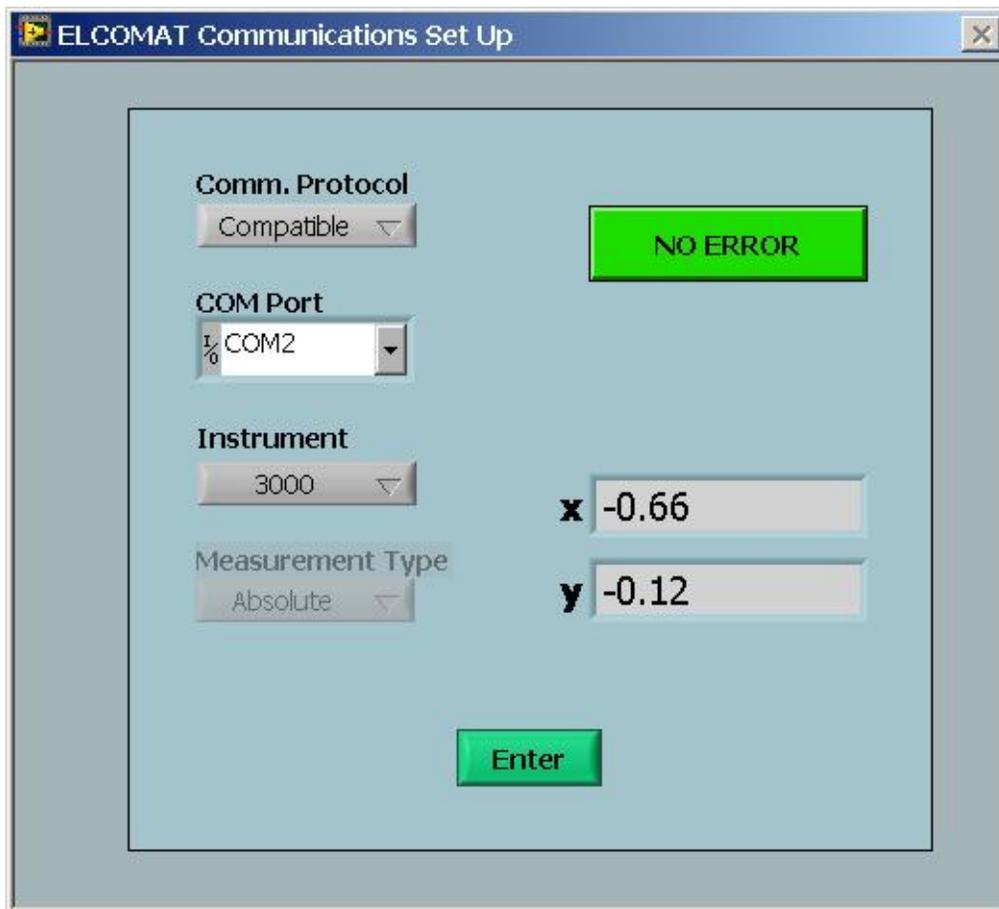
The user can type notes here regarding measurement conditions, special instructions, etc. They will be saved and will appear every time the job is loaded using **Load From File**. **Notes** do not appear on the printed report (see Sample Report at the back of this manual).

- **Plus/Minus On?**

SurfaceView Union Jack reports all heights referenced from the lowest point on the surface, i.e. the lowest point will be reported with a height of "0" and the highest point will be reported with a height of "88.4", for example. If this option is selected SurfaceView Union Jack will report the heights referenced to the midpoint of the range of heights, i.e. using the prior values the lowest point will be reported as "-44.2" and the highest as "44.2" (± 44.2).

Automatic data collection can also be configured on **Job Set Up** (see also ***Automated Data Collection on Plate Measurement***).

ELCOMAT Set Up (Ignore this if you use an electronic level or a visual autocollimator)



- **Comm. Protocol**

- Dummy

A random number generator that mimics an actual ELCOMAT taking readings. This allows the user to test the computer data collection without connecting an ELCOMAT (see ***Automated Data Collection on Plate Measurement***).

- Text

Text communication protocol for a Möller-Wedel Electronic Autocollimator. This is only available on ELCOMAT 2000 and 3000 with serial # greater than 500. It is recommended that Text is selected for the Communications Protocol. On the ELCOMAT display unit press "menu", under RS232 select "text".

- Compatible

Compatible communication protocol for a Möller-Wedel Electronic Autocollimator. This is the only option for ELCOMAT 2000 with serial number less than 500. The display unit must be configured to send the data to the computer instead of the display screen (see ELCOMAT manual).

- Direct

Still under development.

- **COM Port**

Select the COM port on the computer that your instrument is connected to.

- **Instrument** (All instruments are Möller-Wedel Electronic Autocollimators)
 - ELCOMAT Vario
 - ELCOMAT 2000
 - ELCOMAT 3000
- **Measurement Type**

It is recommended that this be set to "Absolute", but it can be set to "Relative" if there is a reason to zero the instrument (see ELCOMAT manual).

- Absolute
 - Relative
- *No Error / Error*

Green indicates that the communication with the ELCOMAT is working properly, turns red when there is a communication problem with the ELCOMAT.

- *Measurement status*

Visible when "Text" is selected in **Comm. Protocol**, it indicates when the X or Y measurements are out of range (see ELCOMAT manual for full list of potential messages).

- X

The current reading of the X axis from the ELCOMAT.

- Y

The current reading of the Y axis from the ELCOMAT.

Administrator Functions

Administrator functions are a series of program attributes that can be set by an administrator. These include the customers and inspectors that appear in the pull down lists, the calibration instruments available, as well as the default Load/Save file path. These settings are saved when the administrator logs out and are applied to the software immediately. All of the administrator settings are saved in the adminsrup.dat file. This allows the administrator to set up this file once (populate lists, set file paths, etc.) and transfer all of those settings to any new install of the software. If adminsrup.dat is deleted or moved from the folder the *Admin Login* button will not appear and all administrator settings will be reset to the default.

The screenshot shows the 'Job Set Up' window of the Union Jack V 2.7.vi software. The window has a menu bar with 'Job Set Up', 'Plate Measurement', '3-D Graph', 'Lines', 'Plan View, Numeric', 'Print', and 'Math'. On the right side of the menu bar are buttons for 'Load From File', 'Save', and 'Exit'. The main area is divided into several sections:

- Customer:** A text field containing 'J. Doe' and a dropdown arrow.
- Date:** A text field containing '6/11/2008' and a 'Log Out' button.
- Serial #:** A text field containing 'AA123456', a 'Populate List From File' button, and a 'Remove' button.
- Job Name:** A text field containing 'Calibration - Grade AA'.
- Inspector:** A text field containing 'CFG & AOD' and a dropdown arrow.
- Instrument:** A text field containing 'Electronic Level', a 'Populate List From File' button, and a 'Remove' button.
- File Name:** A text field containing 'AA-Example.DAT' and an 'Instrument Set Up' button.
- Checkboxes:**
 - Allow Odd Number of Steps? (If checked, the data may not conform to Federal Spec. GGG-P-463c)
 - Employ Adjustable Base Length? (May be required for strict compliance with Federal Spec. GGG-P-463c)
 - Use 1st Step Verification?
- Buttons:** A yellow 'New Job*' button.
- Notes:** A text area with the following text:

This example is a measurement of a Grade AA Granite Surface Plate. It was measured to virtually all the requirements of Federal Specification GGG-P-463c. An adjustable base length sled was required.

The flatness tolerance is calculated to be higher than the maximum acceptable for this size and grade surface plate. However, the accuracy of the calculated surface profile is limited by the 0.2 arcsec resolution of the electronic level used to make the measurements. Higher accuracy is likely required to measure a surface plate of this quality.
- ELCOMAT Set Up:** A section with a 'Load/Save Default File Path' field containing 'C:\Program Files\SurfaceView\Union Jack\SurfaceView Data'.
- Plus/Minus on?:** A checkbox and text: 'If checked, the data will not conform to Federal Spec. GGG-P-463c)'. Below it, a graph shows a red line fluctuating between +10 and -5.

*New Job clears all unsaved data on all pages. To Save, use green button at upper right.

To access administrator functions click **Admin Login** under **Date** near the top-center of **Job Set Up** screen. A login window will appear.

- **Enter Password**

The default password is "admin" (no caps and no quotes). The password entry field is case sensitive.

- **Login**

When you have typed the correct password in **Enter Password** click **Login**. If the password was correct the login window will disappear and you will be in Admin mode until you click **Log Out**. If the password was incorrect you will get a message saying the password was incorrect and you will be returned to the login screen.

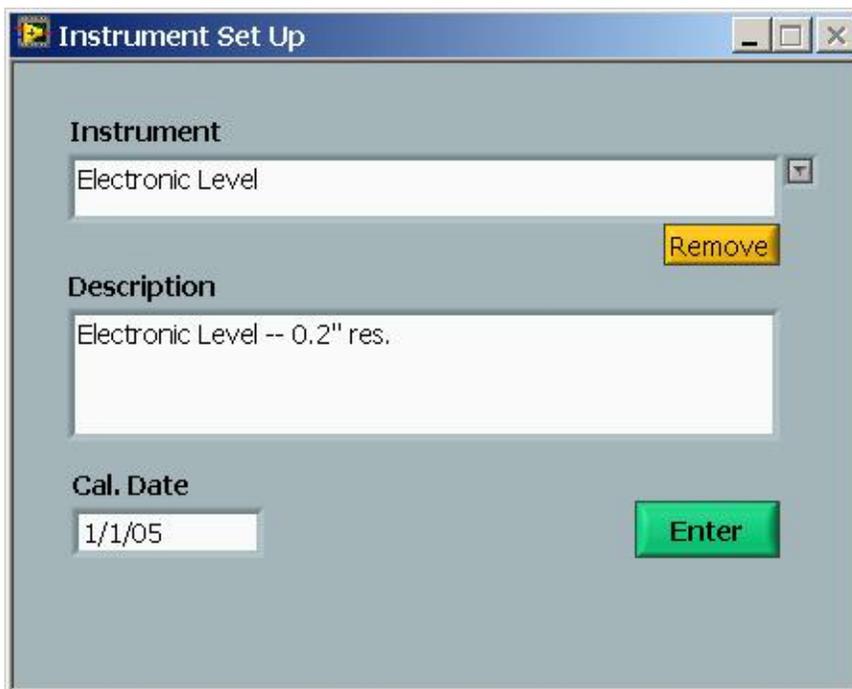
- **Cancel**

Click **Cancel** to exit the Admin Login window without logging in and return to normal **Job Set Up** screen.

Admin Mode allows the Administrator to enter data into the software that will be used many times by the end users. Note that after logging in as an administrator the **Job Set Up** screen has additional buttons. In **Customer** you may type in the names of your customers that you do work for often. These names will appear as a pull down list in the window when the Administrator logs out and the software is used normally. To remove a name from the list, select it from the pull-down list so that it is displayed in **Customer** and then click **Remove** under **Customer**. If there exists a list of customers as a file on your computer, you may choose **Populate List From File**, this allows the Administrator to browse for the correct file. This file must be a Tab delimited text file (*.txt) in which the first column contains the list of names to appear as the pull down list for **Customer**. The list will reflect the order in the file used to populate the list. SurfaceView comes with a sample file of customers and inspectors. They are located in the SurfaceView Data folder (C:\Program Files\SurfaceView\Union Jack\SurfaceView Data) and are called Example_Customers.txt and Example_Inspectors.txt.

The method above is also used for the pull down list next to **Inspector**.

- **Instrument Set Up**



- **Instrument**

Enter instruments to add to the drop down list. As with the other pull down lists any new entry added while logged in as Administrator will be added to the list that is available in normal software use. This will appear on the printed report as "Instrument #:" when **Traceability Reference** is selected on **Print**.

- **Remove**

Will remove the instrument that is currently selected from the list. The instrument will no longer be available on the main ***Job Set Up*** screen during normal use of SurfaceView.

- **Description**
Description of instrument. This is only visible when logged in as Administrator and does not appear on the printed report.
- **Cal. Date**
Date the instrument was calibrated. This is a text field so the date can be in any format. This will appear on the printed report as "Calibrated On:" when **Traceability Reference** is selected on ***Print***.
- **Enter**
Return to ***Job Set Up*** in Admin Mode and save any changes to the instrument, description, or calibration data.

Populate List From File

Customer and **Inspector** have a populate-list-from-file option which allows an administrator to add large lists of customers or inspectors from any Tab delimited text file in which the first column contains the list of customers or inspectors.

- **Add**

List of names from the file will be added to the existing names in the pull-down list. If the current list contains names identical to any in the file they will not be repeated.

- **Replace**
Existing list of names will be deleted and replaced with the list of names in the file you choose.
- **Cancel**
Returns you to Admin Mode on **Job Set Up**; no changes will be made to the list.
- **Remove**
Clicking **Remove** next to any pull-down list will remove the name that is currently selected from the list.

Change Password

Clicking **Change Password** brings up a screen that allows you to change the password needed to access the Administrator functions.



- **Current Password**
Type the current password (this field is case sensitive).
- **New Password**
Type your new password here (passwords are case sensitive and can be any length from 1(not zero) to 72 characters)
- **Re-type New Password**
Password typed here must match password in **New Password**.
- **Change Password**
Click after entering the passwords in **Current Password**, **New Password**, and **Re-Type New Password**. A pop up message will appear that says: "Your Password has been successfully changed." After clicking OK you will be returned to **Job Set Up**.

- **Cancel**

Exits the Change Password screen and returns you to **Job Set Up** screen without changing the password.

- Warnings

- * Incorrect Password!

Appears if the password typed into **Current Password** is incorrect.

- * New Password is blank.

Appears if nothing is entered in the **New Password** (passwords must be at least 1 character long).

- * New Passwords do not match.

Appears if password entered into **New Password** and **Re-Type New Password** do not match.

In addition to the written warnings a red * is also placed next to the field that is causing the error.

Load/Save Default File Path

The default path that SurfaceView will go to when either **Load From File** or **Save** is clicked. If this path becomes unavailable SurfaceView will default to the C:\ directory.

Log Out

Click to exit Admin mode. Exiting Admin mode automatically saves any changes you made.

User Access

Users must have read/write access to the "SurfaceView Data" folder (C:\Program Files\SurfaceView\Union Jack\SurfaceView Data) and they must have read access to the entire "SurfaceView" folder (C:\Program Files\SurfaceView). The SurfaceView software reads and writes to the "SurfaceView Data" folder. If the Windows™ user account does not have read/write access some functionality of the software will be disabled. For example printing of individual lines from the software will return an error if the user does not have write access to the "SurfaceView Data" folder. The **Customer**, **Inspector** and **Instrument** lists will not show up if the user does not have read access to the entire "SurfaceView" folder.

Plate Measurement

#	AE	GC	GE	HD	AC	AG	BF	CE	#
1	82.800	-75.600	136.400	142.200	104.600	64.800	66.800	30.800	1
2	81.400	-67.200	140.200	140.200	104.200	65.800	67.000	31.600	2
3	82.200	-68.200	141.600	142.600	104.000	67.600	66.200	33.600	3
4	80.800	-68.800	141.200	142.200	104.600	68.200	65.800	33.200	4
5	81.600	-68.800	140.400	143.400	104.000	67.200	69.600	34.200	5
6	80.800	-67.400	140.800	142.600	104.400	68.600	67.800	33.000	6
7	80.800	-69.000	140.400	141.200	104.000	67.800	69.200	33.800	7

At the top-left of this screen, the user enters all the dimensions of the table and the sled used to measure the table. Once that has been entered SurfaceView Union Jack will make recommendations for the remaining parameters. If possible it will make recommendations according to Federal Specification GGG-P-463c. The user is warned when the entries do not conform to Federal Specification GGG-P-463c. At the bottom part of the screen the user also enters all of the measured angles from all of the paths.

Note that it is very difficult to measure exactly to the edge of a plate, so a plate of 36 inch width is not likely to have a path width of 36 inches; the path width will be less than 36 inches because the sled will have to be kept some distance from the edge (**Min. Edge Dist.**). See more detail below. Often a technician will only want to measure a portion of a surface plate and it is possible to "trick" SurfaceView Union Jack into giving you the dimensions you want. The example Table-Example.dat that can be loaded with **Load From File** is a 600mm x 800mm portion of a table measured with a 100mm base length. It shows that the measured path is also 600mm x 800mm. In this case, 0 was entered into **Min. Edge Dist.** and the calculations all *appear* to be compliant with Federal Specification GGG-P-463c, but they are not because the physical size of the plate is actually much larger than the 600x800mm entered.

- **Plate Width**

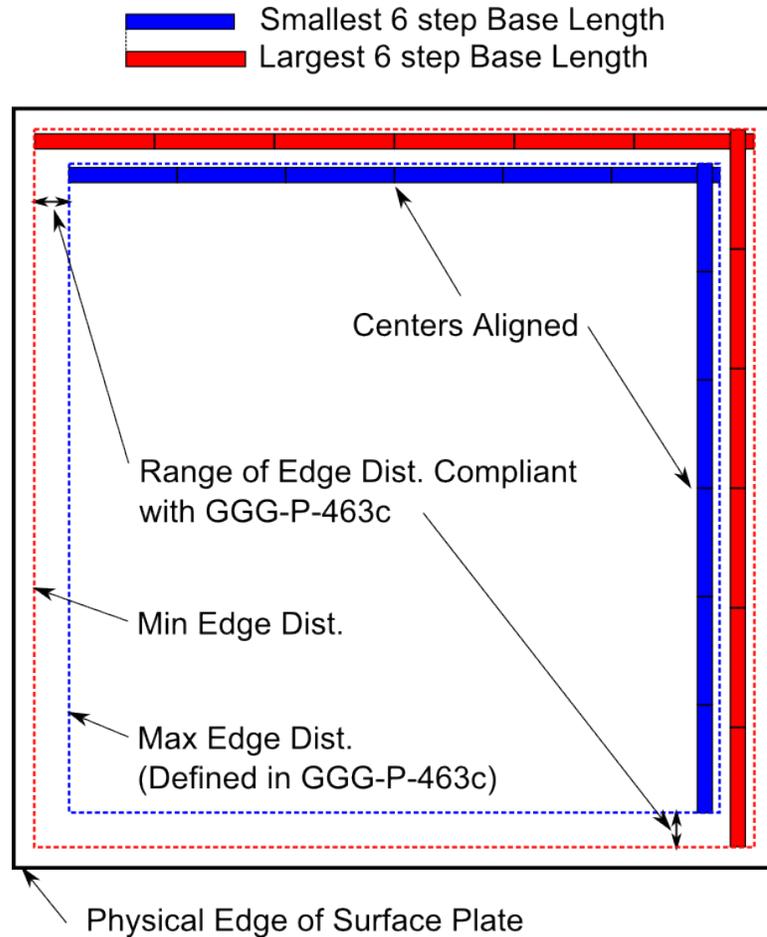
Enter the physical width of the surface plate (the shorter dimension).

- **Plate Length**

Enter the physical length of the surface plate (the longer dimension).

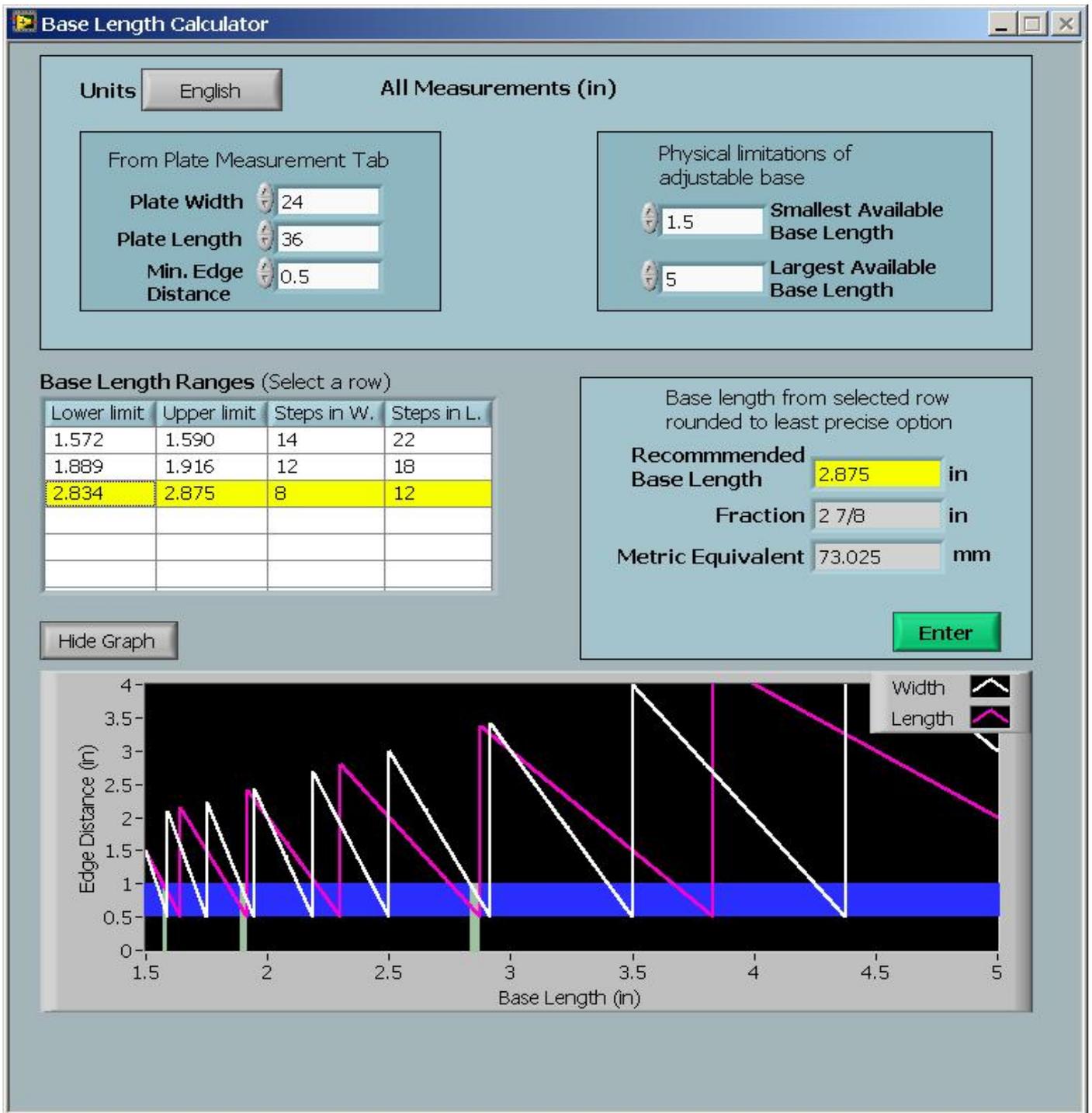
Base Length

Enter the distance between the centers of the feet of the sled under the mirror or level that you will use. SurfaceView Union Jack provides a pop up help screen to help the user determine a base length that will conform to Federal Specification GGG-P-463c edge distance requirements.



- **Help**

Pop-Up window appears to assist the user in selecting a base length to use on the length and width paths that will comply with Federal Specification GGG-P-463c, specifically the maximum edge distance specified in Table IV of Federal Specification GGG-P-463c (see **Min. Edge Dist.** below) and the minimum of 6 measurements on a path. Federal Specification GGG-P-463c does allow for increased edge distance due to limitations of the available equipment by specifying the use of a repeat reading gage to inspect the area missed by the Union Jack layout. SurfaceView Union Jack will recommend a base length that conforms to Federal Specification GGG-P-463c without the use of a repeat reading gage (see Federal Spec Warning/Pass below). This Help window is only available when **Employ Adjustable Base Length?** is selected on **Job Set Up**.



- **Plate Width**

Initially this will be set to the value that was entered on **Plate Measurement**. The user can edit the value, but it will not change the value on **Plate Measurement** when **ENTER** is pressed.

- **Plate Length**

Initially this will be set to the value that was entered on **Plate Measurement**. The user can edit the value, but it will not change the value on **Plate Measurement** when **ENTER** is pressed.

- **Min. Edge Dist.**

Initially this will be set to the value that was entered on ***Plate Measurement***. The user can edit the value, but it will not change the value on ***Plate Measurement*** when **ENTER** is pressed. Federal Specification GGG-P-463c defines a *maximum* edge distance of 1 inch for tables with diagonal length less than 48 inches and 1.5 inches for table with diagonal greater than 48 inches. SurfaceView Union Jack uses the plate size, the measured area, and **Min. Edge Dist.** to evaluate whether the measurement will conform to Federal Specification GGG-P-463c.

- **Smallest Available Base Length**

The smallest distance between the feet of the sled that can be set.

- **Largest Available Base Length**

The largest distance between the feet of the sled that can be set.

- *Base Length Ranges*

This is a list of the ranges of base lengths that will allow the measurement to comply with Federal Specification GGG-P-463c. These ranges correspond to the green highlighted areas on the graph.

- *Recommended Base Length*

- The recommended base length for the width and length paths from the range selected in *Base Length Ranges*. When English units are selected the value is recommended as the nearest major fraction (1, 1/2, 1/4, 1/8, 1/16, or 1/1000) of an inch. For example, for a 48x72 inch table with a 0.5 inch minimum edge distance and 3 to 5 inch available base length; SurfaceView would recommend two different base length ranges, they are:

3.215 to 3.227
3.834 to 3.916.

In this case SurfaceView recommends 3.226 inches (3 226/1000 inches) and 3.875 inches (3 7/8 inches), respectively. Note that in the first range there is not a larger fraction of an inch to round to than 1/1000 inch. When Metric units are selected SurfaceView recommends the largest fraction of a millimeter (1 mm, then 0.1 mm, then 0.01 mm, then 0.001 mm = 1 μ m) that falls in the range.

- *Fraction*

SurfaceView will display the value in *Recommended Base Length* in fractional form when the units are selected as English (e.g. 3.875 = 3 7/8).

- *Metric/English Equivalent*

SurfaceView will convert the value in *Recommended Base Length* to millimeters if English units are selected and to inches if Metric units are selected.

- **ENTER**

Places the value selected in **Recommended Base Length** into **Base Length** on **Plate Measurement** and closes the window.

- **Hide Graph**

This button allows the user to display or hide the graphical representation of the edge distance as a function of the base length used for the length and width. The graph shows sawtooth shaped lines (one for length and one for width paths) that are the distance from the last sled position to the edge of the table if the base length on the horizontal axis is used. The graph highlights in blue the region that is below the maximum edge distance and above **Min. Edge Dist.** The recommended ranges in *Base length Ranges* are where *both* sawtooth shaped lines are in the blue area. These will be highlighted in green on the graph.

- **Min. Edge Dist.**

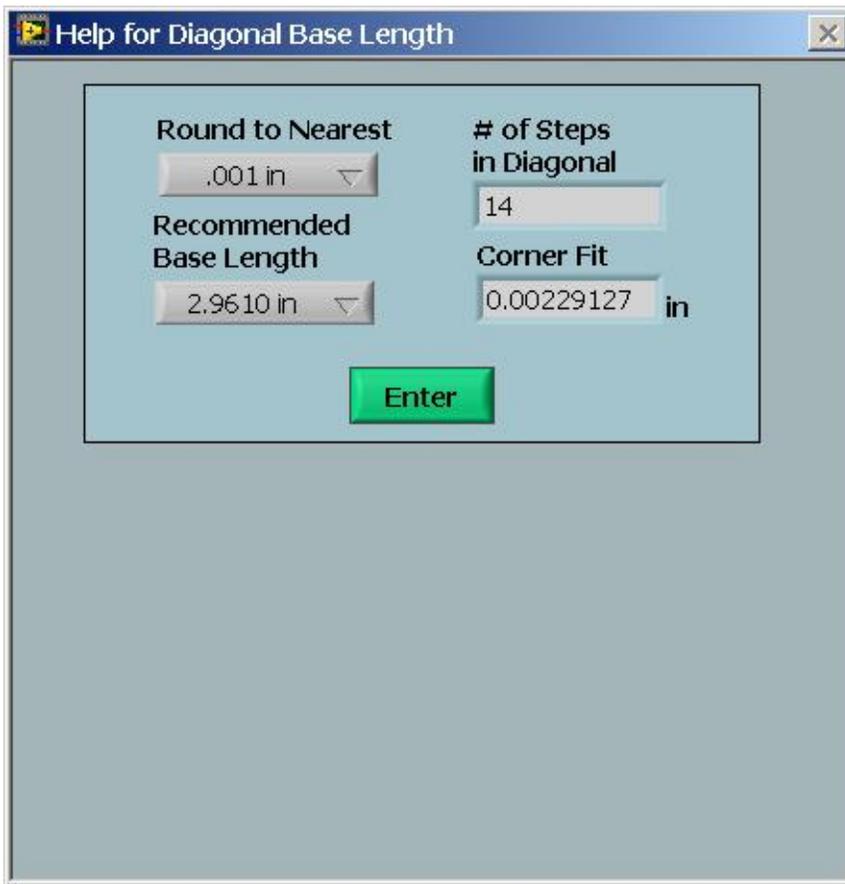
Enter the minimum distance between the physical edge of the surface plate and the edge of the perimeter paths AC, CE, EG, GA to be measured by the sled. Typically this is limited by the bevel, or roll-off, at the edge of the surface, the size of the feet on the sled, and other physical constraints (i.e. the feet must stay on the table). SurfaceView Union Jack uses this to determine the number of steps in the length and width paths.

Diagonal Base Length

The base length for the sled used on the diagonal paths will likely need to be different than for the other paths. Often this is necessary to have all paths meet properly at the corners. SurfaceView Union Jack provides a pop-up screen to help the user determine a base length that will conform to Federal Specification GGG-P-463c so that the paths meet within 0.3 inches at the corner (corner fit) as is required by GGG-P-463c. If the diagonal paths do not meet at the corners SurfaceView Union Jack will display the graph that way. The height of the two perimeter paths and the diagonal paths are set equal there so this is not as accurate as conforming to Federal Specification GGG-P-463c.

- **Help**

- Pop-Up window appears to assist the user in selecting a base length to use on the diagonal paths that will comply with Federal Specification GGG-P-463c.



- **Round to Nearest**

Enter the precision the software will use to round the base length of the adjustable sled to make adjusting the base length practical.

- **Recommended Base Length**

SurfaceView Union Jack will recommend two base lengths for the diagonal measurements; one that is greater, and one that is smaller, than the base length originally entered by the user in **Base Length** on ***Plate Measurement***. Using one of these two base lengths will insure that the diagonal paths will end at the corner defined by the length and width lines (see *Corner Fit* below) within the 0.3 inches called for in Federal Specification GGG-P-463c.

- *# of Steps in Diagonal*

The correct number of steps on the diagonal paths for the selected base length.

- *Corner Fit*

In order to comply with Federal Specification GGG-P-463c this number must be 0.3 inches or less (see *Corner Fit* below).

- **ENTER**

Places the value selected in **Recommended Base Length** into **Diagonal Base Length** on ***Plate Measurement*** and closes the window.

- **Recalculate**

Press this button after changing **Diagonal Base Length** above to recalculate the correct

number of steps, corner fit, etc. It can be pressed any time the user has changed any of the recommended values (**# of Steps**, etc.) to have SurfaceView Union Jack revert back to the recommended.

- **Federal Spec Warning/Pass**

SurfaceView Union Jack provides the user with a warning if one of the values for the size of the plate, the size of the measured path, number of steps in a path, or the path convergence (*Corner Fit*) are not in compliance with Federal Specification GGG-P-463c. In that case, the warning box will have a red background and the field (*# Steps in Width*, etc.) causing the problem will have an orange background. It may require changing more than just the orange field to remove all the warnings or **Base Length** may be entered incorrectly. When all the values are in compliance with Federal Specification GGG-P-463c the text box will have a green background. It is up to the user to determine if the tools and techniques used to take the measurements are in compliance also.

- *# Steps in Width*

The recommended number of steps in the width given the physical size of the surface plate (**Plate Width**), the **Base Length**, and the **Min. Edge Dist.** Although this will be filled in automatically with a recommendation it can be changed by the user. In that case *Path Width* will be updated to reflect the change.

- *# Steps in Length*

The recommended number of steps in the length given the physical size of the surface plate (**Plate Length**), the **Base Length**, and the **Min. Edge Dist.** Although this will be filled in automatically with a recommendation it can be changed by the user. In that case *Path Length* will be updated to reflect the change.

- *Path Width*

The width that will actually be measured given the **Base Length** of the sled and *# Steps in Width*. This value will be smaller than (or equal to, see example Table-Example.dat) **Plate Width** above.

- *Path Length*

The length that will actually be measured given the **Base Length** of the sled and *# Steps in Length*. This value will be smaller than (or equal to, see example Table-Example.dat) **Plate Length** above.

- *Corner Fit*

This number is the distance between the endpoint of the diagonal and the corner (defined as the intersection of the width line and the length line). It assumes that one foot of the sled will start in the exact center of the surface plate (defined as the intersection of AE, GC, BF, & HD). Federal Specification GGG-P-463c allows a maximum for this value of 0.3 in. This value is positive if the diagonal endpoint falls outside the perimeter, negative if it falls inside the perimeter.

- **# Steps in Diagonal**

The correct number of steps on each diagonal. It is assumed that one foot of the sled will land in the center of the surface plate. This value can be changed by the user.

- **Units**

- English: Large dimensions (i.e. **Plate Width**, **Base Length**, etc.) are in inches, surface heights are in μin (1 in = 1000000 μin).
- Metric: Large dimensions are in millimeters, surface heights are in μm (1 mm = 1000 μm).

- Reference Edge (North)
 - SurfaceView Union Jack defines the Reference Edge (often referred to as the North side, see Moody) according to Federal Specification GGG-P-463c and assumes that line AC lies closest to the Reference Edge. Federal Specification GGG-P-463c defines this edge as all of:
 1. the side with the replaceable sticker (not the manufacturer's nameplate) containing the surface plate grade and other calibration information
 2. the edge closest to the single support at one end of the surface plate
 3. one of the shorter sides.
 - Note that Moody shows the "North" side as one of the longer sides. Also note that some manufacturers may not have the surface plate supports and sticker configured in exactly this pattern. SurfaceView Union Jack allows the Reference Edge & line AC to be one of the longer sides as well.
 - This graphic begins with all the paths as solid black lines. As each data column is filled in the graphic will change each completed path to a blue dashed line.

- **Clear Data From All Columns Below**

This button clears all the data entered into each path segment. It will not clear any of the entered table dimensions or anything on ***Job Set Up***.

- **AE, GC, GE, HD, AC, AG, BF, CE**

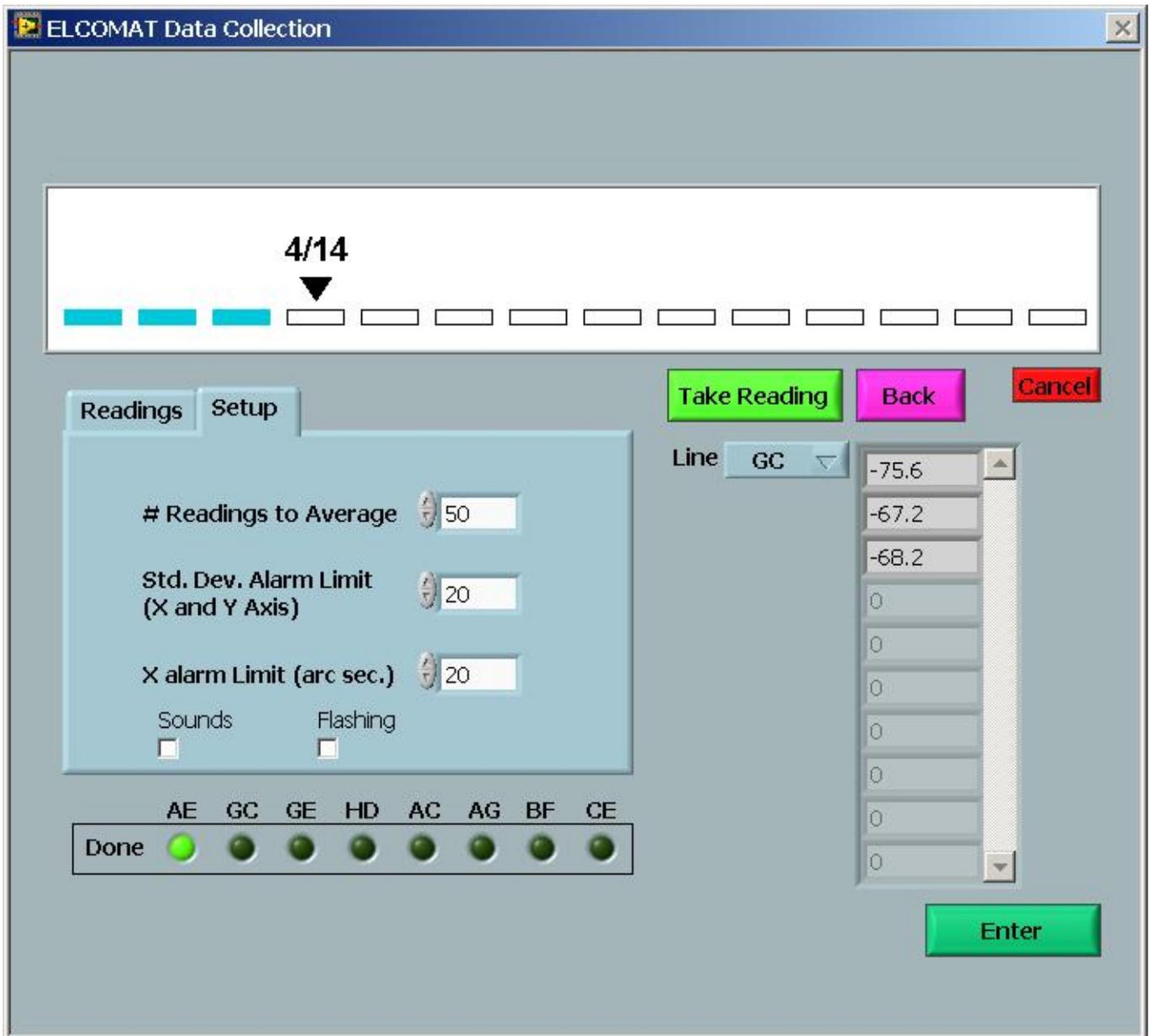
Measured slope values at each station along path in arcseconds. These should be taken in the order of the letters, i.e. profile AE is taken from point A to point E. Furthermore, the sign convention used is such that a station that slopes down toward the direction of the final point on the profile (also the direction of travel of the sled) should be entered as a negative number. The user can "zero" the first measurement of each path or not, SurfaceView Union Jack is compatible with both data acquisition methods.

- #

The station number along each path. Moody refers to each measurement position of the sled as a station.

Automated Data Collection

This window appears when the user clicks **Automated Data Collection** to use a Möller-Wedel ELCOMAT to take measurements automatically. The communication between the ELCOMAT and the computer is configured with **ELCOMAT Set Up** on **Job Set Up**. This screen is designed to help the user be able to take measurements through the use of a remote without walking back to the computer to enter every measurement (see the Remote section below). It provides a graphic indicator telling the user the position along a path where the sled should be positioned for the next measurement. A test/demo of this features capabilities can be performed by setting the **Comm. Protocol** to "Dummy" on the ELCOMAT Communications Set Up window accessed by clicking **ELCOMAT Set Up** on **Job Set Up**.



- **Setup**

- **# Readings to Average**

The user can set the number of readings from the ELCOMAT to average for each measurement. This is useful for smoothing out some unavoidable noise in the data points of the ELCOMAT. The ELCOMAT is calibrated by averaging 100 readings for each data point.

- **Std. Dev. Alarm Limit**

The user can set a limit to the value of the standard deviation (see *Std. Dev.* below) for the X and Y points averaged from the ELCOMAT. This feature allows the user to know if the measurement was made during a particularly unstable moment. The user will most likely have to experiment with this setting to set it at a useful value. If the standard deviation for X or Y is larger than **Std. Dev Alarm Limit** then SurfaceView Union Jack will notify the user (see **Sounds** and **Flashing** below) and a message will appear that must be closed before taking

the next measurement. If this error occurs SurfaceView Union Jack will ignore the measurement and remain on the same station on the path.

- **X Alarm Limit**

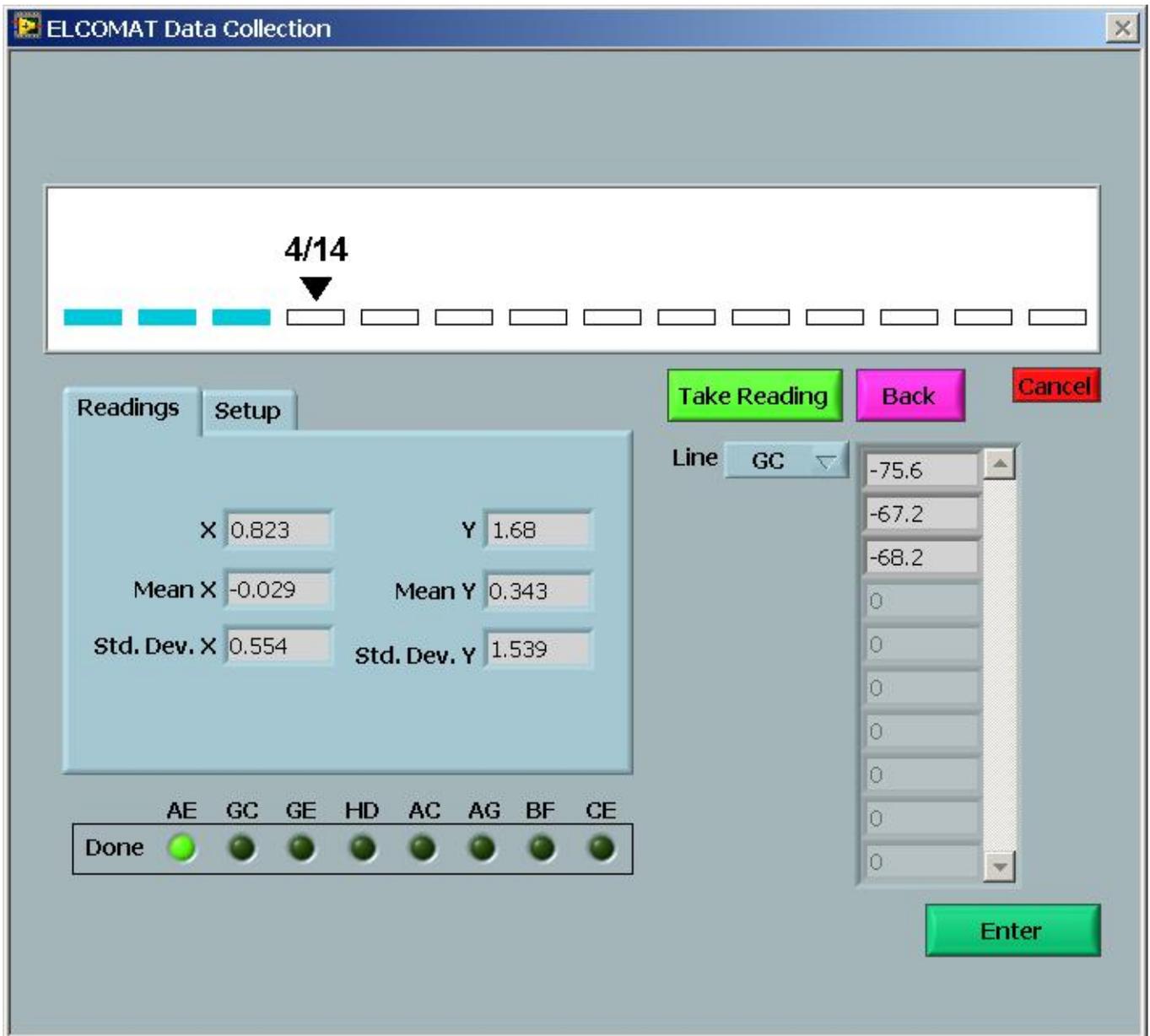
Allows the user to set a limit for the allowable "twist" of the mirror along the path. The autocollimator should be aligned so that the X measurement is near zero and the user can use **X Alarm Limit** to set a limit for all the subsequent measurements along the path. If the X measurement is larger than **X Alarm Limit** then SurfaceView Union Jack will notify the user (see **Sounds** and **Flashing** below) and pop up a message that must be closed. SurfaceView Union Jack will ignore the measurement and remain on the same station on the path. Setting this to the maximum range of the ELCOMAT will effectively disable this feature.

- **Sounds**

SurfaceView Union Jack will produce 3 three distinct sounds during automated data collection if this is selected. One sound for a successful measurement, one when an error occurs, and one when the user moves backward. This is useful when using a remote (see Remote below).

- **Flashing**

SurfaceView Union Jack will flash 3 three distinct screens during automated data collection if this is selected. A green "Good" screen for a successful measurement, a red "Error" screen when an error occurs, and a blue "Back" screen when the user moves backward. This is useful when using a remote (see Remote below).



- *Readings*
 - *X,Y*

This will display all the data points from the ELCOMAT as they are received. Typically these values will change too quickly to be very useful.

- *Mean*

This is the statistical average of the data points received from the ELCOMAT (see **# Readings to Average** above). The Y measurement will be entered into the data for that path if there is no error. The X measurement is checked against the value in **X Alarm Limit**.

- *Std. Dev.*

This is the statistical standard deviation of the X and Y data points received from the ELCOMAT. The X and Y value is checked against the value in **Std. Dev**

Alarm Limit.

- **Take Reading**

SurfaceView Union Jack will receive **# of Readings to Average** data points from the ELCOMAT, the average of those, displayed in *Mean*, will be entered as the measurement for that station along the path. Each measurement will be displayed in the vertical measurement display next to **Line** selector.

- **Back**

SurfaceView Union Jack will erase the measurement in the station prior to the current one. For example, if 3 measurements of 14 have been taken on a path there will be 3 numeric values in the vertical measurement display section and the position graphic will display "4/14" and point to the 4th station. In that case **Back** will erase the 3rd measurement and be ready to retake it immediately (displaying "3/14"). To erase an entire path the user must press **Back** until it is ready to take the first measurement. CAUTION: Once a measurement has been erased using **Back** it is lost.

- **Cancel**

Closes the ELCOMAT Data Collection window and does NOT load any measurements onto the **Plate Measurement** screen.

- **Line**

The user selects the path for which measurements are currently being taken. The graphic at the top will change to reflect the number of stations in each path. This can also be selected with the remote (see below).

- *Done indicators*

An indicator for each path will change from dark green ("Off") to bright green ("On") as the measurements for each path are completed.

- **Enter**

Closes the ELCOMAT Data Collection window and loads all the measurements taken onto the **Plate Measurement** screen. The user can take measurements for some paths, click Enter, and return to the ELCOMAT Data Collection window later to finish taking measurements on the remaining paths.

- Remote

SurfaceView Union Jack automatic data collection with ELCOMAT Electronic Autocollimators is compatible with remotes designed to be used with Microsoft PowerPoint™. It is useful to select **Sounds** and **Flashing** when using a remote. These remotes have three buttons and are usually referred to by the manufacturer as;

- "Next Slide"

Equivalent to clicking **Take Reading** or pressing the right arrow on the keyboard.

- "Previous Slide"

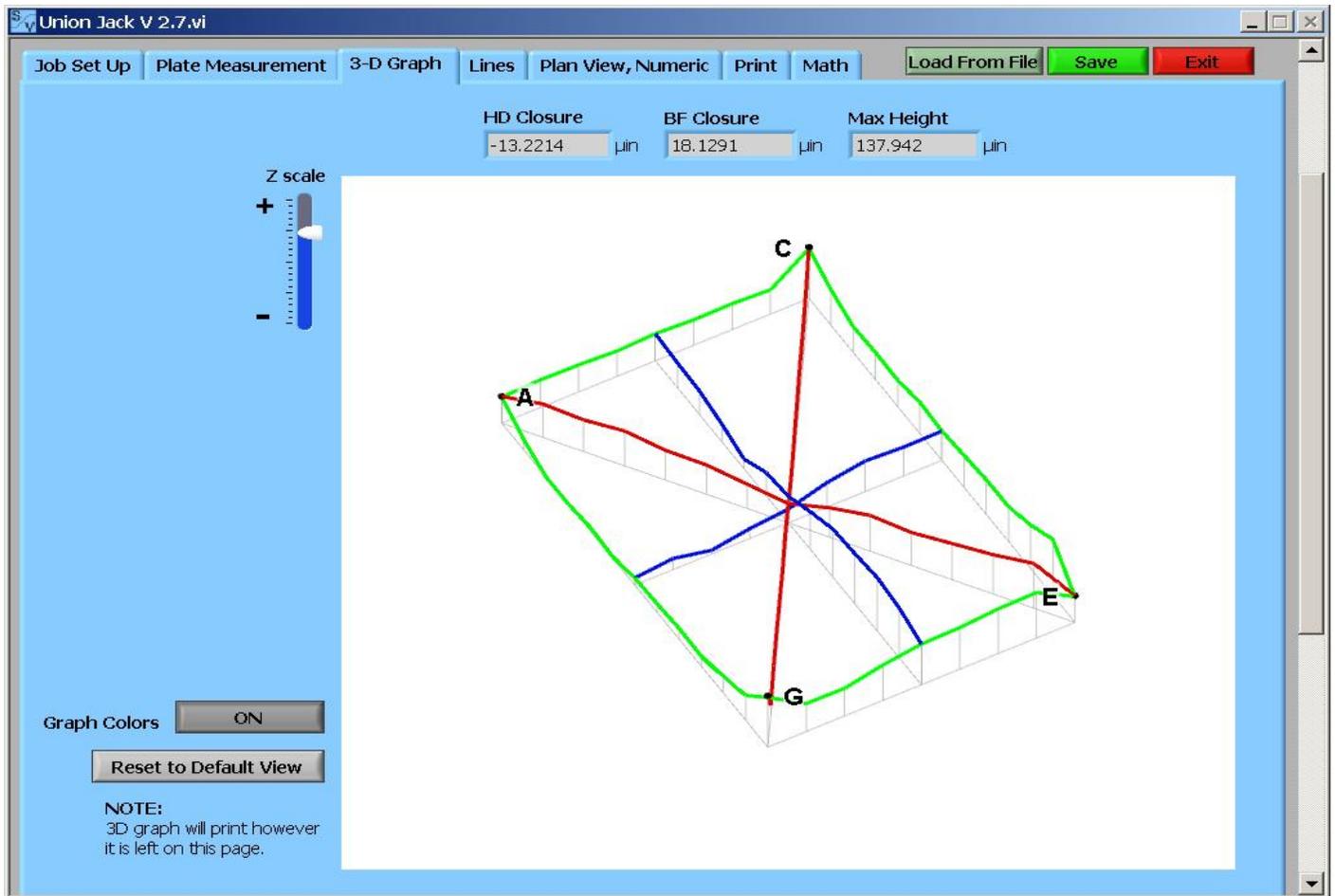
Equivalent to clicking **Back** or pressing the left arrow on the keyboard.

- "Blank Screen"

Equivalent to pressing "b" on the keyboard, this button is used for several functions:

- Select **Line** by pressing "Blank Screen" then using "Next Slide"/"Previous Slide" to choose path. Go back to taking measurements by pressing "Blank Screen" again.
- The "OK" buttons on the pop up messages (i.e. Std. Dev Alarm, X Alarm, Path Finished) can be clicked by pressing "Blank Screen".

3-D Graph



The user can examine the profile of the overall table from many different angles, scalings, and distances (zoom) to have a clear understanding of the figure of the surface. The view that is left on this tab is the view that will print when **3-D Report** is selected on **Print**. The horizontal plane to which all the heights are referenced is parallel to straight lines that connect the opposite corners, i.e. opposite corners (A&E and G&C) are equal distances from the reference plane, but all four corners are not necessarily equal distances from the reference plane (see Moody). This is the convention defined in Federal Specification GGG-P-463c.

- Navigating in the 3D Graph
 - **Z scale**

This control allows you to adjust the z-scale on the 3D graph.

- Rotate graph

Click anywhere on the graph and hold down the left mouse button and move the mouse (click and drag).

- Zoom in and out

The user can zoom in or out by using the scroll wheel on the mouse (you may have to click inside the graph window once before doing this). If you do not have a scroll wheel on the mouse hold down the Alt key and the left mouse button and move the mouse

up or down to control the zoom.

- **Moving**

The user can move the graph around in the view without rotating by holding down the Shift key, holding down the left mouse button, and moving the mouse (Shift + click and drag).

- **Incomplete Data**

A warning appears on the left next to the 3D graph if any of the cells on **Plate Measurement** are left blank. If any of the cells are left blank the 3D graph may still appear but it will be incomplete and the values displayed in *Max Height* and the closure errors will be incorrect.

- **Graph colors**

Turns the Graph colors on or off. When the graph colors are off all the paths will be displays as black.

- **Reset to Default View**

When the user first looks at **3-D Graph** after entering or loading data on **Plate Measurement** the view of the surface plate will always be from the same vantage point. Occasionally the user may become disorientated after rotating, zooming, and rescaling the image. **Reset to Default View** will bring the user back to the first vantage point by resetting the rotation and the zoom only, the z-scale is not affected.

- **Note on printing**

The 3D graph will print in the report exactly as it is left on **3-D Graph**. For example if you rotate the graph to be upside down and turn the colors off it will print upside down and in black and white.

- **HD Closure**

This indicates the difference in the height of the center point as calculated from the two diagonals or HD, it is a measure of the quality of the *measurement*, not the table. Moody suggests a maximum value of $2.5\mu\text{m}$ ($\sim 100\mu\text{in}$) for a good measurement, others suggest an acceptable closure error of about 25% of the maximum height. This value is referenced to the intersection of the two diagonals (AE & GC), i.e. if the value is negative then the center point of HD has been calculated to be below the intersection of AE & GC, if the value is positive then the center point of HD has been calculated to be above the intersection of AE & GC. Of course, physically they are the same point and are exactly the same height. Moody suggests "moving" the error to the edges, SurfaceView Union Jack leaves the error in the center.

- **BF Closure**

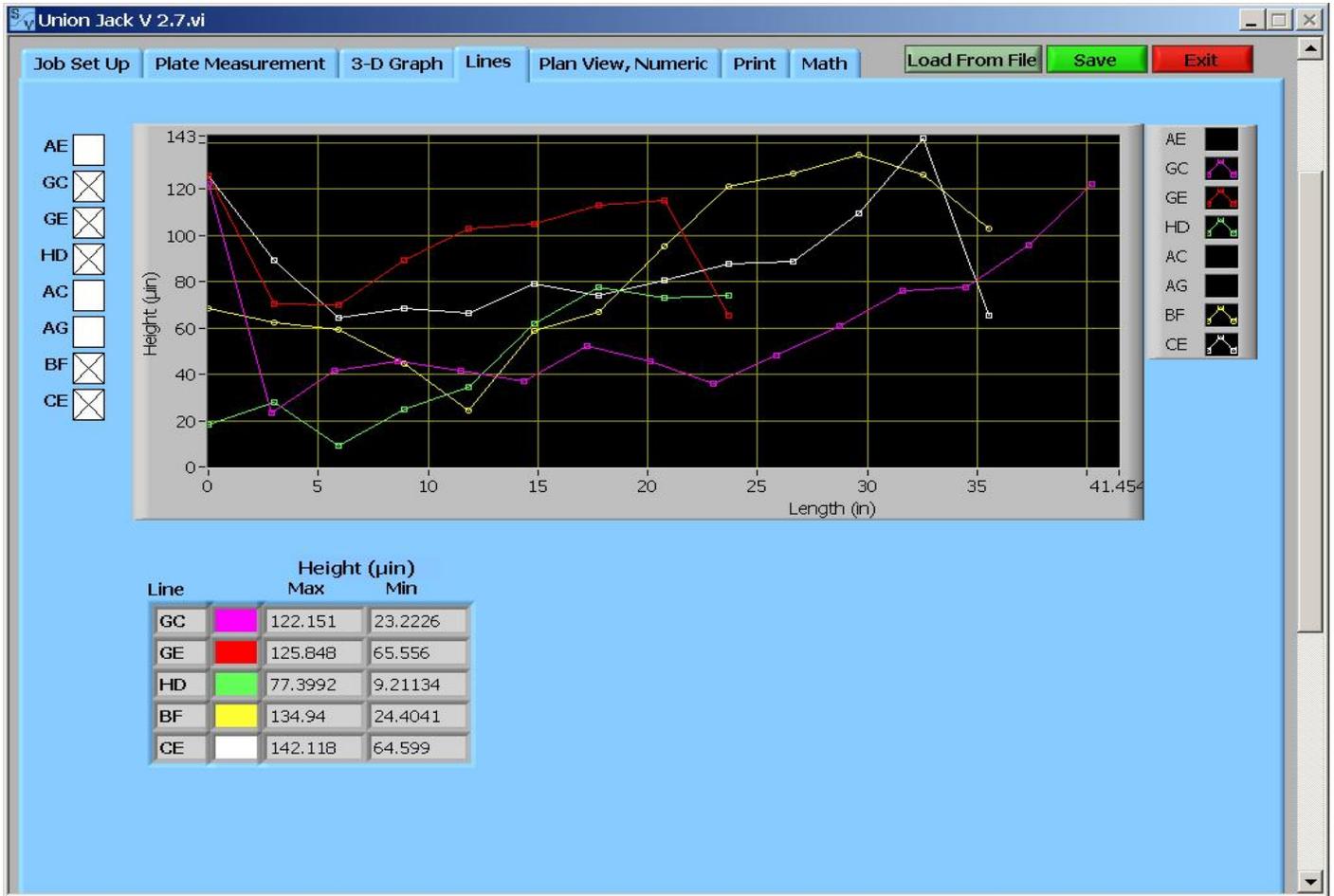
As with *HD Closure*, this indicates the difference in the height of the center point when measured from the diagonals or BF, it is a measure of the quality of the *measurement*, not the table. The sign convention is also the same as *HD Closure*.

- **Max Height**

Federal Specification GGG-P-463c states "All points of the work surface shall be contained between two parallel planes, the base plane and the roof plane, separated a distance no greater than that specified for the respective grades." The *Max height* in SurfaceView Union

Jack is the distance between the "base plane" and the "roof plane". This value is not affected when **Plus/Minus On?** is selected on **Job Set Up**.

Lines

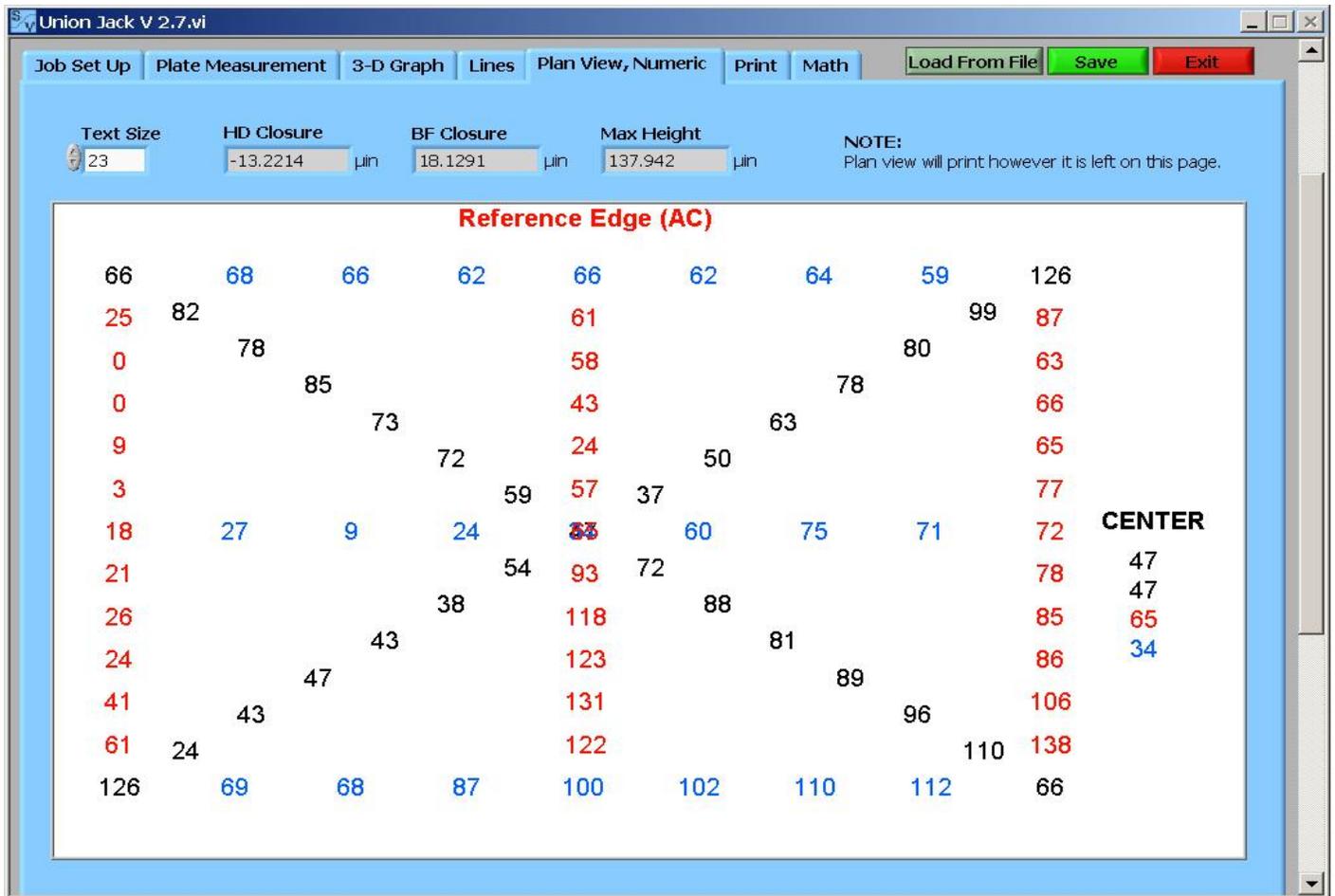


The user can display profiles for individual line profiles on this screen

- *Line*

When a line is selected with the check boxes on the left a row displaying its color on the graph, maximum height, and minimum height will appear and the profile of the path will be displayed on the graph. All the profiles are displayed referenced to the lowest point on the table, not the lowest point on the profile; that means that most profiles (6 of the 8) will not "touch" zero or the maximum of the vertical scale on the graph. The graph colors can be changed by right-clicking on the label at the upper right of the graph and selecting a color. Changes to the graph colors and styles will not be reflected on the printed report.

Plan View, Numeric



This screen displays a numerical value for the height at all the measured locations on the table. Since Federal Specification GGG-P-463c defines the reference edge as one of the shorter sides this view seems incorrect; however, the graphic is set up to fit the text in the correct locations.

- **Text Size**

The user can set the size of the text in the plan view image. The image will always be the same size regardless of the size of the table or the number of steps in the length and width. It can become difficult to read if there are many steps or if the text is too small on a particular table.

- *HD Closure*

See **3-D Graph** section.

- *BF Closure*

See **3-D Graph** section.

- *Max Height*

See **3-D Graph** section.

- Note on printing

Similar to the note on ***3-D Graph***, this image will print exactly how it is left on this tab when **Plan View** is selected on ***Print***. In this case it pertains only to the text size.

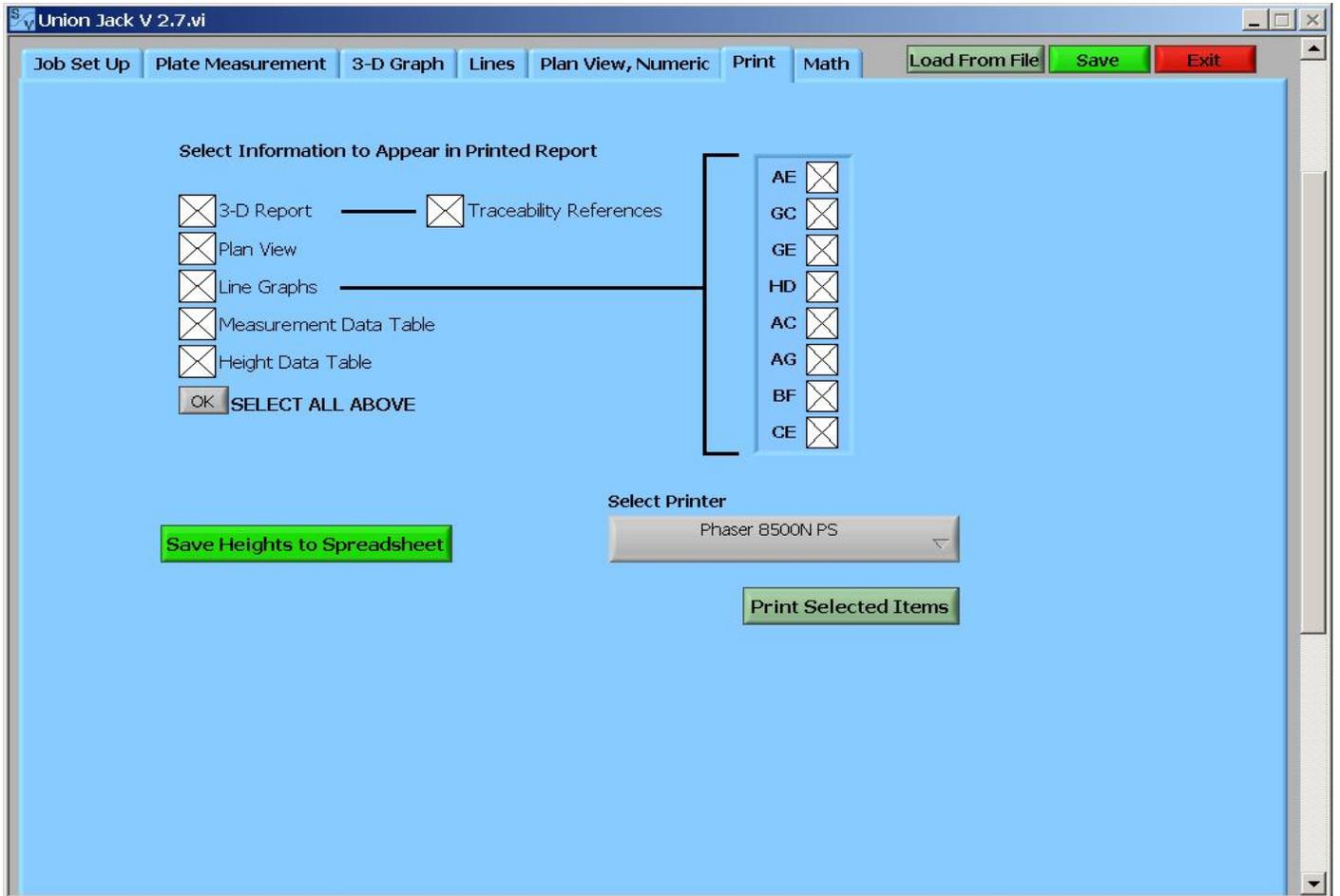
- Reference Edge AC

See ***Plate Measurement*** section.

- Center

SurfaceView Union Jack calculates a height at the center of the plate from 4 different lines (AE, GC, HD, & BF). Each is displayed under the word "CENTER" on the image since all the values overlap and are unreadable at the actual center of the image. Two of the values should always be equal. See *HD Closure* or *BF Closure* in ***3-D Graph*** section for more.

Print



The user can print a report of the surface plate calibration. All, some, or one of the reports can be printed at any time. The report will show the information contained in **Job**, **Serial #**, **File Name**, **Date** (see **Job Set Up** tab) as a footer on all pages and a logo as a header on all pages. The printed report will use the font set in Windows™, it can only be changed through Windows™ settings. The default logo is the SurfaceView logo. See the sample report at the back of this manual for examples of all of the choices below.

- **3-D Report**

If selected the 3-D graph will be printed in the report exactly as it appears on the **3-D Graph** tab. In addition to the header and footer on every page this page will also have the **Base Length, Plate Length, Plate Width, Path Length, Path Width, HD Closure, BF Closure, Max Height**, and minimum height (zero unless **Plus/Minus On?** is selected on **Job Set Up**) as a footer.

- **Traceability Reference**

If selected the 3-D Report page will have the following text between the header image (logo) at the top and the 3D Graph:

All Measurements Made Under Laboratory Conditions and Traceable to NIST Using:

Instrument #:

Calibrated On:
Inspector:

On the line next to "Instrument #:" will be the value entered in **Instrument** on **Job Set Up**, next to "Calibrated On:" will be the value enter in **Cal. Date** on the pop-up Instrument Set Up (Admin. Mode) for this instrument, and next to "Inspector:" will be the value entered in **Inspector** on **Job Set Up**. This will not be automatically selected by clicking **Select All Above**.

- **Plan View**

If selected the plan view will be printed in the report exactly as it appears on the **Plan View** tab.

- **Line Graphs**

If selected the printed report will contain the profiles for the selected paths. The user can select which paths to print on this tab. The printed paths are completely independent of which are selected for display on the **Lines** tab. Each path profile will be printed on its own axes, unlike the display on **Lines** where all paths are displayed on the same axes, and all will be printed as black lines on white backgrounds.

- **Measurement Data Table**

If selected the printed report will contain a data table of the measurements entered on the **Plate Measurement** tab.

- **Height Data Table**

If selected the printed report will contain a data table of the heights along each path. Note that for a path with n measurements there will be n+1 heights.

- **Select All Above**

The user can choose to print all reports with one choice. If clicked the box next to each possible report will be automatically selected, with the exception of **Traceability Reference**.

- **Save Heights to Spreadsheet**

The user can save a .xls spreadsheet file of the heights with this button. A screen will pop up for the user to choose where the file will be saved.

- **Select Printer**

The user selects a printer to print to with this selector. Note that the user can choose to print to a file (e.g. a .pdf file) and view the report before printing a paper copy. Note that because of the different formatting of the report pages SurfaceView Union Jack saves three files when the user chooses to print to a file.

- **Print Selected Items**

This button sends the selected reports to the selected printer to be printed.

- **Add Your Logo to the Printed Report**

The user can add a logo or image to the upper-left corner of the printed report. The default image is the SurfaceView and Vermont Photonics logo. It can be changed by replacing the file titled "Logo.bmp" located in C:\Program Files\SurfaceView\Union Jack\SurfaceView Data. The new file must be titled "Logo.bmp". The image size must be less than 7.5 inches wide and 0.65 inches tall (675 x 60 pixels @ 90 dpi). An image that is wider will not fit on a page and an image that is taller will ruin the formatting of some pages of the printed report.

Math

Union Jack V 2.7.vi

Job Set Up | Plate Measurement | 3-D Graph | Lines | Plan View, Numeric | Print | Math | Load From File | Save | Exit

Enter Angle (arc seconds)
1

Enter Measured Distance
4

Resulting Height
1.93925E-5
(Height Units are the same as The Measured Distance Units.)

Measured Distance

Angle°

90°

= Height

Angle (Degrees) = Angle (Arc Seconds) ÷ 3600
Height = (Measured Distance)*Sin(Angle (Degrees))

This screen is included as a handy place for doing a common calculation in the manufacture and calibration of granite surface plates. It is not essential for the user to enter anything into the entry fields on this tab for SurfaceView Union Jack to be used correctly.

- **Enter Angle**

Enter the angle in arcseconds.

- **Enter Measured Distance**

The distance between the two points which determine the angle in **Enter Angle**. Often this will be equal to distance between the centers of the two feet of the sled (base length), but it could be the length of an entire path.

- *Resulting Height*

This is the height that will result if the angle in **Enter Angle** is maintained over the distance **Enter Measured Distance**.

SurfaceView Grid

SurfaceView Grid is designed very similar to SurfaceView Union Jack. The main difference is that there are no Federal Specifications for the measurement in a grid pattern. Consequently, the user can measure the surface with fewer restrictions on the layout of the measurement pattern. The software for each method is sold separately, but both are covered in this manual.

Because of the similarities between the two versions of SurfaceView it is useful for users of SurfaceView Grid to read the manual section specific to SurfaceView Union Jack. This section for SurfaceView Grid will primarily highlight the main differences, the user should refer to the corresponding section of the SurfaceView Union Jack manual for more detailed explanations. See the Overview and Getting Started sections near the beginning of this manual for general information pertaining to both versions of SurfaceView and for descriptions of the data provided in the example data files.

Grid Must be Measured with a Level

The fundamental difference between the Union Jack and Grid methods of tying all the path profiles together is that the Union Jack uses two points on a profile, thus adjusting the slope AND vertical location of a profile, while the Grid uses only one point and can only adjust the vertical position. The slope information is contained in the reference to the center of mass of Earth.

For the Grid method two reference paths are chosen (the two that cross at the center) and tied together at their intersection. That is, at ONE point they are set to an equal vertical height. Then each perpendicular path is tied to the appropriate reference path at the intersection. Again, at ONE point which only adjusts the profile up or down, not its slope. This means that the largest closure error will generally be at one of the corners since they are the farthest from the reference paths. If you display the closure error on ***3-D Graph*** in SurfaceView Grid you should be able to see where all parallel paths are tied to ONE of the reference paths.

The Grid Method can only be measured with a level because there is an external reference (the center of mass of Earth) while the Union Jack Method can be measured with a level or an autocollimator. The zero point of an autocollimator changes every time the autocollimator is moved (it moves with the autocollimator). Moreover, the level can not be zeroed at the beginning of each path because the external reference is lost, similar to moving an autocollimator. The only way that two *parallel* paths can be aligned to have the correct *relative* slope is through the ultimate reference (the center of mass of Earth). This is different than the Union Jack because the diagonals measured in the Union Jack give information for each axes and are used to connect the endpoints of the perimeter lines (SurfaceView Union Jack allows you to zero at the beginning of each path or not). Moving the TWO endpoints adjusts the overall slope of the profiles.

As an example, imagine a table that is shaped like a bowl. In that case, if we zero the level at the beginning of every path we would expect to measure a profile that begins level (since it was zeroed) and starts rising up in the shape of the path along the bowl. This would be true for every path measured. When these paths were all tied to the appropriate reference path in SurfaceView Grid the resulting surface profile would look like a bowl tipped up on its corner. In fact, what we want to measure is a profile that starts out sloping down, levels near the midpoint, and slopes up at the end. Furthermore, all of the first measurements are not parallel, which is assumed if you zero the level at the beginning of each path. Again, the relative slope of the first measurements of two parallel paths is contained in the ultimate reference to the center of mass of Earth.

The use of two levels is *highly* recommended for measurements made with electronic levels (grid or union jack pattern). One level makes measurements on the sled and a second stationary level provides a reference to the center of mass of Earth that is subtracted to remove any movement of the table due to the weight of the measurement level, flexing of the floor as the technician moves around, etc. It is

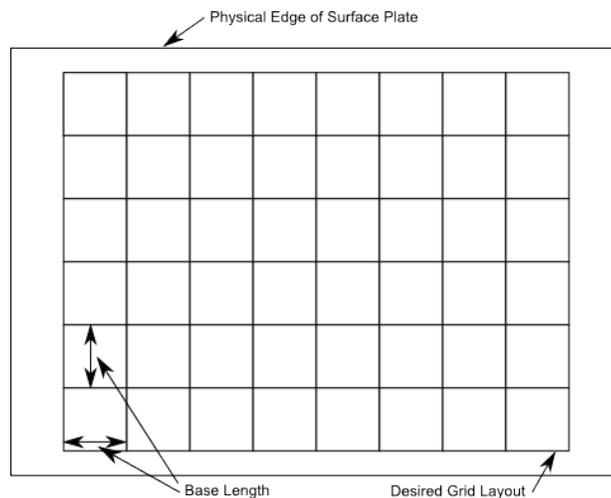
essential that the second (reference) level sit absolutely stationary, on the same surface as the measurement level, and aligned the same direction as the measurement level throughout the entire measurement in that direction (this can be difficult if the reference level is where a measurement will be made later).

Strictly speaking, SurfaceView Grid performs a best fit to the data that will remove any overall tilt of the surface. This can not substitute for the need to have an ultimate external reference, however; nor does it allow the user to zero the level at the beginning of every path. In the example above with the bowl shaped surface the best fit would merely account for the fact that the location of the stationary reference level (somewhere on the sloped surface of the table) is not a special (or level) location.

How to Lay Out Measurement Stations

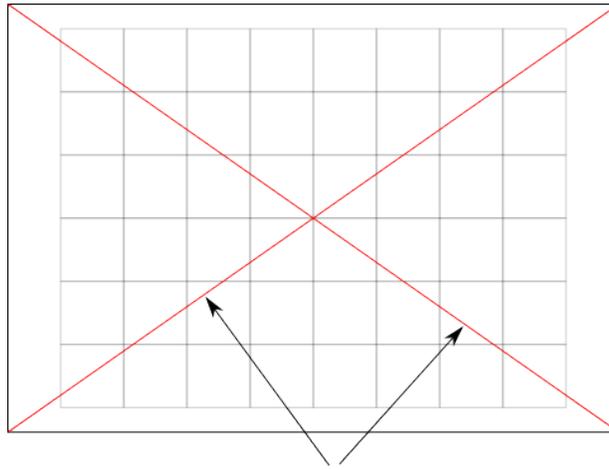
The measurement stations of the grid pattern (or Union Jack pattern) should be laid out before the measurement begins. Since there is no Federal Specification for surface plate measurement with the grid pattern the technician can lay out the grid as s/he likes. Often one will want to measure the same surface with a grid pattern and a Union Jack pattern so it is useful to set up a grid so that one must only add the diagonals to complete the Union Jack pattern (it is also useful to make path AC = path W1). The series of figures below show an example of how to lay out a grid pattern so that the same area can be measured with a Union Jack pattern. It is simple to locate the center of a square or rectangular plate, but SurfaceView Grid does not care where on the plate the grid pattern is relative to the physical edges and physical center. There may be situations where the technician has a good reason not to center the grid pattern on the plate (an irregularly shaped plate, for example). Again, there are no standards for the Grid Method so the technician may choose not to follow this section precisely, it is here as an illustration.

The figure below shows an example of a rectangular surface plate with a centered grid pattern laid out with an even number of measurements in each direction. In this case it appears that one more measurement could fit on each horizontal line by shifting the grid to the side a bit, but an odd number of measurements does not comply with Federal specifications for the Union Jack Method. Also note that from the central point of the grid it is three steps in the vertical direction and 4 steps in the horizontal direction to each corner; a perfect 3-4-5 right triangle. This will also make it possible to measure the surface using the Union Jack Method with a single base length.



Locate Center of Plate

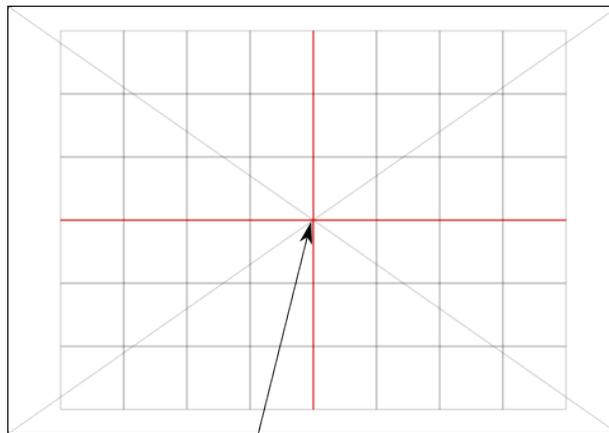
Locating the center of a square or rectangular plate can be done by drawing the two diagonal lines. The intersection of the two diagonals that connect the opposite corners of the *physical plate* is at the center of the plate.



Locate Center of Plate with these Diagonals

Build Grid from Center Point

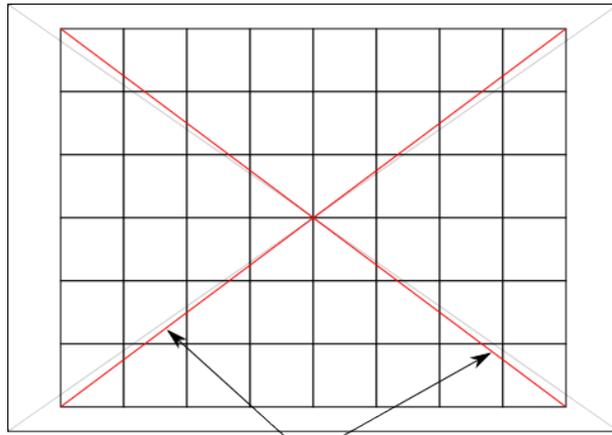
Constructing the grid pattern from the center point can be done by a number of geometrical methods (angle bisection of the diagonals, perpendicular line construction with compass, carpenter's square, etc...), but care should be taken to make sure that the two directions come out perpendicular. The distance between parallel lines should be equal to the base length of the sled used for the level.



Build Grid from Center Point

Check by Measuring Grid Diagonals

Whether the grid is constructed to be measured by a Union Jack pattern or not, centered on the surface or not, the perpendicularity of the grid should be checked. This can be done by measuring the distance between opposite corners of the *grid pattern*, they should be equal. In this case, since the grid is laid out to make perfect 3-4-5 right triangles, each diagonal will measure 10 base lengths. Note also that this is now laid out in a Union Jack pattern and this table could easily be measured with both methods by simply adding the data for the two diagonals

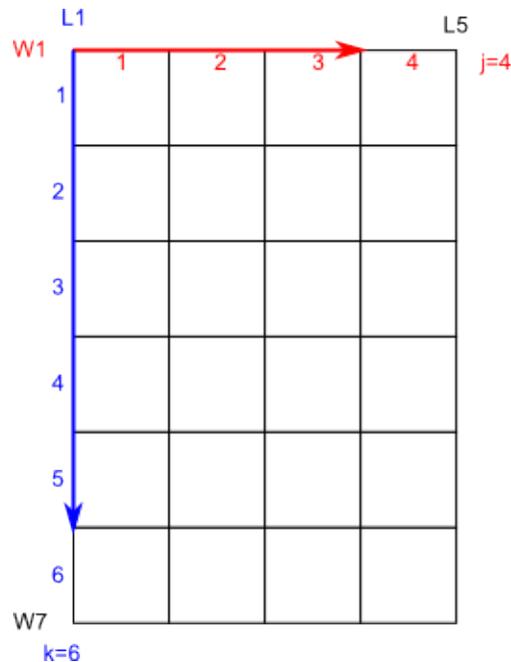


These Diagonals Should Have Equal Lengths

Take Measurements

Once the measurement locations have been laid out it is time to take the data. Assume the grid pattern laid out has j measurements in the width and k measurements in the length (i.e. $j \times k$ grid (width x length) , $k+1$ width paths, $j+1$ length paths, see diagram below). The level *can* be zeroed once at the start of each direction, but we recommend *never* zeroing the level (the *table* should be made level prior to starting the measurement). So once the first measurement of W1 is taken (zero or otherwise) all $k+1$ width paths must be taken without re-zeroing. Take measurements along each width path starting at station 1 (closest to L1) and ending at station j (closest to L(j+1)). Repeat for the length measurements...zero on first measurement of L1 only, start at station 1 (closest to W1), end at station k (closest to W(k+1)).

Be sure the level is facing such that a measurement that slopes up from the starting position to the ending position is a positive number, a downward slope is a negative number.



A common mistake is to assume that there should be the same number of width and length measurements ($j \times k$ measurements in each); then SurfaceView Grid shows a different number of data entry fields and many users assume that it is wrong and there must be a "bug" in the software. This is not so. The number of measurements on width paths will be $j(k+1)$ and on length paths $(j+1)k$.

For the number of measurements to be equal:

$$\begin{aligned} \# \text{ width measurements} &= \# \text{ length measurements} \\ j(k+1) &= (j+1)k \\ jk + j &= jk + k \\ jk + j &= jk + k \\ j &= k \end{aligned}$$

From this we can see that the only way there is the same number of width and length measurements is if $j=k$ (i.e. a square measurement area). We can also see that the difference in the number of width and length measurements will be equal to the difference in j and k . In the diagram above we have 28 width measurements and 30 length measurements; $30-28 = 2 = k-j = 6-4$.

Job Set Up

Grid V 1.02.vi

Job Set Up | Plate Measurement | 3-D Graph | Lines | Print | Math

Load From File | Save | Exit

Customer: J. Doe

Date: 5/23/2008

Serial #: AA123456

Job Name: AA - Calibration

Inspector: AOD & CFG

Instrument: Electronic Level

File Name: AA123456 080623

Admin Login

Notes

This is an example of a Grade AA granite surface plate measured with the grid pattern.

The measurements were made with a SINGLE electronic level with 0.2" resolution. The use of a single level is not recommended (see manual)! The maximum closure error (~49%) reflects the poor method used to measure this precision surface. The resulting surface is qualitatively very similar to that measured using the Union Jack method.

Use 1st Step Verification?

Employ Adjustable Base Length?

New Job*

*New Job clears all unsaved data on all pages.
To Save, use green button at upper right.

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The data entry fields on this screen are identical to those in SurfaceView Union Jack. The Administrator functions work exactly the same as well. Since there is no Federal Specification for the grid measurement the user is automatically allowed to have an odd number of measurements in each path. It is recommended, however, that an even number of measurements be used for each path since SurfaceView Grid uses the central path in each direction to reference all the perpendicular paths.

Plate Measurement

Grid V 1.02.vi

Job Set Up | Plate Measurement | 3-D Graph | Lines | Print | Math

Load From File | Save | Exit

Units: English

Plate Width: 24 in (# Steps in Width: 8)
 (=length of reference edge)

Plate Length: 36 in (# Steps in Length: 12)

Base Length: 2.874 in (Help) | Path Width: 22.992 in

Min. Edge Dist.: 0.5 in | Path Length: 34.488 in

Reference Edge

W1 L1 L9 W13

Length | Width

Length Lines | Clear Data From Table Below

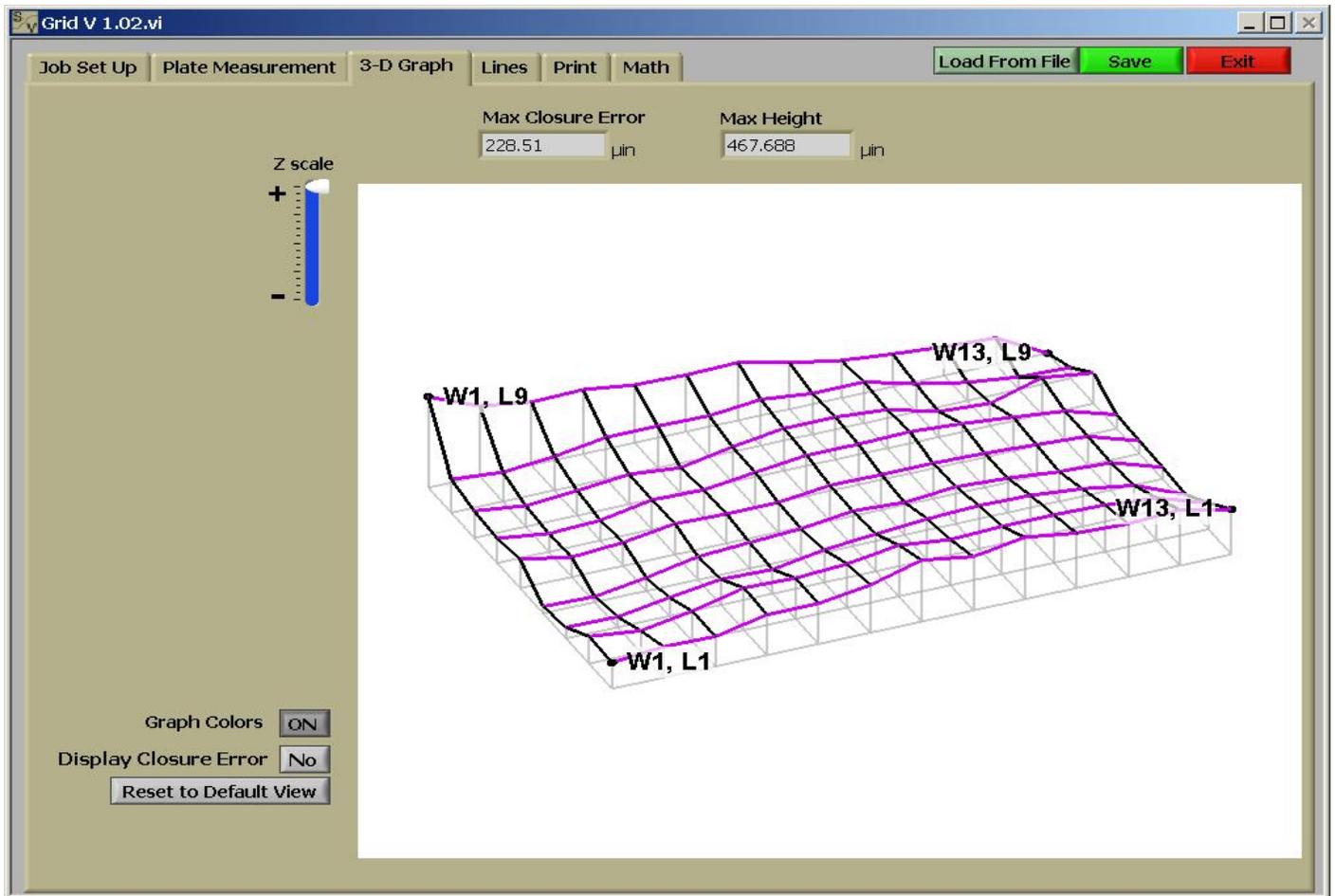
	L1	L2	L3	L4	L5	L6	L7	L8	L9
1	1.600	-1.900	1.100	1.300	-2.100	-1.500	-0.900	0.600	-4.500
2	-1.000	2.100	2.500	3.000	1.000	0.700	0.700	0.900	-4.300
3	1.200	2.800	1.000	2.700	2.000	1.900	-1.100	0.700	-1.700
4	0.500	1.400	1.300	1.900	-0.200	1.400	1.700	1.800	-2.000
5	1.200	-0.400	2.900	1.500	0.200	2.700	4.000	0.200	-0.800
6	2.400	0.500	1.400	2.300	1.600	1.100	2.300	0.800	-1.900
7	-0.100	-0.200	2.400	0.410	0.000	0.500	0.500	-1.600	-1.800
8	1.200	-0.200	-0.300	-0.100	0.200	0.300	-1.800	0.800	-2.200
9	-0.300	0.600	0.300	-1.100	-0.200	0.900	-2.800	-2.800	-0.500
10	-0.200	0.700	-2.200	-1.300	-0.500	-1.900	-0.800	-3.200	-0.700
11	-0.700	-2.000	-3.900	-0.900	-0.600	-0.900	9.000	-1.800	-0.400
12	-0.200	-1.700	-3.100	-2.500	-3.800	-3.000	-1.400	1.800	-6.400

Data for the measurements in SurfaceView Grid are entered in data tables on two tabs; a Length tab and a Width tab. For each surface the data tables will be different sizes depending on the size of the measured area and the base length used. The data table for the width and the length will also be different sizes from each other for a rectangular measurement area (see [How to Lay Out Measurement Stations](#) above). Measurements for a single path are entered into columns of the data table, as in SurfaceView Union Jack. The reference graphic on this screen will show an unreliable layout when **# Steps in Width** or **# Steps in Length** becomes very large (>50), the data and calculated heights will be correct, however.

If **Employ Adjustable Base Length?** is selected on **Job Set Up** the **Help** button next to **Base Length** will be visible. The window that appears after clicking **Help** is the same as in SurfaceView Union Jack except here the user can set **Max. Edge Dist.** The default value is 1.

Plate Measurement provides data entry fields that are defined the same as SurfaceView Union Jack. The recommendations in **# Steps in Width** and **# Steps in Length** are the largest that will fit within the area defined by **Plate Width**, **Plate Length**, and **Min. Edge Dist.** for the value in **Base Length**. We recommend the number of steps be an even number, but SurfaceView Grid will work fine with odd numbers. There are no warnings on this screen regarding the measurement layout.

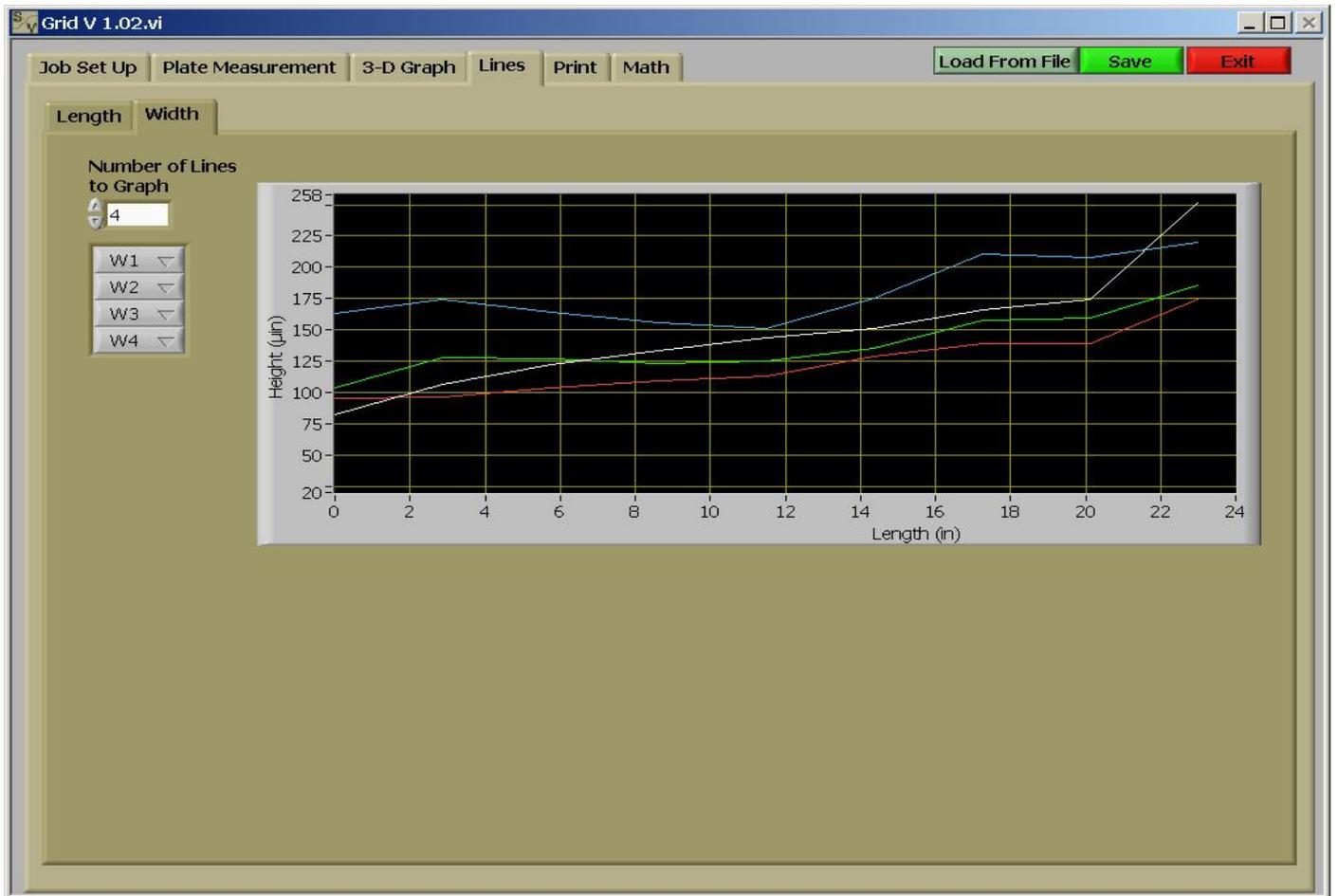
3-D Graph



The value displayed in *Max Closure Error* is the maximum value of closure error. There are many path crossings on the grid and most will have different heights as determined from width or length paths, the largest of these differences is displayed in *Max Closure Error* (see also [Grid Must be Measured with a Level](#) above for more).

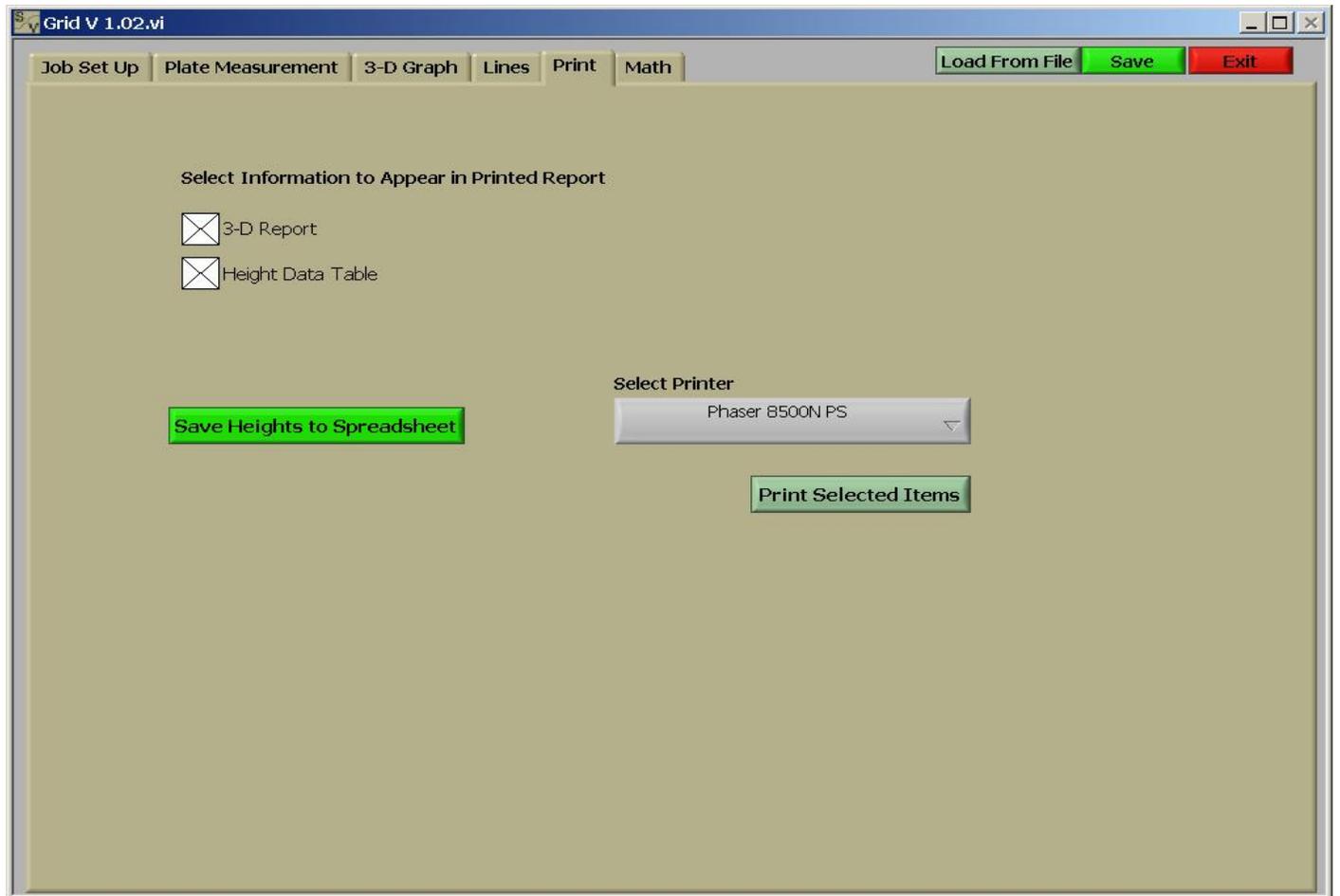
The user can elect to "average" out the closure error by selecting "No" next to **Display Closure Error**. If "Yes" is selected the profile of each path will be displayed as it was calculated from the measurements. In most cases, the user should be able to see which paths were used as reference paths and the closure error that results (typically) at the corners. If "No" is selected SurfaceView Grid will start at the intersection nearest the center (the crossing of the two reference lines) and adjust the higher point down and the lower point up by the same amount. The points further from the center on each path are then adjusted by the same amount. This process is repeated as SurfaceView Grid works its way out from the middle toward each corner until all the intersections have been corrected.

Lines



Like **Plate Measurement** this screen has a Length tab and a Width tab for displaying the profiles of each path. The user must set the number of path profiles to graph using **Number of Lines to Graph**. Setting this will adjust the number of path selectors available to the user below.

Print



Here the user can select what will be displayed on the printed report. ***Save Heights to Spreadsheet*** allows the user to save three(3) .xls files of the calculated heights. One is from the length measurements, one from the width measurements, and one of the heights after the closure error correction calculation has been performed (see ***3-D Graph***). They will be saved to .xls files with "Length ", "Width ", and "Corrected " appended onto the beginning of the text in **File Name** on **Job Set Up**. The values that appear in the printed report when **Height Data Table** is selected are the same as those saved in the "Corrected " .xls file.

Math

Grid V 1.02.vi

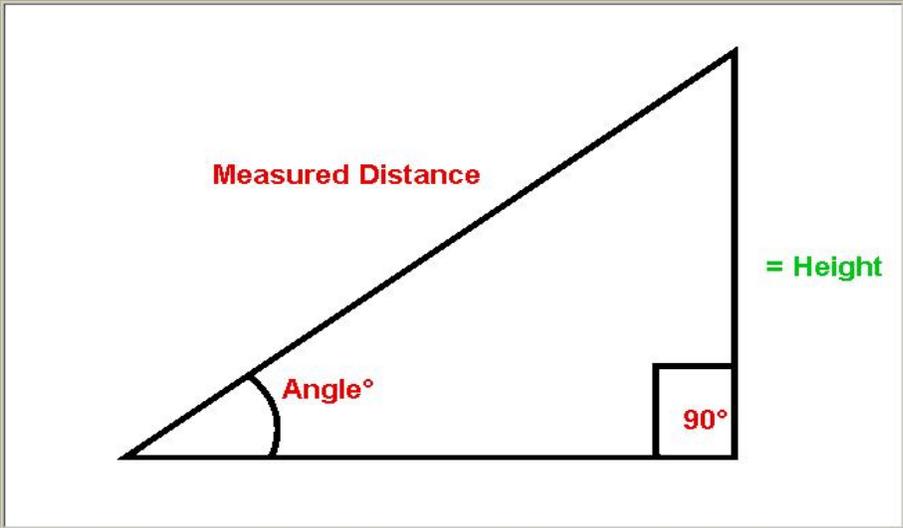
Job Set Up | Plate Measurement | 3-D Graph | Lines | Print | Math

Load From File | Save | Exit

Enter Angle (arc seconds)
1

Enter Measured Distance
4

Resulting Height
1.93925E-5
(Height Units are the same as The Measured Distance Units.)



Angle (Degrees) = Angle (Arc Seconds) ÷ 3600
Height = (Measured Distance)*Sin(Angle (Degrees))

This screen is identical to SurfaceView Union Jack.

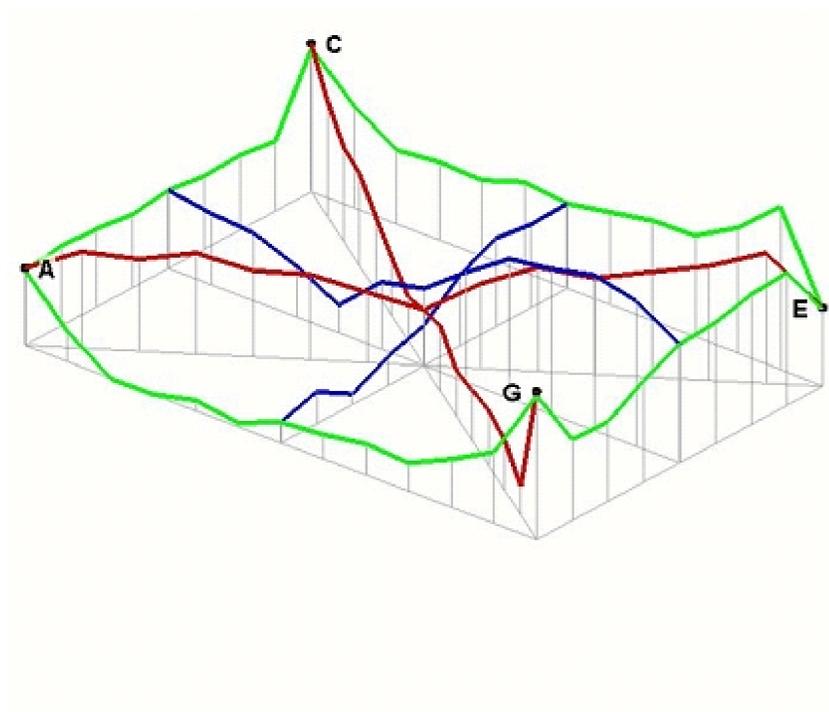
Example Report

All Measurements Made Under Laboratory Conditions and Traceable to NIST Using:

Instrument #: Electronic Level

Calibrated On:

Inspector: CFG & AOD



Job: Calibration - Grade AA
 Serial #: AA123456
 File Name: AA-Example.DAT
 Date: 6/11/2008

L&W Base Length = 2.874 in
 Diag. Base Length = 2.961 in
 Plate L x W = 36.000 x 24.000 in
 Measured L x W = 34.488 x 22.992 in

Closure HD = -13 μ in
 Closure BF = 18 μ in
 Max = 138 μ in
 Min = 0 μ in

Reference Edge (AC)

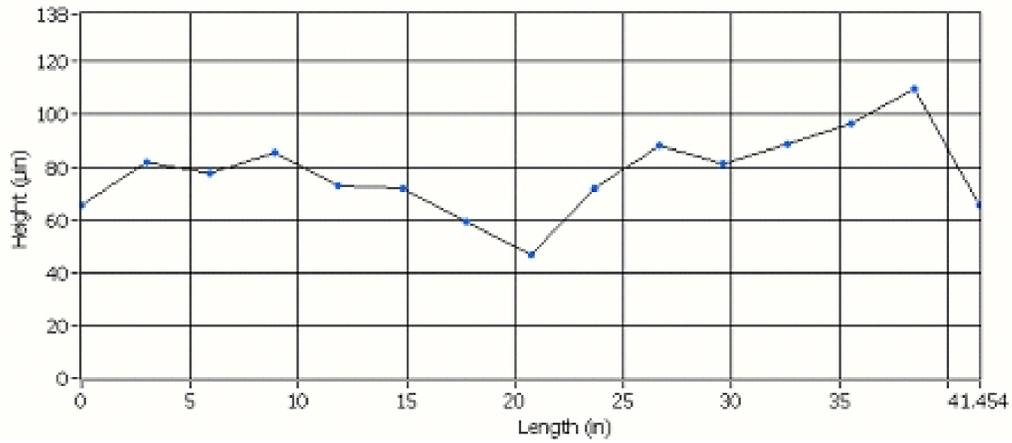
66		68		66		62		66		62		64		59		126
25	82							61						99		87
0		78						58						80		63
0			85					43				78				66
9				73				24			63					65
3					72			57	37	50						77
18		27		9		24		43		60		75		71		72
21						54		93	72							47
26					38			118		88						47
24				43				123			81					65
41			47					131			89					66
61		43						122				96				106
61	24							122						110		138
126		69		68		87		100		102		110		112		66

CENTER

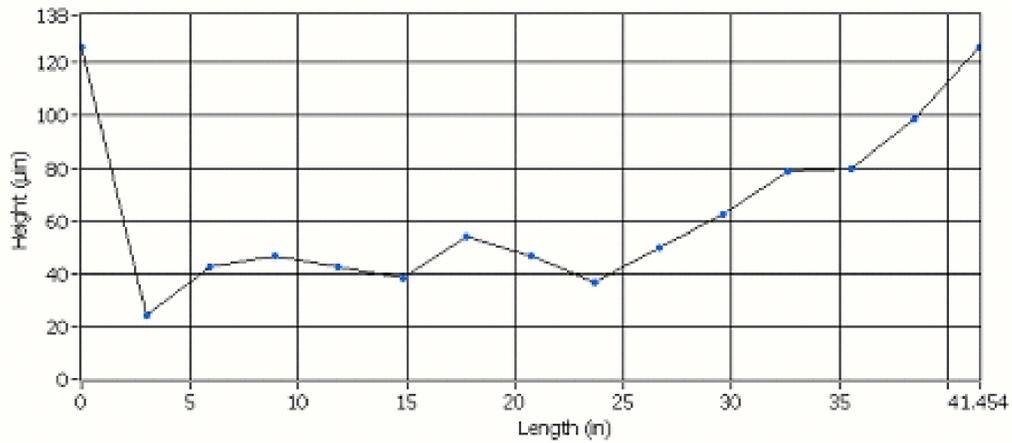
Job: Calibration - Grade AA
 Serial #: AA123456
 File Name: AA-Example.DAT
 Date: 6/11/2008



AE



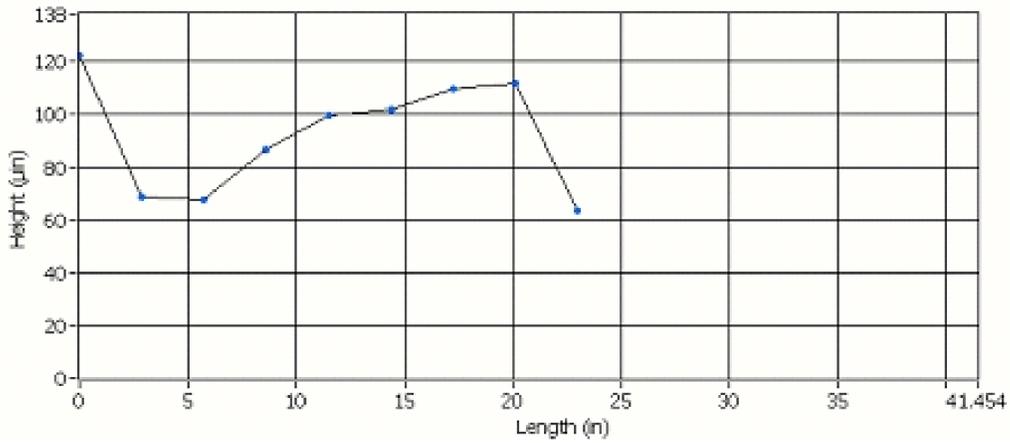
GC



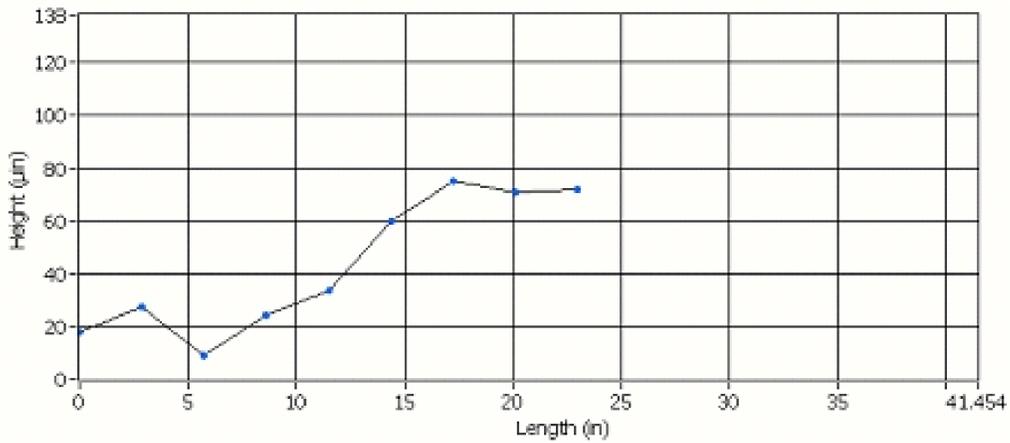
Job: Calibration - Grade AA
Serial #: AA123456
File Name: AA-Example.DAT
Date: 6/11/2008



GE



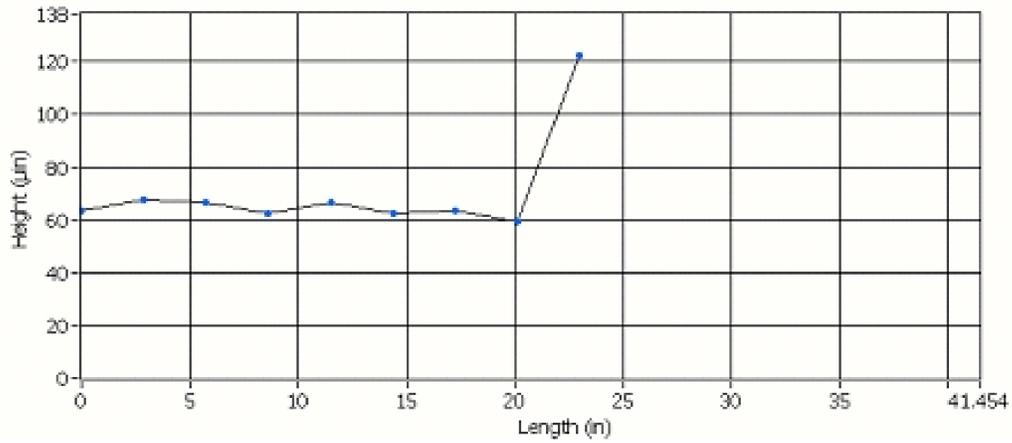
HD



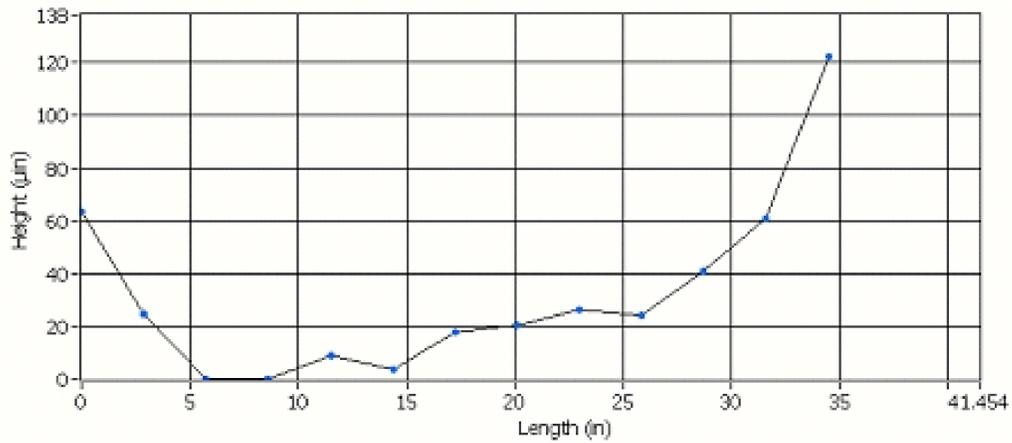
Job: Calibration - Grade AA
Serial #: AA123456
File Name: AA-Example.DAT
Date: 6/11/2008



AC



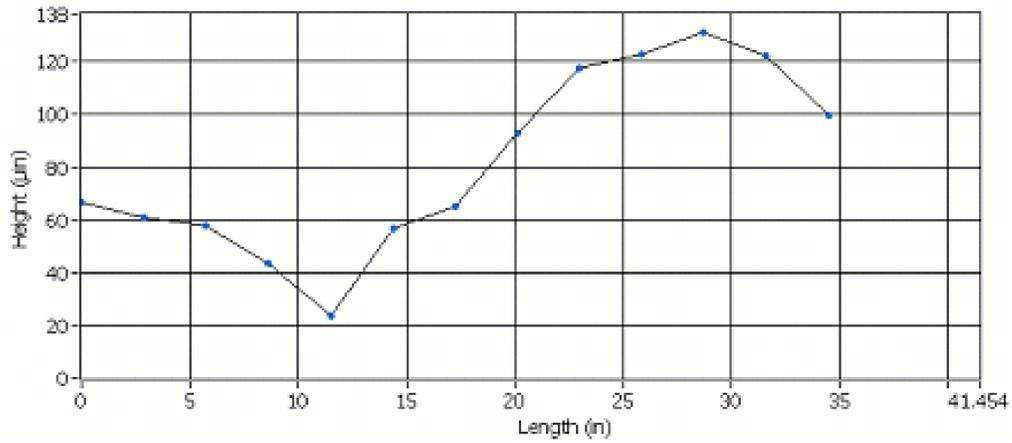
AG



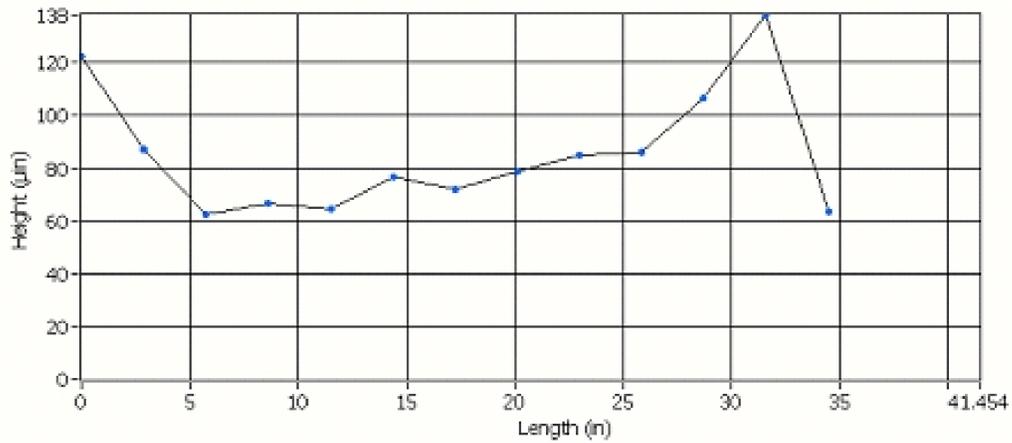
Job: Calibration - Grade AA
Serial #: AA123456
File Name: AA-Example.DAT
Date: 6/11/2008



BF



CE



Job: Calibration - Grade AA
Serial #: AA123456
File Name: AA-Example.DAT
Date: 6/11/2008



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Angle measurements in Arcseconds

	AE	GC	GE	HD	AC	AG	BF	CE
1	82.800	-75.600	136.400	142.200	104.600	64.800	66.800	30.800
2	81.400	-67.200	140.200	140.200	104.200	65.800	67.000	31.600
3	82.200	-68.200	141.600	142.600	104.000	67.600	66.200	33.600
4	80.800	-68.800	141.200	142.200	104.600	68.200	65.800	33.200
5	81.600	-68.800	140.400	143.400	104.000	67.200	69.600	34.200
6	80.800	-67.400	140.800	142.600	104.400	68.600	67.800	33.000
7	80.800	-69.000	140.400	141.200	104.000	67.800	69.200	33.800
8	83.400	-69.200	136.800	141.600	108.800	68.000	69.000	33.800
9	82.800	-67.600				67.400	67.600	33.400
10	81.200	-67.600				68.800	67.800	34.800
11	82.200	-67.400				69.000	66.600	35.600
12	82.200	-68.400				72.000	65.600	28.000
13	82.600	-67.200						
14	78.600	-66.600						

Job: Calibration - Grade AA
Serial #: AA123456
File Name: AA-Example.DAT
Date: 6/11/2008



VERMONT PHOTONICS
SurfaceView™
Moeller Meterology Division

Height measurements in μin

	AE	GC	GE	HD	AC	AG	BF	CE
1	66	126	122	18	64	64	66	122
2	82	24	69	27	68	25	61	87
3	78	43	68	9	66	0	58	63
4	85	47	87	24	62	0	43	66
5	73	43	100	34	66	9	24	65
6	72	38	102	60	62	3	57	77
7	59	54	110	75	64	18	65	72
8	47	47	112	71	59	21	93	78
9	72	37	64	72	122	26	118	85
10	88	50				24	123	86
11	81	63				41	131	106
12	89	78				61	122	138
13	96	80				122	100	64
14	110	99						
15	66	126						

Job: Calibration - Grade AA
Serial #: AA123456
File Name: AA-Example.DAT
Date: 6/11/2008