MetroPro™
Reference Guide
Version 7.6.1
OMP-0347F

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MANUAL REVISION INFORMATION

The document (OMP) number and the applicable revision letter for this manual appear on the title page. The publication date appears below.

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B	March 1995	6.0.10
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D	April 1998	7.2.2
E	April 2001	7.4.2
F	October 2001	7.6.1

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Note: Provides helpful information.

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SECTION 6 - SPECIAL RESULTS (CONTINUED)

SECTION 7 – LATERAL CALIBRATOR AND MASK EDITOR

SECTION 8 - SPECIAL FUNCTIONS

APPENDIXES

A Closer Look at MetroPro

Section
1

To effectively use MetroPro, you'll need to know some basic terminology, MetroPro's structure, and how it handles data.

This Reference Guide covers the details of MetroPro software; what a result means, what a control does, how to use the Mask Editor, using plots, making measurement reports, plus many other special functions.

Introductory information and installation instructions are covered in *Getting Started With MetroPro.* Guidelines for using the applications supplied with MetroPro are covered in separate application booklets.

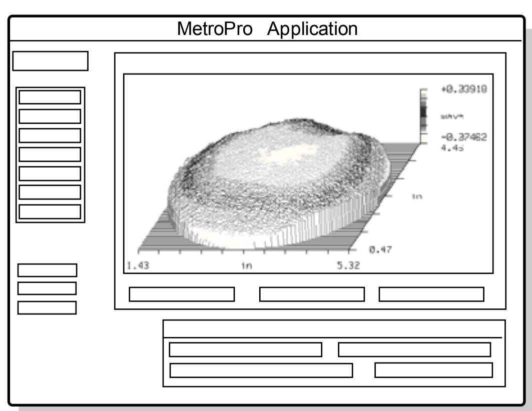
Instrument Names

MetroPro operates Zygo's latest instruments, as well as many earlier versions.

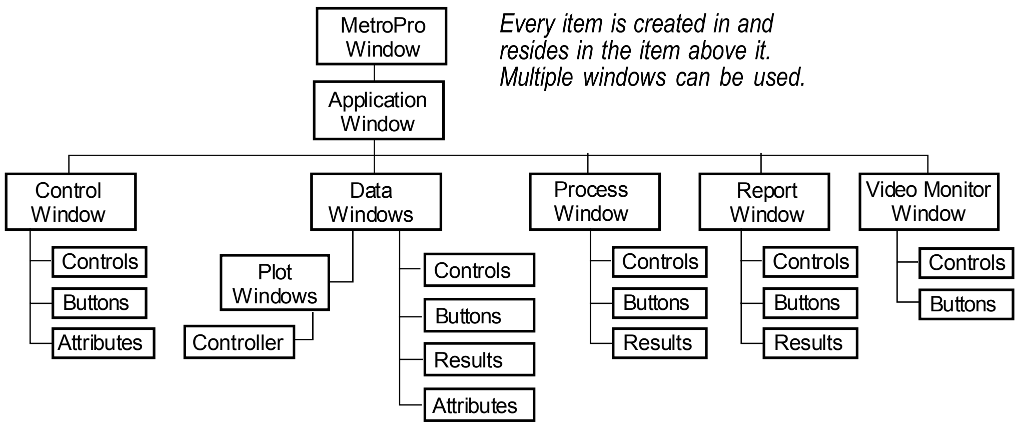
Term used	***Refers to…***
Interferometer	GPI-XP, Mark IVxp, SI-10
Motion Interferometer	ZMI interferometers
Microscope	NewView, Maxim•GP, Maxim•3D
Phase Microscope	Maxim•GP, Maxim•3D
Scan Microscope	NewView

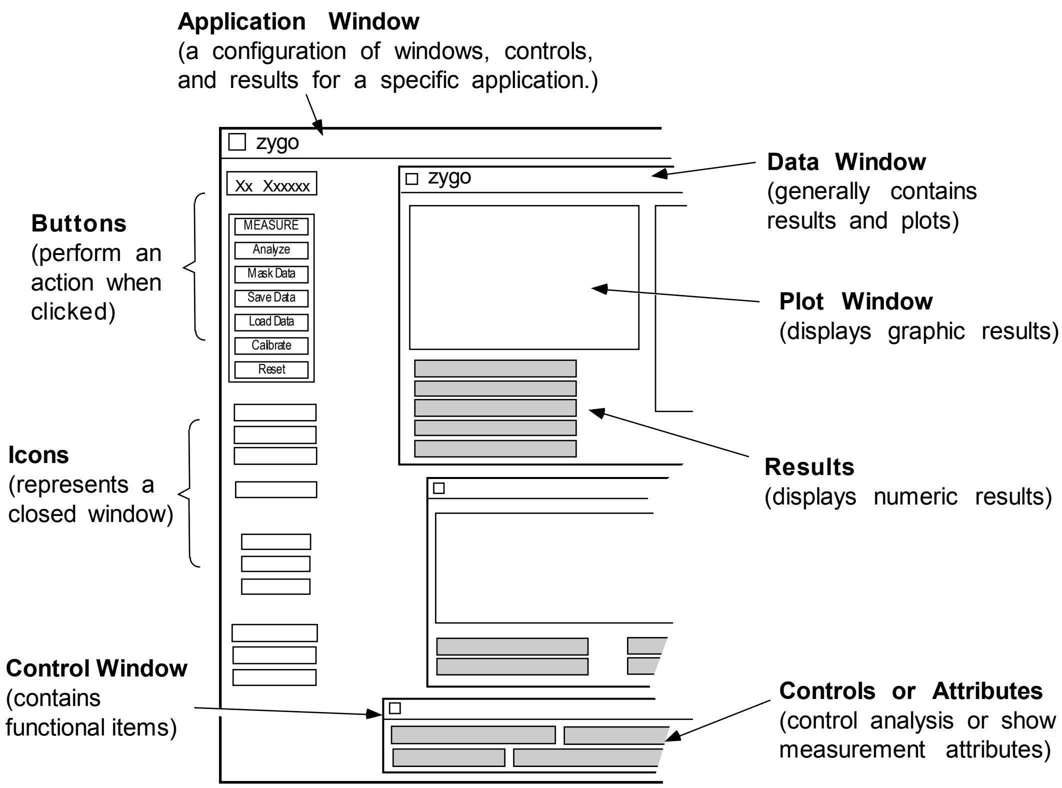
The Structure of MetroPro

MetroPro displays items in hierarchical or "nested" windows. The controls, buttons, results, plots, and other features within a particular window vary depending on the window. Each item, whether a window, control, result, or button, has its own associated menu. The menu varies depending on the item.



The Structure of MetroPro (continued)





The Structure of MetroPro (continued)

Item	***Description***
MetroPro Window	The screen displayed when the program starts, it may contain multiple Application windows or icons.
Application Window	Represents one application or use of the instrument; it may contain Control, Data and other windows or icons.
Control Window	Used to control the measurement; it may contain buttons, controls, and attributes.
Data Windows	Used to view the data; it may contain Plot windows, controls, results, attributes, and buttons. There are two basic forms - map (a three dimensional data matrix) and profile (a two dimensional data grid).
Plot Windows	Show graphic representations of measurement data. The most common three dimensional plot is the Filled Plot. A two dimensional plot is called a Profile Plot. A device called a “Controller” is used to control each plot display.
Process Window	Used to gather results from multiple measurements; and for controlling statistical processing analysis; it may contain controls, buttons, and copies of boxes.
Report Window	Used to compose measurement results and information for saving to a file, logging to a file, or for printing; it may contain controls, buttons, and copies of boxes.
Video Monitor Window	Used to place measurement results and information on the Video Monitor screen; it may contain controls, buttons, and copies of boxes.
Controls	Software controls used to manage the acquisition or analysis of data.
Buttons	On-screen push buttons that are activated with the mouse to perform general system functions or open other special windows.
Results	Display numeric measurement results.
Attributes	Status boxes that show information about the current measurement.
Icon	A window in its minimized state; it appears similar to a button.

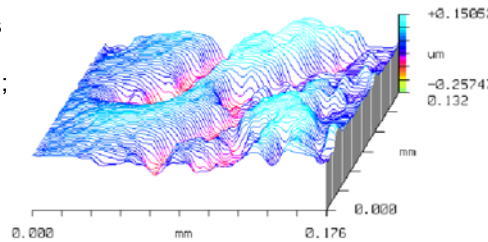
What Are Data Windows?

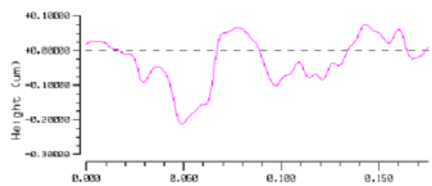
A data window is a view of the test part at a specific stage of the analysis. The analyses performed on the test part are determined by what data windows are opened. When new plots and results are added into a data window, they are immediately calculated and displayed. Most applications have data windows that are labeled to depict their function.

Data windows are created with the New Data Window command, which is accessed through the Application Window menu. Before creating a data window, clear the screen displays of measurement data by clicking the Reset button.

Many data windows can exist in two forms: map and profile. A *map* is an area of data; a map data window displays plots and results based on three dimensions. A *profile* is a line of data; a profile data window displays plots and results based on two dimensions. Profile data windows are vector data subsets of the parent data window map.

A typical surface has features in 3 axes. This is called a "map"; the surface is represented by a matrix of height values corresponding to the test surface.



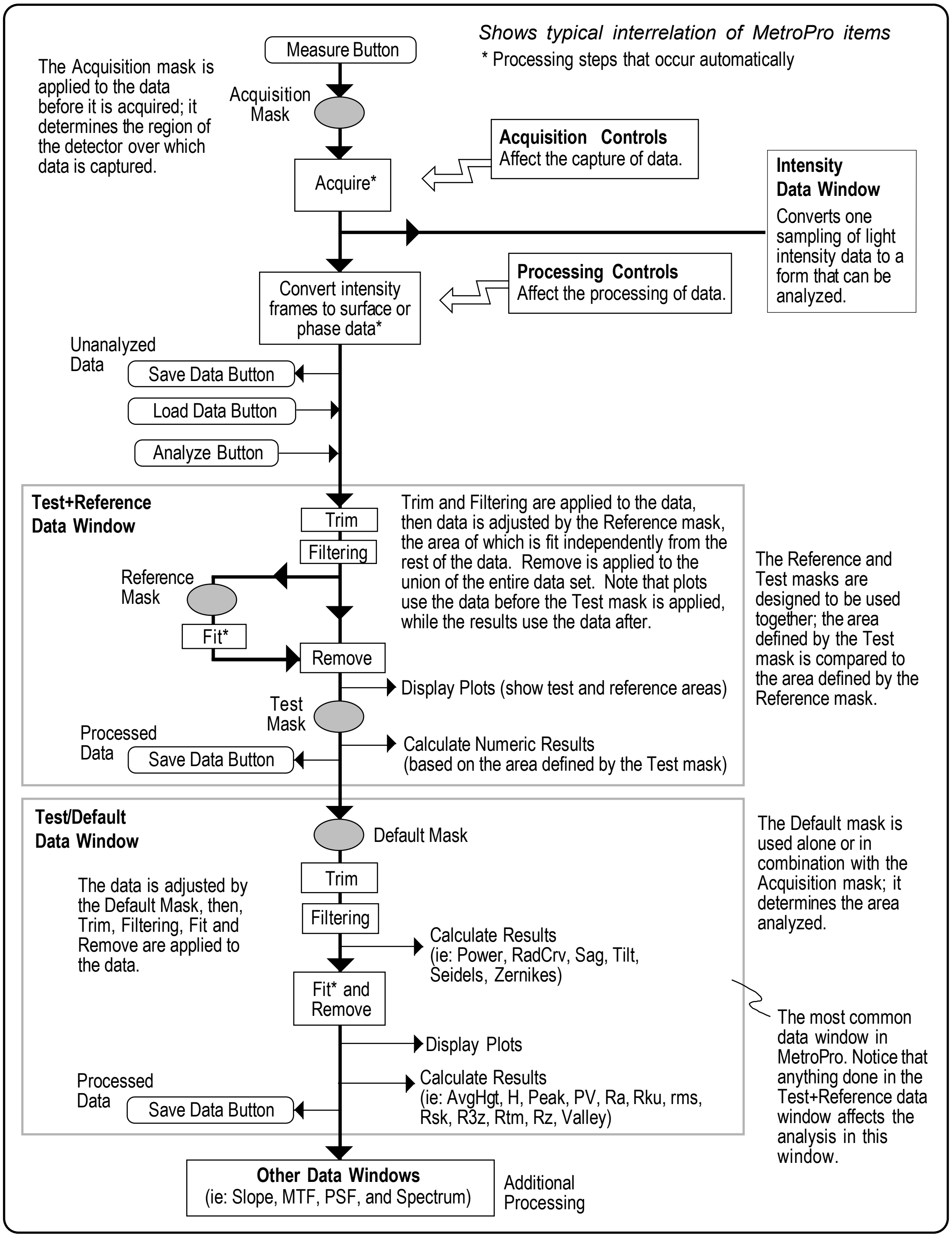


A slice through the map creates a "profile". Results are based on 2 dimensional data.

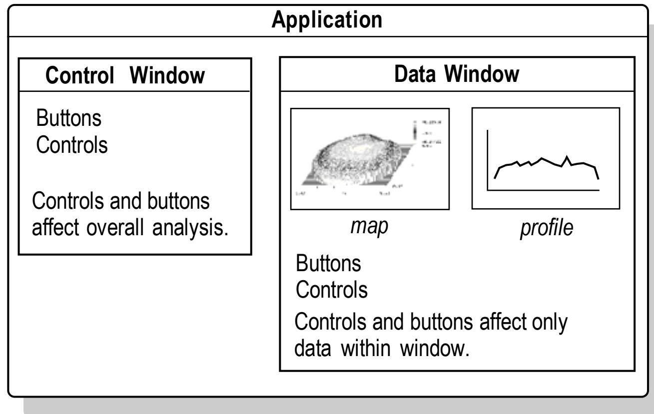
One special data window of interest is the Test+Reference data window. It is used with test and reference masks for relational type measurements where one area of the part (test) is compared in relation to another area on the same part (reference). It shows the results of acquiring, converting, and connecting the measurement data, and then manipulating a test region and a reference region. The test and reference regions are specified by masks; these areas may be disjointed, overlap, or be the same area.

Plots in data windows using test and reference areas use the data points in the union of the reference and test regions. Results are calculated on the points in the test region. However, results with the suffix “All”, are calculated on the points in both test and reference regions. If the Remove control is set to any setting other None, a fit is performed on the reference region, and remove is performed on the union of the reference and test regions. See “MetroPro Processing Flow” later in this section.

MetroPro Processing Flow



The Key to Understanding MetroPro Applications

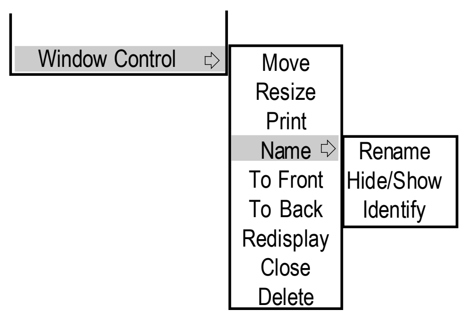


The most basic elements of any MetroPro application are control windows and data windows.

The control window contains controls for the application. Some are specialized for the particular application, but the large majority are similar from application to application. Controls determine how data is obtained and how it is analyzed.

A data window is a look at the data somewhere along the analysis path. There are numerous varieties of data windows. Data windows are named such that they indicate what data is displayed within. There are two general types of data windows, map and profile. A map data window shows three dimensional data; a profile data window shows two dimensional data, based on a slice through the three dimensional data. The controls, results, and plots available in each data window vary. Controls within data windows affect only the data within that window.

Finding Out What an Item Is



Knowing the original software name can help you find out more about an item in question. Use the original name when looking for information in this manual.

The Identify command provides information about the item under the mouse pointer when the command is selected. The Identify command is useful when the names of windows, boxes, and buttons have been changed in the application or when the window title bar is hidden. For windows, the Identify command is accessed with the Window Control → Name → command. For controls, results, attributes, and buttons, the Identify command is accessed with the Name → command. The Identify command is not available for icons

When the Identify command is selected, a Message box appears with information dealing with the item. Click the OK button to clear the Message.

Section
2

Controls and Buttons

For MetroPro to acquire data and analyze it the way you want, you need to know what the controls and buttons do. They are listed here under the item's name.

This section provides an alphabetical listing of MetroPro controls and buttons. Where applicable, specific applications are listed. Details for selecting and changing control settings are provided.

Refer to the button or control of interest by name in this section. All entries for buttons have the word "button" in them.

Buttons

A button is a small on-screen box that causes some action when you click on it with the left mouse button. To create buttons use the New Button command.

Buttons that are located in the Mask Editor, Calibrator, plot Controllers, and other specialized software items are explained under the item in which it resides.

Use the Button's menu to modify the button.

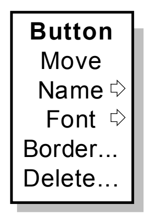
Move relocate the button.

Name change the button name or get information.

Font select the button's type style.

Border change the line width of the surrounding box.

Delete erases the button from the screen.



Controls

Controls are used to adjust settings that affect the measurement and the analysis of measurement data, or to enter user or test part information. Most controls within control windows serve as global controls affecting all measurements. Controls within other windows are used to control the analysis only within that particular window. Controls are blue and are created with the New Control command.

Controls (continued)

To enter text or a number in a control, click on the box with the left mouse button, type entries with the keyboard, and then press [Enter]. To change a selection, click on the box with the left mouse button.

Controls that are part of a unique function, such as those in the Mask Editor, Calibrator, and other items are explained under the item in which it resides.

Use the Control's menu to modify the box.

Units select measurement unit.

Move relocate the button.

Name change the control name or get information.

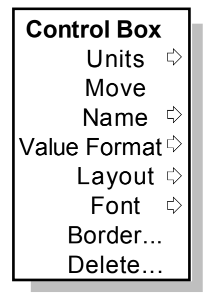
Value Format select the way numbers are displayed. For example, one selection makes it possible to have numeric values left-padded with zeroes instead of spaces.

Layout change the way the box looks.

Font select the control's font type and size.

Border change the line width of the surrounding box.

Delete erase the control from the screen.



actual menus will vary

Most controls are also available as attributes. Attributes normally reflect the setting of a corresponding control at the time the measurement was taken. Attributes display status information of the current data set and appear as black boxes. An attribute may appear to look just like the control, except for its color. Unique attributes are listed under "Results" in *Section 3* of this guide.

Saving Control Settings

Normally, the settings of controls return to factory default settings when an application is closed and reopened. You can however, save the present configuration of control settings and later load these; this quickly sets all controls to your predetermined settings.

In a Control Window, select the New Button command and create the Save Settings button and Load Settings button.

- To *save* your control settings click the Save Settings button. In the File Handler, click the "Current Selection" box , enter a name for the settings file, ending with ".set", and then press [Enter]. Click the Done button to close the File Handler.
- To *load* your control settings click the Load Settings button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

Control Settings and Their Interaction

The settings of certain MetroPro controls are interrelated. This means that changing the value of one control can change the selections available in other controls. The following controls fall into this category:

Acquisition Mode
Camera Mode
FDA Res
Scan Length
Scan Type

These controls have a hierachical interaction. Changing the value of a control *higher* in the list can change the selections available lower in the list. Changing a control *lower* in the list has no effect on the selections available in controls higher in the list. Wherever possible, MetroPro tries to preserve the user's settings.

However, it is important to remember that changing one setting for a control can impact other control settings that have a common functionality.

4PtTw Mode

ABS Geometry Applications. Four Point Twist Mode selects the portion of the rails used for calculating 4PtTw. Settings are None, Boxes, Circles, or Thirds. Boxes use a small rectangular area of each rail. Circles use a small circular area of each rail. Thirds use the last third of each rail and includes rail edges. 4PtTw Mode is not applicable to AAB 1, AAB 1 (Wide), AAB 2, Proximity, or Proximity 3 slider types.

A + B button

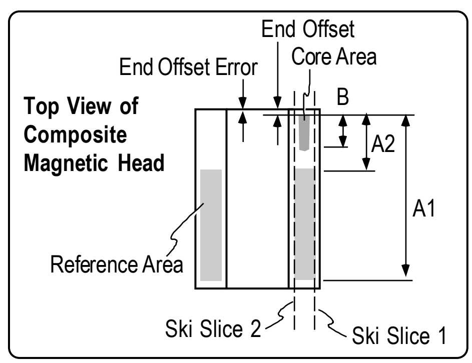
Three Flat Application. Click to select the current measurement; the instrument must be positioned in the proper setup before you measure. The transmission flat (A) is on the instrument, transmission flat (B) is on the 2-axis mount.

A + C button

Three Flat Application. Click to select the current measurement; the instrument must be positioned in the proper setup before you measure. The transmission flat (A) is on the instrument, the test flat (C) is on the 2-axis mount.

A1

ABS Geometry Applications. Specifies the dimension from the End Offset to the bottom of the reference area used for reference remove.



A2

ABS Geometry Applications. Specifies the dimension from the End Offset to the top of the reference area used for reference remove.

AAB 1 Min Area (%)

ABS Geometry Applications. Specifies the minimum area size of a valid ABS region, as a percentage of the total number of points in the ABS. When greater than zero, regions smaller than this percent of the total number of points in the ABS area are deleted. The default setting is 0. Slider Type must be AAB1, AAB1 (wide), Proximity, or Proximity 3.

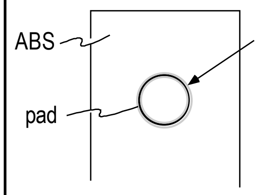
AAB1/Prox Trim

ABS Geometry Applications. Specifies the number of pixels to remove from the data after identifying the hogout region and before identifying the ABS areas. Applicable when the Acquisition Mode control is Scan, and the Slider Type control is AAB1, AAB1 (Wide), Proximity 3, or Proximity. It is useful when scan measurements have captured "wall" data (data up the sides of the ABS) around the ABS or between the ABS and hogout regions that interferes with the calculation of accurate fit coefficients. Valid values are from 0 to 7; the default setting is 3.

ABS (Pad) Trim

ABS Geometry Applications. Specifies the number of pixels to trim from the ABS around the hole left by removing a pad. Range: 0 (default) to 5.

Works in conjunction with Pad Trim and Pad Cutoff controls. Applies only when the Remove Pads control is On.



Close-up of Slider Rail

ABS Reference Length

Trimmed PTR Application. Specifies the length of the ABS surface. It is used to separate the ABS from the unetched glass region. Slice the head vertically in the Filled Plot in the surface data window to determine a valid distance.

Absolute Cutoff

Advanced Texture Application. Specifies a cutoff by height, when the Cutoff Mode control is set to Absolute. Only summits with heights greater than this value are analyzed. Part of the summits analysis.

Acquisition Mode

Selects the way data is obtained. Settings are Phase, Scan , or Fringe. The applicable setting depends on the instrument.

Phase tells the software to convert multiple frames of intensity data into phase data. This setting is used for Zygo's interferometers and phase microscopes. *Scan* tells the software to covert multiple frames of intensity data into surface data. This setting is for Zygo's scan microscopes. *Fringe* tells the software to analyze one frame of intensity data, such as with the Static Fringe application, when data exists as a fringe pattern. This setting is for large aperture interferometers without phase modulation.

Add Data button

Opens a text entry box, which is used to specify the name of an existing data file in the current directory. The specified data file is added to the current data. The summed data map becomes the current data set. Bad pixel locations in either data map remain bad pixels. If data sets don't intersect in space, there is no data. To cancel the action, press the right mouse button or the ESC key. Adding one data set to another may be used to view the effects of combining aberrations.

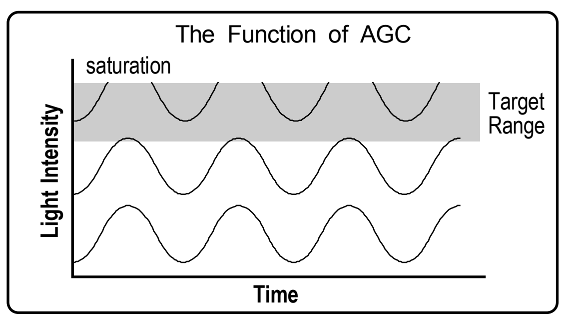
The manipulated data set must exist in the current directory. You can change directories by clicking the Save Data button or Load Data button, and specifying the directory with the File Handler.

AGC

Selects if AGC (Automatic Gain Control) is used to automatically adjust for the optimum light level during the measurement. AGC is a system level control feedback loop that samples the camera output while adjusting the instrument variable light level controller for the best signal from the camera for the specific part under test. The AGC function maximizes the signal-to-noise of the camera data by raising the light level to a point just below where any pixels become saturated.

For most conditions AGC should be On, as it compensates for different test part reflectivity and varying laser output. In addition, AGC adjusts for the optimum light level of the test part defined by an optional Acquisition mask. When AGC is Off, the variable light level controller is set to either the setting specified by the Light Level control or the last setting used with AGC on.

This graph illustrates the function of AGC. The sine wave represents alternating light and dark fringes. AGC adjusts the light intensity output from the instrument as high as possible without saturation. The Target Range control defines an acceptance band before saturation.



AGC Mode

Selects the mode of operation for the light level automatic gain control of the instrument. Settings are Normal Reflectivity or High Reflectivity. The AGC Mode does not affect the acquisition of data, it only affects the AGC function.

Normal Reflectivity adjusts the light intensity output from the instrument as high as possible without saturation; this setting is used for most test parts. *High Reflectivity* readjusts the threshold level of the AGC function to help prevent camera saturation. Use this setting when the test part has a reflectivity greater than 90% and the video monitor screen is very bright.

Align To

ABS Geometry Applications. Used to select the edge to calculate the Slider Angle when Slider Type is set to Two Rails (Generic), Two Rails (Bisect), Three Rails (Generic), Three Rails (Bisect), Three Rails (Split), or Three Rails (Defined). For other slider types, this control is ignored. Settings are Top of Rails or Bottom of Rails.

Use Top of Rails when there are left and right rails of equal length and when a line connecting the top of the rails is perpendicular to the long axis of the slider. Use Bottom of Rails when this condition is not met or if a third rail extends past the two rails. Note that if the microscope cannot resolve to the bottom of the taper, the Bottom of Rails setting will not work.

Alignment

Selects the type of alignment done when subtracting data with fiducials. Settings are Fiducials or None. Click it to select Fiducials.

Align Pattern Script File

This control is used in conjunction with the Run Align Pattern Script control and the Align Pattern button. This control specifies the name of the pattern script file that should be run at each pattern alignment site after the Align Pattern button is clicked. Applicable to systems with the programmable stage option.

Alignment Scaling

Selects how fiducials are aligned. Settings are Isomorphic or Anamorphic. Isomorphic scales both axes equally. Anamorphic scales to the best fit.

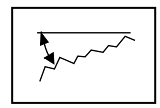
Alignment Tol

Specifies the pixel tolerance allowed when aligning fiducials. Enter a numeric value. This control is used in conjunction with the Alignment Scaling control.

Analyze button

Recalculates measurement data using the present control settings; it does not acquire new data. Click the Analyze button to recalculate data after changing control settings, such as Remove or Trim. Pressing F2 is the same as clicking the Analyze button.

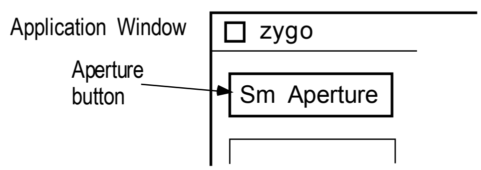
Angle Units



Selects the master unit system for all angle based results; settings are Degree or Radian. It applies to results such as TltAng, TltMag, Tilt X, Tilt Y, and Seidels.

For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or µm.

Aperture button



Selects the interferometer aperture in use. This button is part of the interferometer applications. It is permanent; it can not be moved or deleted. Selections are Sm Aperture or Lg Aperture.

Sm Aperture is for a 4-inch or 6-inch aperture or when you are using the smaller channel of a large aperture system. In this setting, the PMR attached to the instrument is selected and its driving circuitry is activated.

Lg Aperture is for systems with a 12-inch or 18-inch aperture. In this setting, the instrument's PMR is turned off and a remote PMR is activated.

Aperture ID (%)

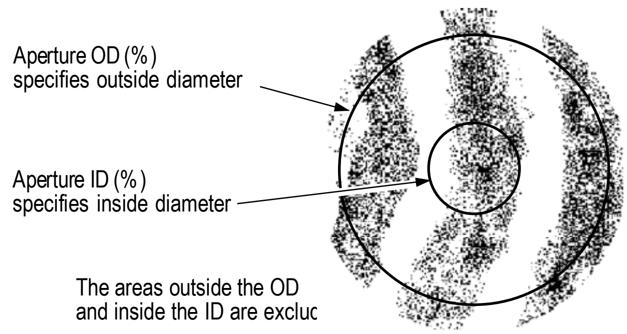
Specifies the inner diameter of an automatic round aperture mask. The size is specified as a percentage of the data set. Data inside this mask is excluded from the analysis. The Auto Aperture control must be On.

Aperture OD (%)

Specifies the outer diameter of an automatic round aperture mask. The size is specified as a percentage of the data set. Data outside this mask is excluded from the analysis. The Auto Aperture control must be On.

Auto Aperture

Activates an automatic circular mask creation. When Auto Aperture is On, a circular default mask is automatically created when a measurement is made. This mask is centered over the middle of the data; its size is specified by the Aperture ID (%) and Aperture OD (%) controls. Results are calculated only on the region enclosed by the circular mask.



When Auto Aperture is On, any existing default mask is cleared so a new circular default mask can be created. The automatic aperture mask function is not compatible with the Test and Reference masks; an error message appears if you try to use the Auto Aperture feature with these masks. The automatic aperture mask function is compatible with the Acquisition mask.

Auto Center button

PTR Application. Moves the stage to center the pole tip within the PTR test mask. Requires a programmable stage.

Auto Center Mode

PTR Application. Determines the positioning of pole tips prior to making a measurement. Settings are Off or Pole Tip. When set to Pole Tip, the software drives the stage to center the pole tip within the PTR test mask. Requires a programmable stage.

Auto Focus

Selects how to use auto focus in the stitch sequence. Settings are Off, First Measurement Only, All Measurements. Off disables auto focus. First Measurement Only uses auto focus only on the first measurement of the stitching sequence. All Measurements enables auto focus for all measurements of the stitch sequence.

Auto Focus Min/Mod %

This is the minimum modulation (in percentage) necessary to obtain a valid height data point for use in the auto focus calculation. A lower value includes weakly modulating points. A higher value includes only strongly modulating points. The value is usually a low number, as low as 1.

Auto Load Masks

Activates automatic loading of a mask file specified with the Masks File Control box.

Auto Load Pattern

Activates automatic loading of a pattern file specified with the Pattern File Control box.

Auto Mask

Enables the automatic creation of masks. It's function varies depending where it is used.

Disk Flatness Application. Defines the portion of the data that will be analyzed. The control is either On or Off. When On, the software uses the values entered in the Inner Flyable Radius and Outer Flyable Radius controls to define the mask.

Corner Cube Application. When On, a mask is automatically created that surrounds each corner cube sector. It is used to isolate the sectors for results on each individual sector. When Off, individual sector results are not calculated.

Auto Run Script

When On, the script file specified by the Script File control, is automatically run when the application is opened. Off is the default setting.

Auto Save Data

Auto Save Data activates the automatic saving of a data file after the measurement. Its settings are On or Off. When Auto Save Data is On, data is saved every time the Measure button or the Run Pattern button is clicked. The names of the data files are determined by the Auto Save Data File control.

Auto Save Data Dir

This control allows you to specify a directory path in which to automatically save data files. The directory may have any number of levels. When the data is being auto-saved, the directory path will be created automatically if it does not already exist. It is possible for the directory path to be automatically generated using a combination of control values such as Lot Number, Part Number, Part Serial Number, and Pattern File. Refer to the "Special Codes" section of *Section 8* of this manual for additional information.

Auto Save Data File

Specifies the name of the data file to automatically save and how the name changes with subsequent measurements. To enter a file name, click on the box with the left mouse button, type a name, ending with ".dat" and press [Enter]. The file name must be 20 characters or less The default auto save data file name is "MyData000.dat". The Auto Save Data control must be On. It is possible to have additional information, such as Lot Number, Part Number, Part Serial Number, and Pattern File Name, appear in the data file name. Refer to the "Special Codes" section of *Section 8* of this manual for additional information.

The mode of operation of the Auto Save Data File control is selected with the Mode command from the control's menu. The current mode of operation is indicated by an asterisk (*). Modes are Normal, Prompt, or Auto-Increment.

When the Mode is *Normal*, the data is saved under the specified name after the measurement is complete. If additional measurements are made, the file is overwritten with new data. When the Mode is *Prompt*, the software asks you to enter the file name after each measurement.

When the Mode is *Auto-Increment*, the file name is incremented by one and a new data file is created after the measurement is complete. This lets you create a series of data file names without typing a file name after each measurement. For example, "MyData000.dat" becomes "MyData001.dat". One digit in the name provides for ten increments, two digits for 100 increments, and three digits for 1000. When the maximum increment is reached, digits roll over and 999 becomes 000.

Auto Save Data Sag Width

This control is operational only if MetroPro was started with the –windowsDialog command line option. This control specifies the sag width for saving data when taking measurements with the Auto Save Data Type control set to ZEMAX.

Auto Save Data Type

This control is operational only if MetroPro was started with the –windowsDialog command line option. It provides a selection of data file types with which to save files when taking measurements. The Auto Save Data control must be set to On. File Format selections include: Binary, ASCII, CODE V, OSLO, ZEMAX, and SDF. (Refer to "Appendix B, File Formats" and "Appendix C, Command Line Options" for additional information.)

Auto Save Seq

Activates the automatic saving of a sequence file. When On, the sequence file named by the Seq File control is saved to file.

Auto Seq Buckets button

When the Acquisition Mode control is set to Phase, the instrument acquires multiple "buckets" of intensity data for the phase algorithm. The Auto Seq Buckets button displays the complete sequence of intensity data in the plots in the Intensity Data window. It is primarily used as a diagnostic tool.

Auto Seq button

Activates an auto sequence function. The auto sequence function can automatically make multiple measurements and save the data. Various events are controllable: the number of measurements, time delays before and between sequences, and the automatic saving of data files.

Auto Seq Delay

Auto Seq Delay (Auto Sequence Delay) specifies a time delay in hours, minutes, and seconds before an auto sequence is started.

Auto Seq Interval

Auto Seq Interval (Auto Sequence Interval) specifies a time delay in hours, minutes, and seconds between measurements or auto sequences.

Auto Seq Max Count

Auto Seq Max Count (Auto Sequence Maximum Count) specifies the number of auto sequences to perform, from 0 to 9999.

Auto Seq Operation

Auto Seq Operation (Auto Sequence Operation) selects the auto sequence mode. *None* means that auto sequencing is disabled. *Measure* means that the instrument is set to take a series of measurements. *Run Pattern* means that the programmable stage option is set to run the current pattern file. *Run Script* means that the MetroScript file specified in the Auto Seq Script File control will be run.

Auto Seq Script File

Specifies the script file to be run during an auto sequence when the Auto Seq Operation control is set to Run Script.

Auto Step Cal Avgs

Step Height Application. Specifies the number of averages to be performed during an auto step calibration sequence. A recommended minimum value is 5.

Auto Step Cal button

Step Height Application. Click to initiate an automatic calibration sequence. The instrument measures the step height standard, averages the results, and computes a scalar value required to bring the measured height in agreement with the nominal height. When completed, you are asked if it is okay to replace the system calibration file.

Auto Store

The Auto Store control- in the Process window, activates the automatic storing of measurement values in temporary memory for Control Charts and Process Stats. When Off, values are not stored.

Auto Tilt

This control enables or disables tilt removal at the start of a measurement. Settings are On or Off. This control applies only to microscopes with programmable pitch and roll stages.

Stitching Application. Selects how to use auto tilt in the stitch sequence. Settings are Off, First Measurement Only. First Measurement Only uses auto tilt only on the first measurement of the stitching sequence.

Auto Tilt button

Click to make the microscope stage perform an auto tilt adjustment based on the current settings of the auto tilt controls. This button applies only to microscopes with programmable pitch and roll stages.

Auto Tilt Domain

Specifies an area or range of degrees of usable fringes. This control applies only to scanning microscopes with programmable pitch and roll stages.

Auto Tilt Iterations

Specifies how many times to perform the auto tilt operation. On some instruments, repetition allows the auto tilt operation to converge and obtain a more accurate adjustment. A value of 2 causes the operation to be performed initially and then repeated. A value of 3 is the highest setting that should be required. This control affects the operation of the auto tilt function when the Acquisition Mode control is set to Phase.

Auto Tilt Max Adjust

This control is used for any auto tilt function. Specifies the maximum adjustment allowed from the starting pitch and roll positions. This control applies only to microscopes with programmable pitch and roll stages.

Auto Tilt Min Contrast

Specifies the minimum tilt fringe contrast in percent. Contrast is based on values from 0-100, with 100 being the highest contrast. Fringes with lower contrast than the entered value are considered unacceptable. This control applies only to phase microscopes with programmable pitch and roll stages.

Auto Tilt Min/Mod %

This is the minimum modulation (in percentage) necessary to obtain a valid height data point for use in the auto tilt calculation. A lower value includes weakly modulating points. A higher value includes only strongly modulating points. The value is usually a low number, as low as 1.

Auto Tilt Mode

This control, in conjunction with the Acquisition Mode control, determines the technique used to remove tilt. When the Acquisition Mode is Phase, a modulation technique is used; when set to Scan a scanning technique is used. Settings are Software or Hardware. Hardware only applies to instruments with applicable hardware. This control applies only to microscopes with programmable pitch and roll stages.

Auto Tilt Pitch Offset

Used for any auto tilt function. The value entered in degrees is added to the stage pitch position calculated for null tilt. This control applies only to microscopes with programmable pitch and roll stages.

Auto Tilt Pitch Tol

Specifies a tolerance value in degrees for the pitch axis. The calculated pitch angle is compared to this value. If the absolute stage pitch value is less than the respective tolerance, no adjustment is performed. This control applies only to microscopes with programmable pitch and roll stages.

Auto Tilt Roll Offset

Used for any auto tilt function. The value entered in degrees is added to the stage roll position calculated for null tilt. This control applies only to microscopes with programmable pitch and roll stages.

Auto Tilt Roll Tol

Specifies a tolerance value in degrees for the roll axis. The calculated roll angle is compared to this value. If the absolute stage roll value is less than the respective tolerance, no adjustment is performed. This control applies only to microscopes with programmable pitch and roll stages.

Auto Update

The Auto Update control, in the Video Monitor window, activates the automatic updating of the video monitor screen with the contents of the Video Monitor window after each measurement. When Off, the video monitor screen is not updated with information.

Average Overlap Regions

Selects if the stitching algorithm averages overlap regions. Settings are On or Off. It is recommended that this control be On. Averaging the overlap regions results in a stitched image with less discontinuity.

B

ABS Geometry Applications. Specifies the distance along the ski jump region from the End Offset where the ski jump peak analysis occurs. See A1.

B + C button

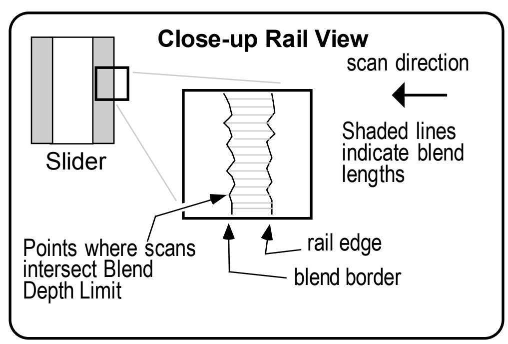
Three Flat Application. Click to select the current measurement; the instrument must be positioned in the proper setup before you measure. The transmission flat (B) is on the instrument, the test flat (C) is on the 2-axis mount.

Blend Depth Limit

Edge Blend Application. Specifies a distance below the ABS so that the roughness of the ABS is effectively ignored when calculating blend length results. Typically, settings are from 6 to 25 nm. When set to zero, the start of the blend is where the blend intersects the line fitted to the ABS.

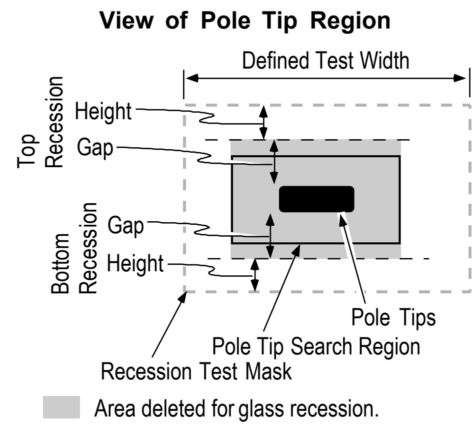
Blend Fit

Edge Blend Application. Selects the fitting of a parabola to points along the rail edge and blend border; it affects the displays and results. Settings are None, Edge, and Edge and Border. None means no fitting is used; it is the default setting. Edge fits a parabola at the edge of the rail to remove visual edge effects. Edge and Border fits a parabola to the edge of the rail and at the blend border location; it is used to remove edge and border effects from the screen displays.



Bottom Recession Gap

PTR Applications. When the Mask Mode is set to Defined, it defines the height of an area below the pole tips that is *not* included in the recession test mask.



Bottom Recession Height

PTR Applications. When the Mask Mode is set to Defined, it defines the height of an area below the Bottom Recession Gap that is included in the recession test mask.

BR / CR button

Three Flat Application. Click to select the current measurement; the instrument must be positioned in the proper setup before you measure. Either the transmission flat (B) or test flat (C) must be rotated. The transmission flat (B) is on the instrument, the test flat (C) is on the 2-axis mount.

Bucket

Specifies which bucket of intensity data to use in the plots and results within the intensity data window. Functions only when MetroPro is run in the diagnostic mode.

Calc High Frequency

Advanced Texture Application. When On, high frequency information is calculated for and displayed in the HiF plots. When Off, calculation time is reduced.

Calc Low Frequency

Advanced Texture Application. When On, low frequency information is calculated for and displayed in the plots. When Off, calculation time is reduced.

Calculate button

In general, it calculates final results based on a number of separate measurements. Click the Calculate button after all measurements are complete.

PHom Application; calculates the homogeneity results based on four measurements. Three Flat Application; calculates the vertical and horizontal cross-sections and draws the profile plots. Two Sphere Application; calculates the results after all measurements are done.

Calculate Shape Results

Advanced Texture Application. When On, results (such as Max Ext, Min Ext, and Aspect) about the shape of a peak or a valley are calculated. Part of the peaks/valleys analysis.

Calibrate button

Opens the Calibrator window. See Calibrator for more details on the calibration function.

Camera Mode

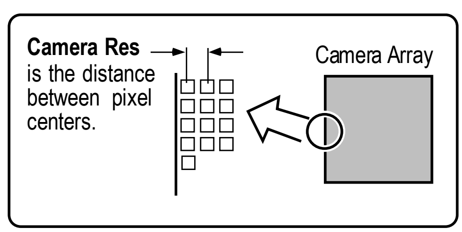
Camera Mode selects the effective camera size for acquiring test data; it defines the measurement resolution in pixels. The selections for this control vary based on the actual camera installed in the instrument. If there is not an active instrument, Camera Mode displays None.

Typical selections for Camera Mode include: 160x120, 320x240, and 640x480. Generally, the selections are the full camera array or aperture. The greater the number of pixels, the finer the resolution, but the longer it takes to process the data. The Camera Mode selections also indicate the speed (in Hz) at which data is collected.

Additional information on specific Camera Mode selections may be found in the applicable instrument manual.

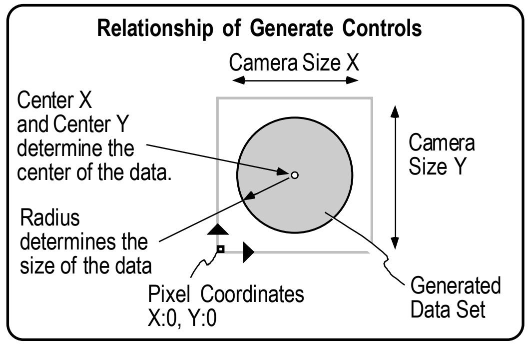
Camera Res

When generating a data set, this control specifies the distance between camera pixels. Entering a value in the Camera Res control has no affect on measurements, as resolution information is overwritten by a system calibration file.



Camera Size X

When generating a data set, this control specifies the number of camera pixels in the x dimension. Settings are: 50 to 512.



Camera Size Y

When generating a data set, this control specifies the number of camera pixels in the y dimension. Settings are: 50 to 480.

Cat's Eye button

Three Zone Radius Scale Application. Initiates a measurement of a part with three different radii, when at the cat's eye position. The interferometer and test part must be setup in the cat's eye position before clicking.

CatsEye button

Two Sphere Application. Click to select the cats eye measurement. The interferometer and test part must be setup in the cat's eye position before you measure.

Cavity button

PHom Application. Click to select the Cavity measurement. For the cavity setup, the test part is removed and the measurement beam reflects off the reference flat.

Center Rail Reference Remove

ABS Geometry Applications. Selects a surface fit to the left and right ABS and removed from the center ABS. Selections are Plane, Sphere, or Cylinder. This control is applicable to all Three Rails slider types and Proximity 3.

Center Rail Trim

ABS Geometry Applications.   Specifies number of pixel layers to remove from edges of the center rail. The Center Rail Trim Mode control specifies where the trim is performed, either to All edges or Outside edges. This control is applicable to all Three Rails and Proximity slider types.

Center Rail Trim Mode

ABS Geometry Applications. Selects the edges where the number of pixel layers entered in the Center Rail Trim control are trimmed. Settings are All or Outside.

Center X

Specifies the x-axis center location in pixels of a generated wavefront. An entry of -1 places the Center X in the middle of the Camera Size X dimension. See Camera Size X.

Center Y

Specifies the y-axis center location in pixels of a generated wavefront. An entry of -1 places the Center Y in the middle of the Camera Size Y dimension. See Camera Size X.

Clear button

In general, this button removes all information from the window in which it is located. Some specific functions are detailed below.

Process window; removes all stored measurement values from temporary memory, which also erases all values from Process Stats and Control Charts. Video Monitor window; clears all information form the video monitor display. PHom Application, Three Flat Application, and Two Sphere Application; erases all current measurement information; click when starting a new measurement series.

Clip Cutoff (%)

ABS Geometry Applications.   (Applicable to TPC slider types only)   Specifies a percentage of the stepped areas to use when fitting a plane; this plane is then used to calculate height results between a plane fitted to the ABS. The default setting is 0 (Off). Use if the stepped areas are extremely rough; a suggested setting is 60.

Code V Type

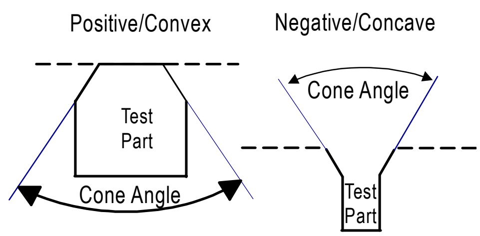
The type of CODE V data saved when the Save Zernikes button is clicked. Settings are WFR (wavefront) or SUR (surface). This control should be used when saving data as Code V Zernike data as described in "Appendix B."

Coef (0 to 36)

This discussion includes 37 Control boxes, from Coef 0 to Coef 36. Settings: positive or negative number. This group of controls are used to enter the coefficients for Zernike Polynomials when generating a Zernike data set. The number of Coef X controls used should match the number of Zernike Terms selected in the same Control window.

Cone Angle

This control specifies the cone angle to remove from the data during analysis. It is used in conjunction with Fixed Angle Cone and Variable Angle Cone, which are options in the Remove control. An entry is required for Fixed Angle Cone.



The acceptable range is: 5 to 180;–180 to –5. A positive value indicates a convex cone, and a negative value a concave cone. While this control is not required with the Variable Angle Cone option, if a value is entered, the software will use the value as a starting point when determining the best-fit cone. Access this control from the New Control menu. See the Remove control in this section for additional information on Cone Angle.

Comment

Serves as a user entry box for typed remarks. To enter text, click on the box with the left mouse button. An entry field appears, in which you type whatever you want, such as a company name, a part description, or a technician name. When you have completed the entry press [Enter].

Comment differs from an Annotation in that it is saved with a data set, an Annotation is not. Change the size of the Comment box by using the control's Width command.

Confocal 0 button

Two Sphere Application. Click to select the confocal 0 measurement. The interferometer and test part must be positioned in this setup before you measure.

Confocal 180 button

Two Sphere Application. Click to select the confocal 180 measurement. The interferometer and test part must be positioned in this setup before you measure.

Confocal 270 button

Two Sphere Application. Click to select the confocal 180 measurement. The interferometer and test part must be positioned in this setup before you measure.

Confocal 90 button

Two Sphere Application. Click to select the confocal 90 measurement. The interferometer and test part must be positioned in this setup before you measure.

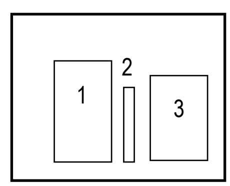
Connect Data button

Reconnects data using connect and its associated parameters such as Min Area Size and others. Part of a manipulate function.

Connection Order

Selects how data is connected when the Acquisition Mode control is set to Phase. During the processing of data, regions of data are connected or joined together to form the details of the test sample. Connect is defined as the process of taking wrapped (modulo 2π) phase data and turning it into unwrapped (continuous) phase data.

Settings are Location or Size. *Location* connects data areas by location; it starts with the largest area and connects it to adjacent areas, radiating outward until all areas are connected. *Size* connects consecutive data areas by size; this connects largest data areas first, which by having more points and provide a more reliable starting point.



The box shown here represents a data set; regions 1, 2, and 3 are all in the same plane. The connect algorithm uses a least squares technique to establish the proper offset that must be added to regions 2 and 3 to place them on the same surface as region 1. If Connection Order is Location, areas 1 and 2 are first connected, then region 3 is added. But region 2 may be at the wrong offset and affect the plots. If Connection Order is Size, the greater number of data points in regions 1 and 3 provide a stable platform which to add region 2.

Connection Type

Specifies what portion of the surface is used in the connect process to join multiple regions when the Acquisition Mode control is set to Phase. Settings are Standard (use all data) or Modal (use dominant surface).

Connect Taper Last

ABS Geometry Applications. When On and Taper Location is not 0, connects data from region above the taper cut first. It is only utilized at *measure* time; it is *not* an Analyze control. The default setting is Off, and it can only be used during phase measurements.

Cont Pattern button

Click to continue running the current pattern from its present location. Applicable only to systems with programmable stages.

Conv Intens To Data button

Takes intensity data and dumps it into the surface/wavefront data window. Sometimes used as a debugging tool. When this action is performed, the only valid measurement units for results and plots are “zygos”, which are internal intensity units.

Core Location Tolerance

ABS Geometry Applications. Specifies a tolerance distance to the left and right of the Nominal Core Location within which to locate the core.

Core Nominal Location

ABS Geometry Applications. Specifies the nominal location of the core from the outside edge of the rail.

Core Rail

ABS Geometry Applications. Selects which rail has the core region. Settings are Left or Right.

Cutoff Mode

Advanced Texture Application. Cutoff determines what summits are analyzed. Cutoff Mode selects the method used in specifying the cutoff, Relative or Absolute. The corresponding control, Relative Cutoff or Absolute Cutoff, must also be set. Part of the summits analysis.

Data Fill

Determine if missing data points in plots are filled, based on the setting of the Fill Max control. Settings are Off (default) or On. Only affects the plot displays, it does not change the data or affect saved data.

Data Fill Max

Specifies the maximum size in pixels of a data hole that is filled when the Data Fill control is On. It is the total number of pixels in any one data hole.

Data Sign

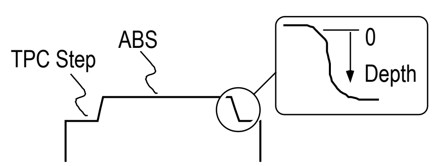
Changes the sign of the data. The normal sign of phase data is such that increasing phases correspond to decreasing cavity length and increasing surface heights. The Data Sign control allows you to change the sign, if due to your setup, the measurement data appears reversed in the results on screen. Settings: Normal (default) or Inverted.

Defined Test Width

PTR Applications. When the Mask Mode is set to Defined, it defines the width of the recession test mask. It must be wider than the Pole Tip Region Size X entry.

Depth

Wall Angle Application. Specifies the distance from the top of the ABS down. This data is used to calculate wall angle. Generally, set depth to 1/2 to 3/4 of the nominal step height.



profile view of one rail

Deskew Data

ABS Geometry Applications. When On results are compensated for rotation of the slider in the field of view. This control is available in the Slider (All), Slider (ABS), Top/Left, Bottom/Right, and Center ABS Data windows; the effect varies depending on the data window where it resides. Off is the default setting.

In the Slider (All) Data window it effects these results: Taper Angle, Cntr Taper Tilt, and Hogout Tilt. In the Slider (ABS) Data window it effects these results: Twist, TwistHt, TwistHt (Coef), CmbAng (Avg), CamberHt, Crown, and Crown 2. In the individual rail data windows it effects all Camber, Tilt, RadCrv, and Crown results.

Diagnostics

Stitching Application. Selects if diagnostic information from the stitch algorithm is provided. Choices are On or Off.

Discon Action

Selects how discontinuities or ambiguous data is handled, when the Acquisition Mode control is set to Phase. A discontinuity occurs when very steep pixel-to-pixel slopes or steps greater than half the wavelength of the light source are found in the data. Missing data in plots may indicate discontinuities. Settings are Filter, Delete Regions, or Ignore.

When *Filter* is selected, discontinuities are deleted based upon the setting of the Discon Filter control. Once the connect is finished, if discontinuities are detected, suspected areas are deleted from the phase data and the connect is repeated. (Connect is the process of joining data points together into a map representing the test part.) This process continues until no discontinuities remain in the data. A part may be so rough that none of it is measurable; if this is the case you would receive an error message. If discontinuities are present, it takes additional processing time.

When *Delete Regions* is selected, areas or regions that have discontinuity are removed. Use this option for special cases only. An example where Delete Regions is useful is when the test part has hundreds of separate discontinuous areas of data, in which some of these areas may have discontinuities. In this case, areas with discontinuities are removed and the analysis continues. However, with a typical test part comprised of one area of data with a few discontinuities, the entire area would be eliminated and the connect process would fail.

When *Ignore* is selected, data is checked for discontinuities, but they are not removed. This is primarily for debugging and should not be selected.

Discon Filter

Specifies the degree to which discontinuities are removed from data. A discontinuity occurs when very steep pixel-to-pixel slopes greater than half the wavelength of the light source are found in the data. The greater the value, the more discontinuities are removed, but the more likely that data is removed as well. Discon Filter is only applicable when the Discon Action Control box is set to Filter. Settings: 0 (none) to 100 (all), default is 60.

When should you change this value? If you are measuring rough parts, and the processing time has increased, you should try raising the filter value. This reduces the number of iterations it takes to remove discontinuities. If you see large areas of data missing where you think there should be data (and you see some screen indication that the discontinuity filter has been at work), then reduce the filter number.

Discr Mode

The Discr (discriminator) Mode control specifies how camera frames are processed during data acquisition. Settings are Normal (default) or RAM. When set to Normal, acquired data is processed in real-time. When set to RAM, the raw frame data is stored in the computer's RAM and processed later. This setting can reduce the "could not keep up with frame grabber…" error.

Disk Velocity (RPM)

Disk Flatness Application. Specifies the revolutions per minute for the disk.

Display Measurements

Selects whether individual measurements are displayed on screen during the stitch sequence. Settings are On or Off.

Display Stitched Surfaces

Stitching Application. Specifies whether individual stitched surfaces are displayed. Settings are On, Off.

DMI Mode

Selects the frequency of the measurement beam of the motion interferometer or distance measuring interferometer (DMI). Choices are Freq 1 or Freq 2. This is part of the DMI Test window; used with the radius scale option.

Edge Dimension (%)

ABS Geometry Applications. Specifies where to locate the slices on the rail for the analysis as a function (percentage) of the rail width. Range: 0 to 100, 20 (default). The width of the entire rail is 100%. The slices are located in from each side of the rail selected with the Core Rail control or Ski Jump Rail control. See A1.

Edit Pattern button

Click to open the Pattern Editor window, which is used to define, save and load pattern files. Applicable only to systems with programmable stages.

Edit Pattern Pos button

Click to open the Position Editor window. Applicable only to systems with programmable stages.

Edit Report button

Opens a text editing program so the report file may be modified.

End Offset

ABS Geometry Applications. Specifies the distance from the first row of good pixels across both rails to the beginning of the ski jump slices. See A1.

Etch Area Phase Cutoff

PTR Applications. Specifies a phase cutoff value for the etched area. The value establishes a cutoff plane above the etched area, data above this plane is deleted from the area defined by the Nominal Etch Width control; the remaining data is the etch region.

Etch Regions

PTR Applications. Selects where the software will look for etch areas. All Sides tries to identify areas on the top and bottom, as well to the left and right of the pole tips. If an area does not have any etch data, only the applicable results are calculated. Top/Bottom divides the etch area in half at the midpoint of the pole tips, creating a top and bottom etch area. Only the Undershoot Trim Depth results are calculated.

Etched Pole Cutoff

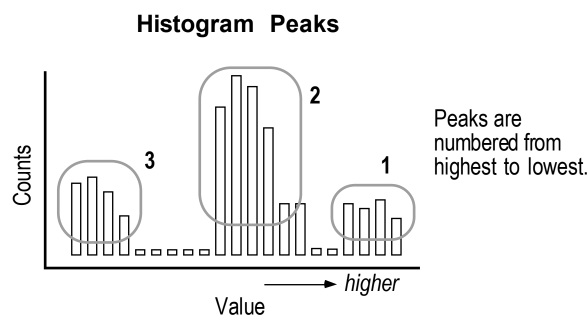
Trimmed PTR Application. When the Trim PTR Search control is set to Intensity Data, this control is used to determine how much of the pole area to define as the etched pole region after removing the unetched pole region from the pole area. This control is initially set to 4; values may range from 0 to 25. Increase the value to delete more data; decrease the value to retain data.

Exit Pupil Diam

Specifies the actual exit pupil diameter of an afocal wavefront for the MTF analysis. An entry is required to calculate the Cutoff Freq (afocal) result.

Expected Peak Number

Specifies the number of histogram peaks in the histogram data that the user expects to find. Serves as a discriminator for the peak finding algorithm. Applicable when the Mask Mode control is set to Peaks Midpoints or Peaks Relative.



Extended Scan Length

For a scanning microscope with an extended scan option only. Specifies the length of the scan. The Scan Length control must be set to Extended. The value entered should be the vertical range of detail in the part plus 10%.

Failure Action

Selects the action to take if there is an error during a stitch sequence. Settings are Abort, Retry, or Continue. Abort will stop the stitching sequence. Retry repeats the measurement and aborts the sequence if it fails again. Continue ignores the error and goes to the next location.

FDA Res

Scanning Microscopes. FDA is a mathematical method for processing complex interferograms in terms of phases and spatial frequencies. FDA transforms data to the frequency domain, where it is analyzed to calculate surface height.

The objective is mechanically scanned to generate a sequence of interferograms, which are transformed to get phase information. Fourier analysis is used to extract a range of phases for each color or wavelength in the spectrum of the white-light source. The source spectrum together with the corresponding phases is a frequency domain representation of an interferogram. The particular combination of phases found by FDA uniquely defines the surface height map.

In traditional, single-wavelength, phase-shift interferometry, the interference pattern is transformed into a matrix of phase values with an algorithm, such as the “five-bucket” method. With FDA, it is as if the five-bucket algorithm is applied for every one of the wavelengths in the source spectrum. The resulting phase measurements would be different for each wavelength. Having this type of data resolves the slope 2 π ambiguity problem common to single-wavelength, phase shift interferometry.

The essential idea behind FDA is that it examines interference phase, not the original intensity data measured by the detector. To change intensity data to the frequency domain, the data is transformed using a Fast Fourier Transform. Distance is calculated by determining the slope of the line showing the rate of change of interferometric phase with spatial frequency. The NewView instrument uses a simple linear least-squares fit to several phase values having high signal-to-noise ratio. The final distance calculation is done in either one of two ways, depending on whether or not a phase offset is included.

The settings of the FDA Res control determine the resolution of the analysis as shown in the following table. The selections available in the FDA Res control are affected by the Scan Type control setting. Refer to the entry for Scan Type later in this section.

FDA Res Control - Summary of Selections

FDA Res	Technique	Vert. Res.	Conditions of use
High	Centroid detection of envelope peak, uses least squares slope result and phase offset, with FFT. Equivalent to phase shifting interferometry without 2π phase ambiguity.	~0.1 nm	Maximum vertical resolution.
Normal	Centroid detection of envelope peak, uses least squares slope result, with FFT.	~3 nm	Rough surfaces, typically > 75 nm Ra
Low	Fast centroid detection of envelope peak, without FFT.	~20 nm	Extended scan option, Scan Length control set to Extended.
Phase 1	Hybrid approach, combines vertical scanning interferometry and phase shifting interferometry techniques in a single measurement. Data is acquired at optimal focus.	~0.1 nm	NewView 5022/5032 only, 80 nm bandwidth filter required, general purpose for scans <150 nm. The Scan Type control must be set to Phase.
Phase 2	Hybrid approach, combines vertical scanning interferometry and phase shifting interferometry techniques in a single measurement. Data is almost instantaneously acquired at optimal focus.	~0.1 nm	NewView 5022/5032 only, 40 nm bandwidth filter required, for step heights from 0 – 5 µm and low magnification objectives. The Scan Type control must be set to Phase.

File Format

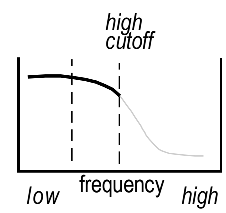
Selects the format of a report file. The report file is a text file containing user-specified measurement information and results. Settings are As Displayed, Comma Separated, or Tab Separated.

The *As Displayed* format makes an exact copy of the Report window and puts it into the Log File. It includes any spaces you have put between results. The As Displayed format is generally used when outputting the contents of the Report window to a printer. *Comma Separated* format places double quotations around text items, separates all fields with commas, and removes any spaces between items. The Comma Separated format is used when the report file is transferred to a spreadsheet program for further processing. *Tab Separated* format is identical to the comma separated format, except fields are separated by tabs instead of commas.

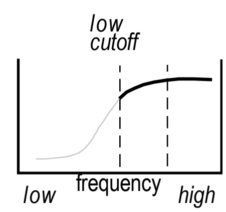
Filter

Activates data filtering options. Filtering is used to highlight the roughness (high frequency components) or waviness (low frequency components) of a test part. Filtering controls are available in both "map" and "profile" data windows. Settings are Off, Low Pass, High Pass, Band Pass, and Band Reject. The affect of filtering varies based on the settings of the Filter Type and Filter Window Size controls. Off disables data filtering; all other filter controls are ignored.

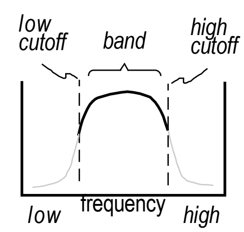
Low Pass allows the low spatial frequency components to pass through the filter; roughness is removed. Its affect is determined by the Filter Type control. When FFT Fixed filtering is selected, the cutoff is specified by the Filter High Wavelen or Filter High Freq control.



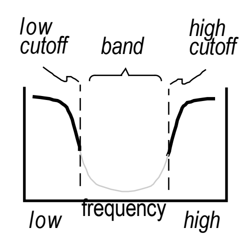
High Pass allows the high spatial frequency components to pass through the filter; waviness is removed. Its affect is determined by the Filter Type control. When FFT Fixed filtering is selected, the cutoff is specified by the Filter Low Wavelen or Filter Low Freq control.



Band Pass passes the spatial frequency components that are in-between two cutoff values; the Filter Type must be set to FFT Auto or FFT Fixed. When FFT Fixed filtering is selected, the lower cutoff is specified by the Filter Low Wavelen (or Freq) control and the higher cutoff is specified by the Filter High Wavelen (or Freq) control.



Band Reject removes the spatial frequency components that are in-between two cutoff values; the Filter Type must be set to FFT Auto or FFT Fixed. When FFT Fixed filtering is selected, the lower cutoff is specified by the Filter Low Wavelen (or Freq) control and the higher cutoff is specified by the Filter High Wavelen (or Freq) control.



The following table shows the interaction of filter controls. Immediately following the table are explanations for each of the filter controls.

Which Filtering Controls Need to be Set?

Filter Type	Filter	Filter Low Frequency Filter Low Wavelength	Filter High Frequency Filter High Wavelength	Filter Window Size	Filter Cutoff	Filter Trim
Average	Low Pass	NA	NA	Yes	NA	Yes
Average	High Pass	NA	NA	Yes	NA	Yes
Median	Low Pass	NA	NA	Yes	NA	Yes
Median	High Pass	NA	NA	Yes	NA	Yes
2 Sigma	Low Pass	NA	NA	Yes	NA	Yes
2 Sigma	High Pass	NA	NA	Yes	NA	Yes
FFT Auto	Low Pass	NA	NA	NA	Yes	Yes
FFT Auto	High Pass	NA	NA	NA	Yes	Yes
FFT Auto	Band Pass	NA	NA	NA	Yes	Yes
FFT Auto	Band Reject	NA	NA	NA	Yes	Yes
FFT Fixed	Low Pass	NA	Yes	NA	Yes	Yes
FFT Fixed	High Pass	Yes	NA	NA	Yes	Yes
FFT Fixed	Band Pass	Yes	Yes	NA	Yes	Yes
FFT Fixed	Band Reject	Yes	Yes	NA	Yes	Yes

Filter Cutoff

This control is activated when the Filter Type control is set to FFT Auto or FFT Fixed. There are two selections: Sinusoid and Gaussian. These settings represent two methods of attenuating the frequency components.

Filter High Freq

Specifies the frequency of the higher cutoff point between roughness and high frequency data when the Filter Type control is set to FFT Fixed, and the Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Filter High Wavelen control.

Filter High Wavelen

Specifies the wavelength of the higher cutoff point between roughness and high frequency data when the Filter Type control is set to FFT Fixed, and the Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Filter High Freq control.

Filter Low Freq

Specifies the frequency of the lower cutoff point between waviness and roughness data when the Filter Type control is set to FFT Fixed, and the Filter control is set to High Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Filter Low Wavelen control.

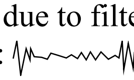
Filter Low Wavelen

Specifies the wavelength of the lower cutoff point between waviness and roughness data when the Filter Type control is set to FFT Fixed, and the Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is output in the Low Filter Freq control.

Filter Size

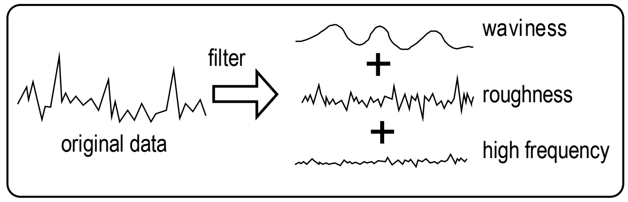
Advanced Texture Application. Selects the number of data points used to generate a new filtered data point when the Filter Type control is set to Average, Median, or 2 Sigma. Settings are 0, 3, 5, or 7. As the filter size is increased the affects of filtering are increased. It functions as a low-pass filter to remove high frequency noise from the data. It has a low impact on the software processing required.

Filter Trim

Controls the preservation of data edges during the filtering processing when filtering is activated with the Filter control. When On, filtering performs normally and some edge data is lost. When Off, edge data is preserved that is usually lost due to filtering. Set to On, if you notice "ringing" effects at the data edges (for example: ).

Filter Type

Selects the filtering algorithm when the Filter control is activated. Filtering separates data into waviness, roughness, and high frequency components.



The choices are: Average, Median, 2 Sigma, FFT Auto, or FFT Fixed. Use filtering with caution, as filtering can help to isolate frequencies, but it modifies the entire data set, and may not work uniformly on edge data. See Filter.

Average uses all valid data points in each filter window (as determined by the Filter Window Size control) and averages them. The averaged value is then used to replace the data point at the center of the window. These averaged values are used to generate a new data array. It is the fastest of the filtering types. When used, the Filter High/Low Wavelen (or Freq) controls are ignored.

Median selects the middle or median value of all the valid data points in each filter window. The median is the value of the middle point when the points are sorted from smallest to largest. The median value is then used to replace the data point at the center of the window. These median values are used to generate a new data array. Median filtering preserves edge detail better than the average algorithm. When used, the Filter High/Low Wavelen (or Freq) controls are ignored.

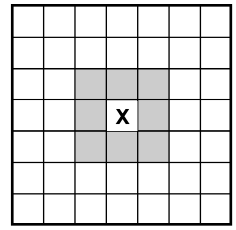
2 Sigma uses data points that are within two times the rms value in each filter window and disregards data values that are out of this range. Points within the 2 sigma range are averaged. The averaged value is then used to replace the data point at the center of the window. These averaged values are used to generate a new data array. When used, the Filter High/Low Wavelen (or Freq) controls are ignored.

FFT Auto and *FFT Fixed* use a Fast Fourier Transform algorithm; and the Filter Window Size control is ignored. FFT Auto automatically selects filter cutoff points based on the test data; it should be used as a starting point only. FFT Fixed sets filter cutoffs based on the entries in the Filter High/Low Wavelen (or Freq) controls. If FFT filtering is used, the instrument must be calibrated.

Filter Window Size

Selects the number of data points used to generate a new filtered data point when the Filter Type control is set to Average, Median, or 2 Sigma. As the window size is increased, the affects of filtering are increased.

The box shown here represents a data array of 49 points. Each square represents a data point; X is the data point being filtered. Window Size 3 includes the shaded points. Window Size 7 includes all points shown. As the Window Size increases more points are used in the filtering algorithm.



Fit

For profile plots. Determines how shapes are fit to profile data. Settings are First Profile or All Profiles. First Profile fits the shape in the Remove control to the first slice only; it is removed from all. All Profiles fits the shape in the profile Remove control to all slices; it is removed from all.

Flip Data X button

Flips the current data set horizontally and redisplays. Part of a manipulate feature.

Flip Data Y button

Flips the current data set vertically and redisplays. Part of a manipulate feature.

f-number

Specifies the f-number of the test optic. The f-number of an optic or lens is a number expressing the ratio of its focal length to the diameter of its aperture. Settings: any number greater than 0; default is 0.000 (plano optic).

Focus

This control enables or disables automated focus at the start of a measurement. Settings are On or Off. Applicable only to microscopes with at least a motorized z-drive.

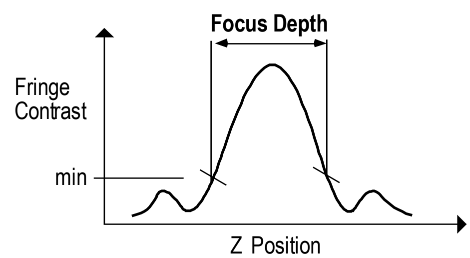
Focus button

Click to make an auto focus adjustment based on the current settings of the focus controls.

Focus Data

Specifies which type of data to examine for the purpose of selecting a surface for auto focus and tilt. Settings are: Height and Intens. Height uses the height data and looks for surfaces of different average height. Intens uses intensity data and looks at the intensity data (Fringe Remove: On) for surfaces of different average intensity. (1) The Focus Data control, the Focus N surfaces control and the Focus Surface control all work in conjunction. Ultimately, a region of height data is analyzed for the auto focus and tilt calculations. If the part being measured has multiple regions (or surfaces) of different heights or different reflectivities, the controls can be set to select one of those surfaces. These three controls affect the operation of both the auto focus and the auto tilt functions when the Acquisition Mode control is set to Scan, or if the Acquisition Mode control is set to Phase and the Focus Mode control is set to Scan.

Focus Depth



Specifies the dimension of a focus envelope, it only applies to a phase microscope with a motorized z-drive. The Focus Depth control affects the operation of auto focus when the Acquisition Mode control is set to Phase. The value is a measure of the Z position range over which good contrast fringes are obtained. A plot of fringe contrast verses Z position resembles a bell-shaped curve. For lower magnification objectives, the bell shape is very wide. For higher magnification objectives, the bell shape is narrower and may have significant side lobes. The Focus Depth control should be set to a value no greater than the width of the useful portion of the bell.

The Focus Depth value is used to calculate step sizes for adjusting the Z position. The focusing algorithm consists of an initial coarse focus algorithm and a final fine focus algorithm. The goal of the coarse focus algorithm is to position the central lobe of the bell-shaped curve. The Z position is adjusted iteratively up and down from the starting position using a step size calculated as one-half of the Focus Depth control value. The algorithm is satisfied when a certain minimum average contrast and number of modulating points are obtained. The step size must be small enough so that the central lobe is not missed. However, if the step is too small, the algorithm will require too many iterations.

The goal of the fine focus algorithm is to obtain contrast of at least the value entered in the Focus Min Contrast control. The algorithm tries to find the peak of the bell using an initial step size calculated as one-forth of the Focus Depth value. Whenever the peak is crossed over, the step size is cut in half and the direction is reversed. If the step becomes small enough so there is no significant change is contrast, the algorithm returns to the position of highest contrast and ends without error; even thought the contrast is less than Focus Min Contrast.

Focus Drop

Specifies the distance the objective drops down before it begins to auto focus. Applicable only to the Maxim•3D with a motorized z-axis, a Zygo Motion Controller, and a 40x Mirau objective. Settings: 0.0 to 1000 µin, default 400 µin (units selectable).

Focus Light Level Offset Pct

This control specifies an adjustment (in percent) to the light level for both focus and tilt functions for the scanning technique only. The scanning technique normally requires a little more light than when measuring. Therefore, this control is normally set to a small positive number less than 10. The offset is applied relative to the Light Level Pct control. Applicable only to microscopes with the scanning focus and tilt option.

Focus Max Adjust

For the auto focus function, this control specifies the maximum adjustment allowed from the starting Z position. For scanning microscopes, both the Pifoc and z-axis drive are used depending on the length of the scan.

Focus Min Contrast

Specifies the minimum contrast (in percent) for focus, it only applies to a phase microscope with a motorized Z-drive. Contrast is based on values from 0-100, with 100 being the highest contrast.

Focus Min Mod (%)

Specifies the minimum modulation (in percent) for points to be included in the analysis of interference data. This control is normally set to a small number, as low as 1. This affects both auto focus and auto tilt.

Focus Mode

This control, in conjunction with the Acquisition Mode control, determines how auto focus is performed. Settings are Software, Scan, or Hardware. Hardware applies only to instruments with applicable hardware.

Acquisition Mode	*Focus Mode*	*Auto Technique*
Scan	Software	scanning
	Scan	scanning
Phase	Software	modulation
	Scan	scanning

Focus N Surfaces

Specifies how many distinct surfaces to expect. See (1) under Focus Data.

Focus Offset

Specifies the distance (negative or positive) to change the z-axis position for optimal focus. This control is used for all auto focus functions. The correct value to enter is part dependent. The focus algorithm focuses on the highest portion of the part. This control should be set to a distance halfway between the highest and lowest portions.

Focus Retry Max Adjust

Specifies the maximum adjustment distance if the auto focus algorithm fails. If the first focus attempt fails due to lack of data, and if this control is set to a value greater than the Focus Max Adjust control, then a second attempt is made using this value. This control is used for scanning microscopes only.

Focus Scan Rate

Selects the scan rate used to acquire height data for the auto focus and tilt calculations. Selections are: Normal, Fast, and Slow. Slow uses the same scan rate that is used when acquiring height data for a measurement. The Normal and Fast selections use scan rates that are three and five times faster than Slow, respectively. A slower scan rate provides the most accurate and reliable operation, but takes more time. A faster scan rate takes less time, but may be less accurate or less reliable, especially if the fringe contrast is low. This control affects the operation of both the auto focus and the auto tilt functions when the Acquisition Mode control is set to Scan, or if the Acquisition Mode control is set to Phase and the Focus Mode control is set to Scan.

Focus Surface

Specifies which surface in the part is used for auto focus and tilt. Settings are Highest and Largest. Highest specifies the highest (or brightest) surface. Largest specifies the surface having the largest number of data points. See (1) under Focus Data.

Focus/Tilt button

Microscope Applications. In one operation, this button initiates both auto focus and tilt. It is available in a Control Window via New Button.

Focus/Tilt Delay

Specifies a time delay in seconds after the auto focus and tilt algorithm adjusts the microscope focus and stage tilt. This may be necessary in rare cases to allow the microscope and part stabilize before a measurement is taken. Requires a motorized z-axis and programmable stage.

Focus/Tilt X Offset

Specifies a distance in the x-axis that the part, prior to adjusting instrument focus and stage tilt, is moved to locate it under the focus spot. Applies only to a microscope with hardware auto focus and tilt.

Focus/Tilt Y Offset

Specifies a distance in the y-axis that the part, prior to adjusting instrument focus and stage tilt, is moved to locate it under the focus spot. Applies only to a microscope with hardware auto focus and tilt.

Fringe Limit

Static Fringe Application. Use to get rid of spurious fringe spacing and dirt. As the limit is lowered, holes appear in the data and increase the lower the setting. As the limit is raised, holes disappear and a greater variety in fringes are accepted. The range is from 1.0 to 10.0, the default is 2.0

By adjusting this control, you are able to control the usable data points in the results. Its use is somewhat subjective, based upon your measurement criteria. Fringe Limit does not affect acquired data; however, it does affect the data used for the results. When adjusting Fringe Limit, observe the Filled plot for data holes. If you want data to dropout, so dirt or other questionable areas are disregarded, lower the number in the control and remeasure. If you see large areas with data dropout in the Filled plot, raise the number in the control and remeasure. See Fringe Threshold.

Fringe Orientation

Static Fringe Application. Selects the direction of the fringes in the static image. Settings are horizontal or vertical.

Fringe Spacing

Static Fringe Application. Determines what to accept for fringe spacing in the fringe pattern. The lower the value, the more variety in fringe spacing is allowed, but the lower the accuracy. The Fringe Spacing control changes the length of the convolution filter, thus determining what to accept for fringe spacing in the fringe pattern. Generally, this control does not have to be used, unless the fringe pattern has an extreme variety in spacing, such as that found in parts with power. The range is from 0.0 to 1.0, the default is 0.9. See Fringe Threshold.

Fringe Threshold

Static Fringe Application. Controls the number of data points acquired. As the threshold is lowered, more data is gathered, but if too low, non-data areas are also seen as data. As the threshold is raised, there is less background noise, but some fringe centers are not accepted. The range is from 0.0 to 1.0, the default is 0.2.

When adjusted properly, it eliminates the detection of false fringes caused by intensity noise in the fringe pattern. The goal is to acquire as much good data as possible without noise. Fringe Threshold affects the data acquired, so it should be used with care. After changing this control, remeasure to see the effect.

The following table is a guide for using the fringe controls.

Problem	*Fringe Threshold*	*Fringe Limit*	*Fringe Spacing*
Too few fringes acquired	↓	↑	↓
Too many fringes acquired	↑	↓	na
Discontinuities	na	↓	na
Relative use of control	often	sometimes	rarely

Generate button

Creates a data set based on the settings of the generate controls. Part of MetroPro's generate function.

Gen Setup Type

This control allows entry of a code number for a type of measurement. When generated data is saved to a file, the setup code will be saved with it. This will make it possible to load the data into certain MetroPro Applications.

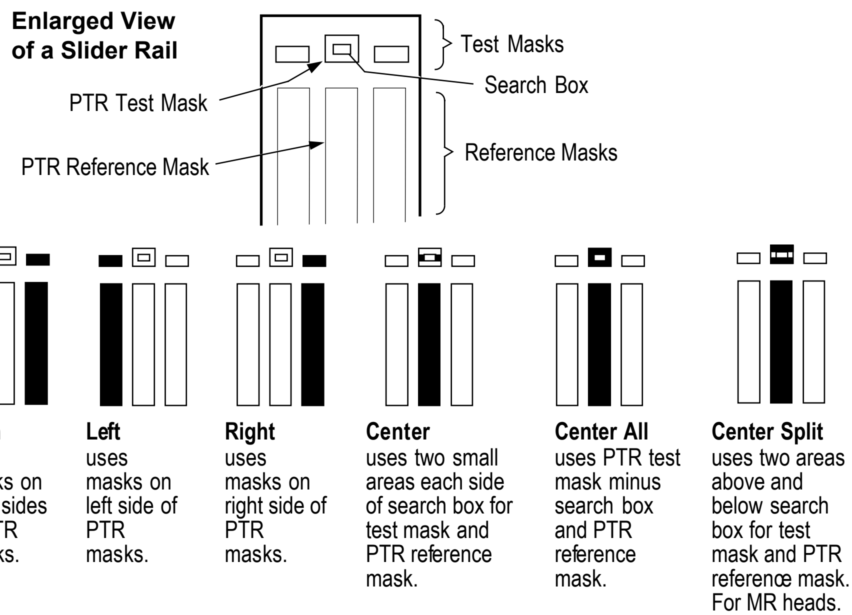
Setup	*Code*	*Application*
Wedge (Transmitted)	1	Angles
Wedge (Reflection)	2	Angles
90 Degree Prism Ext	4	Angles
90 Degree Prism Int	6	Angles
Single Pass	0	Corner Cube
Double Pass	1	Corner Cube

Get Zernikes button

Creates Zernike elements based on the current data set; it is used for generating data. It provides entries for the Center X, Center Y, Radius, Zernike Terms, and Coef X controls.

Glass Location

PTR Applications. Selects where glass test and reference masks are created on the slider for determining results in the Glass window. Settings are Both, Left, Right, Center, Center All, or Center Split. The Left and Right settings are useful for TPC heads or heads where the pole tip is very close to the left or right edge of the ABS. The Center setting is useful when the pole tip is very close to the trailing edge.



Goto Focus Zero button

Prompts the operator for confirmation, then moves the Z axis to the focus zero position. . This button applies only to microscopes with auto focus.

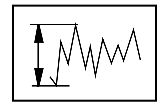
Goto Tilt Zero button

This button prompts the operator for confirmation, then moves the pitch and roll axes to the tilt zero positions. This button applies only to microscopes with programmable pitch and roll stages.

GR&R Output File

Specifies the name of the output file to be created by the GR&R Application. Available in New Control via Miscellaneous.

Height Units



Selects the master unit system for all height-based results; settings are English, Metric, or Optical. It affects the Z units in the Filled plot and Oblique plot, and the Y units in the Profile plot. It also applies to most results, such as AvgHgt, H, Peak, PV, Ra, RadCrv, rms, R3z, Rtm, Rz, Sag, and Valley, and the y-axis in the Profile plot.

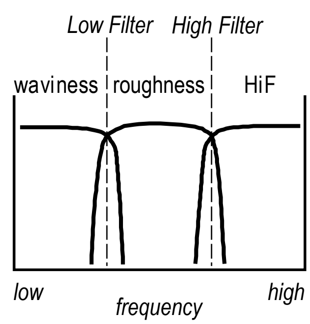
For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or µm.

High Clip

Specifies a vertical cutoff plane through the data, relative to zero. All data is removed above the entered value. The zero location is specified by the best fit surface with the Remove control. High Clip serves as a simple filter to remove spikes in the data. See also Low Clip.

High Filter

Advanced Texture Application. Activates data filtering options for the upper limit of the bandpass filter. To obtain high frequency data, set the High Filter control to Auto or Fixed. When set to Auto, the software arbitrarily sets the upper cutoff. The Auto setting should only be used as a starting point. When set to Fixed, a cutoff value must be entered in the High Filter Wavelen or the High Filter Freq controls. When set to Off, there is no upper limit to the filter.



High Filter Freq

Advanced Texture Application. Specifies the frequency of the higher cutoff point between roughness and high frequency data when the High Filter control is set to Fixed. When a value is entered, a corresponding value is output in the High Filter Wavelen control.

High Filter Wavelen

Advanced Texture Application. Specifies the wavelength of the higher cutoff point between roughness and high frequency data when the High Filter control is set to Fixed. When a value is entered, a corresponding value is output in the High Filter Freq control.

Histogram Filter Window Size

Selects the number of data points used to generate a new histogram data point when the Mask Mode control is set to Histogram, Peaks Midpoints, or Peaks Relative. It smoothes the histogram of the incoming data. The default setting is 11. See Mask Mode.

Histogram Threshold (%)

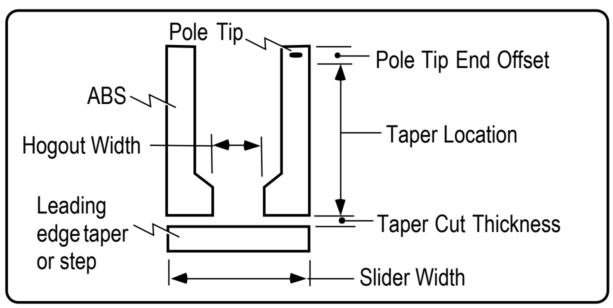
Specifies the mininum percentage of the histogram data for a peak to be considered valid when the Mask Mode control is set to Histogram, Peaks Midpoints, or Peaks Relative. It removes noise from the histogram of the incoming data. The default setting is 0.01. See Mask Mode.

Hogout Trim

ABS Geometry Applications. Specifies the number of pixels to trim from the outside of the hogout area. Valid values are 0 - 15; the default setting is 0.

Hogout Width

ABS Geometry Applications. Specifies the width of the recessed area between the rails. An entry is required to calculate hogout results or when using a microscope with an auto focus option. Its effect varies depending on the Slider Type selected.



When Slider Type is Three Rails or TPC, the Hogout Width is ignored. When Slider Type is Two Rails or Three Rails (Split), it is only used when auto focus is needed. When Slider Type is Two Rails (Generic), Two Rails (Bisect), Three Rails (Generic), or Three Rails (Bisect), an entry of 0 (zero) ignores the hogout region if present; an entry greater than 0 defines the lower half of the height data as the hogout region, and the upper half as the ABS. For AAB 2 sliders, Hogout Width determines how much of the center connecting data to delete from analysis between the rails; an entry of 0 bisects the data. For AAB 1 and AAB 1 (Wide) sliders, it is used to identify the crossbar region between the rails. For AAB 1, AAB 1 (Wide), Proximity, and Proximity 3 sliders, Hogout Width is used in defining the hogout region, if present, for analysis.

Home Stage button

Moves the programmable stage to home position. Home is an absolute reference position for an axis. Applicable only to systems with programmable stages.

Ignore Bright Pts

Reserved for future use.

Image Zoom

Microscopes with image zoom option. Set the Image Zoom control to match the zoom setting selected with the microscope's zoom thumbwheel. This ensures proper lateral resolution of each camera pixel. If the setting of the control and the thumbwheel do not match, results will be erroneous. Settings are 0.5X, 0.75X, 1X, 1.5X, 2X, or Free.

The control functions only for microscopes with the image zoom option; for other microscopes, the control is locked at the 1X setting. If there is not an active instrument, the control displays None.

Select Free when the thumbwheel is set between detent positions. Each time the Image Zoom control is set to Free, you must perform calibration before making the measurement to provide absolute units of measure. Note that calibration performed at a Free setting is only temporary, settings are not saved. See Section 7 for calibration procedures.

Incident Angle

Specifies the angle of the incoming light from the z-axis for the BRDF analysis. It is the polar angle of s-polarized in.

Inner Diameter

Three Zone Radius Scale Application. Specifies the inner diameter of the part with three radii, which is being measured. Enter the diameter of the area defined by the inner mask.

Inner Flyable Radius

Disk Flatness Application. Defines the radius of the inner extent of disk at which the head flies over the disk during use.

Inner Masks File

Three Zone Radius Scale Application. Specifies the name of the mask file defining the inner zone of a part with three radii. The masks defined by the inner mask file included with the application should be adjusted to match your specific part.

Inner Radius

Stitching Application. Specifies the radius of an internal circular area in which there is no data. Applicable when the Type control is set to Annulus. If zero, the entire area as specified by the Outer Radius control is used.

Inner Zone button

Three Zone Radius Scale Application. Initiates a measurement of the inner zone of a part with three different radii.

Instrument

Selects the active instrument when multiple instruments are connected to the computer. In a system with one instrument connected to the computer, the box has no function.

Intens Avgs

This control is relevant only when the Acquisition Mode control is set to Phase or Intens. Specifies the number of intensity averages to be performed during subsequent measurements. Intensity averaging is performed by averaging the intensity values of each pixel of multiple camera frames. Settings: 0 to 62, default is 0. Zero and 1 have the same effect.

Averaging is used to improve the measurement repeatability of the instrument by increasing the signal-to-noise ratio of the data acquisition system. The camera and instrument board must be synchronized to insure that intensity averaging gives proper results. If averaging is active (a value greater than 1 has been entered), and the camera and instrument are not synchronized, an error message is displayed when the measurement is made. Zygo offers intensity averaging and/or phase averaging. Intensity averaging is faster than phase averaging but should be used only when there is no perceptible fringe drift.

Normal resolution intensity averaging is performed at a rate of five acquisitions per second, allowing rapid measurements to be performed with improved repeatability. However, drift and vibration in the instrument can limit the effectiveness of intensity averaging. Since the intensity values are averaged over time, drift in the interferometer cavity causes the contrast of the interference fringes to decrease. If the drift is great enough, the contrast can be significantly reduced, decreasing the signal-to-noise ratio and negating the advantages of averaging, or causing data loss. A drift of one full fringe in the interferometer cavity during measurement time reduces the contrast and causes data loss.

Intf Scale Factor

Applicable to interferometer applications. Interferometers function by dividing a wavefront into two or more parts, principally a reference wavefront and a test wavefront, which travel different paths and then combine to form an interference fringe pattern. The geometrical properties of the interference fringe pattern are determined by the difference in optical path traveled by the recombining wavefronts.

All the interferometer receives as input information is the test wavefront. It cannot tell whether this wavefront has traveled through a window, reflected from a surface, what angle it has reflected from a surface, etc. The Intf (Interferogram) Scale Factor specifies how this input wavefront error (read directly from the fringe pattern as one wavelength per fringe) is scaled to properly represent the output parameters which the user wants to display in the results. The default setting is 0.5

Why the Intf Scale Factor default of 0.5?

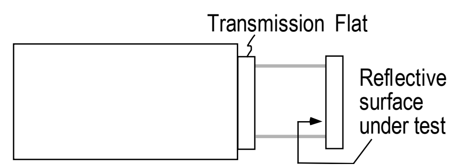
Consider the specific example of a wavefront reflecting off of a surface. This is exactly what happens in the setup of normal incidence, double pass testing of a flat surface.

For this setup, users often want to see results of the surface errors, not the reflected wavefront error that is being directly measured via the fringe pattern. They are different by a factor of 0.5.

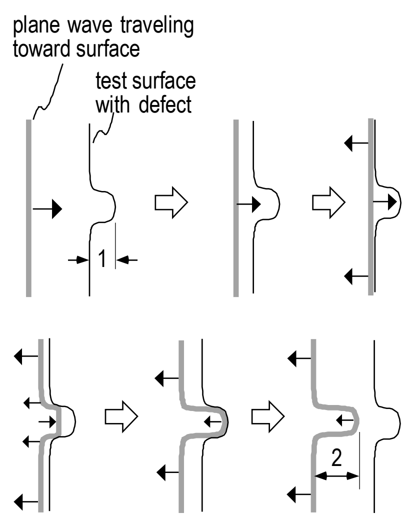
Let's examine what happens when a perfect plane wave is incident on a test surface, which has a defect 1 unit deep.

The wavefront hits the flat portion of the surface first; while part of the wavefront continues to travel into the defect the rest of the wave has already reflected off of the "good" portion of the surface and is traveling back toward the interferometer. By the time the center of the wave has reached the deepest part of the defect, the majority of the wave has traveled 1 unit away from the flat portion of the surface. As a result the returning wavefront has a defect that is 2 units deep, even though the surface defect is only 1 unit deep.

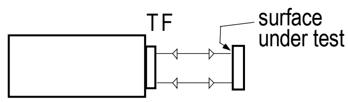
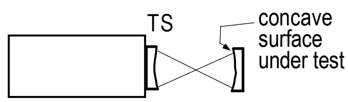
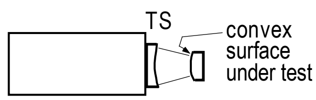
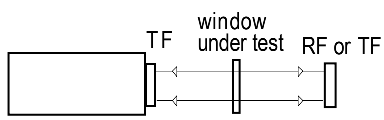
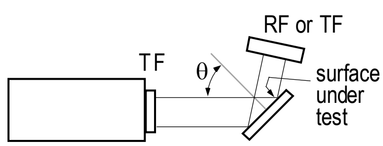
Measuring Surface Form Error



Plane Wavefront Incident on Test Surface



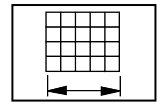
The following table shows some common Fizeau test setups and the appropriate Intf Scale Factor as based on the desired results. In the diagrams and text, TF refers to transmission flat, TS to transmission sphere, RF to reference flat, and normal incidence is when the laser beam is perpendicular to the surface under test.

Description	***Example Test Diagrams***	***What to show in results***	***Intf Scale Factor***
Fizeau double-pass, normal incidence, one reflection from test surface		surface form error	0.5
		reflected wavefront error	1.0
			
Fizeau double-pass, transmission through window		double-pass transmitted wavefront error	1.0
		single-pass transmitted wavefront error	0.5
Fizeau double-pass, incident angle θ on test surface, two reflections from test surface		reflected wavefront error at angle θ	0.5
		reflected wavefront error at normal incidence	$\frac{1}{2 \cos \theta}$
		surface form error	$\frac{1}{4 \cos \theta}$

Invert Data button

Inverts the current data. What was a peak on the phase map becomes a valley and what was a low region becomes a high region. Clicking this button twice in succession puts the phase map back to its original state. Part of a manipulate feature.

Lateral Units



Selects the master unit system for all lateral based results; settings are English, Metric, or Camera (pixels). It affects the X units in the Profile, MTF Profile, Autocovariance, and Power Spectrum plots, and the X-Y units in the Oblique plot. Applies to any measurement derived from camera pixel positions, such as Length/Circum, RadCrv, and Radius.

For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or µm.

Light Level

Sets the starting position of the variable light level controller used during data acquisition when the Acquisition Mode control is set to Phase and the AGC control is On. Settings: 0 (brightest) to 159 (darkest), default is 80.

The variable light level controller is part of the instrument's automatic gain control (AGC) feedback loop, and is used to provide optimum illumination of the test part. The Light Level control provides manual attenuation control when AGC is off. By changing the value entered in the light level box, the amount of light used during data acquisition is varied.

Normally, the amount of light reaching the camera is regulated by the AGC feedback loop. If AGC is On, the AGC function uses the value specified in the light level box as a starting point for the position of the variable light level controller for subsequent measurements. If AGC is Off, the measurement is made with the variable light level controller in a fixed position and not changed during data acquisition.

Light Level Pct

Specifies the light level in percentage to use when making the measurement. This may be different than the light level used for part viewing. The Light Level Pct control works in tandem with the Light Level window. The Light Level Pts control setting is changed when the light level window is opened, the light level is changed, and the Set button is clicked.

When the Acquisition Mode control is set to Phase and the AGC control is On, it specifies the starting point for the AGC function.

Light Level Range

Selects the optical power range for the laser in the MESA instrument. Selections are Low or High. When High, the laser output is from zero to maximum. When Low, the maximum power level of the laser is reduced, and the light level control has finer resolution. The Light Level Range should be set to Low, unless there is not enough light to measure successfully.

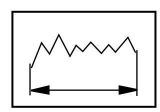
Limits Error

Determines how the user is notified when results are out of user set limits. When On, an error message is displayed on screen when a result is out of range of the user set limits. When Off, there is no user notification, other than the usual result box color change, which is green for pass and red for fail.

Line Type

For profile plots. Specifies how fit is performed when the profile Remove control is set to Line; choices are 2 Point and Normal. Normal allows the software to find the points to fit a line. 2 Point uses entries the Ref Pt 1 and Ref Pt 2 controls to define the line to fit. 2 Point requires valid data at each point.

Linear Units



Selects the master unit system for all linear based results; settings are English or Metric. Applies to boxes such as Wavelength-In and Camera Res.

For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or µm.

LLC Delay

Specifies a time delay, in seconds and tenths, after the light level control (LLC) filter in moves until a frame of data is taken. Settings: 0.0 to 10 seconds, default is 0.0. Applicable only to Zygo instruments with a LLC, such as Mark IVxp or Maxim•3D.

This control is only used in extremely noisy environments that cause the filter to vibrate. The error message "Cannot calibrate for acquire" is a sign that you might have a noisy environment. Use of this control increases the time required to make a measurement.

Load Data button

Opens the File Handler, which is used to recall existing saved data files and load them into an application. Only one data set can be loaded into an application at a time.

To load a file, click the button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

Load Settings button

Opens the File Handler, which is used to recall existing settings files and load them into an application. Only one settings file can be loaded at a time. A settings file contains information on the configuration of MetroPro controls.

To load a file, click the button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

Load Zernikes button

Opens the File Handler, which is used to recall existing saved Zernike files and load them into an application. It can be used when generating data. When Zernike data is loaded, the settings of the Radius, Center X, or Center Y controls are blank.

To load a file, click the button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

Log Dir

Specifies the name of a directory path in which to log report files. The directory may have any number of levels. When a report is being logged, the directory will be automatically created if it doesn't already exist. It is possible to have additional information, such as Lot Number, Part Number, Part Serial Number, and Pattern File Name, appear in the Log Directory. Refer to the "Special Codes" section of *Section 8* of this manual for additional information.

Log File

Specifies the name of a report file. The report file is an ASCII file containing a listing of the Result, Attribute, and Annotation boxes, inside the Report window, along with their contents. The report file can be downloaded to another computer for further processing. . It is possible to have additional information, such as Lot Number, Part Number, Part Serial Number, and Pattern File Name, appear in the Log Directory. Refer to the "Special Codes" section of *Section 8* of this manual for additional information.

Log Report button

Adds the present contents of the Report window to the report file. It can be used to selectively add only the applicable results or existing results to the report.

Logging

When On, activates Report window logging. Logging appends the contents of the Report window to the report file after each measurement.

Lopoff (%)

ABS Geometry Applications. Specifies how much of the Pole Tip Cut End Offset area for each ABS to use to calculate Trailing Edge Height. It is the lowest lopoff percent of the area that is used for the calculations. A suggested setting is 10.

Lopoff Delete Pole

ABS Geometry Applications. Enables or disables removing the pole tip from the Pole Tip Cut End Offset area for calculating Trailing Edge Height. Selections are: None (do not remove any poles), Left & Right (remove poles from both ABS regions), Left (remove poles from left ABS only), Right (remove poles from right ABS only) or Center (remove pole from the center ABS region). Use this control in conjunction with the Trailing Edge Location control. (i.e. Use Delete Pole Center only when Trailing Edge Location is Center, Center1, or Center2.) Remove Fringes must be On for this control to work.

This control should only be used on sliders with MR pole tips to ensure that non-pole data is not deleted, which would cause erroneous Trailing Edge results.

Lot Num

Used to enter a number for a lot or group of parts. The Lot Num control has three modes of operation: Normal, Auto-Increment, and Prompt. To enter a number, click on the box with the left mouse button, type a number with the keyboard and press [Enter].

The mode of operation of the Lot Num control is selected with the Mode command from the control's menu. The current mode of operation is indicated by an asterisk (*). When the Mode is *Normal*, the data is saved under the specified lot number. When the Mode is *Prompt*, the software asks you to enter a lot number before each measurement.

When the Mode is *Auto-Increment*, the lot number is incremented by one for the next measurement. Only the right-most 15 digits are incremented until a non-digit character is found. For example: "1234" increments to "1235"; "Test-01-10" increments to "Test-01-11"; "Test-12X" is unchanged because the entry ends with a letter. One digit in the lot number provides for ten increments, two digits for 100 increments, and three digits for 1000. When the maximum increment is reach, digits roll over; 999 becomes 000.

Low Clip

Specifies a vertical cutoff plane through the data, relative to zero. All data is removed below the entered value. The zero location is specified by the best fit surface with the Remove control. Low Clip serves as a simple filter to remove valleys in the data. See also High Clip.

Low Filter

Advanced Texture Application. Activates data filtering options for the lower limit of the bandpass filter. To obtain waviness data, set the Low Filter control to Auto or Fixed. When set to Auto, the software sets the cutoff wavelength between waviness and roughness data to a fraction of the lateral extent of the data to establish a starting point for filtering. The Auto setting should only be used as a starting point. When set to Fixed, a cutoff value must be entered in the Low Filter Wavelen or the Low Filter Freq controls. When set to Off, there is no lower limit to the filter. See High Filter.

Low Filter Freq

Advanced Texture Application. Specifies the frequency of the lower cutoff point between waviness and roughness data when the Low Filter control is set to Fixed. When a value is entered, a corresponding value is output in the Low Filter Wavelen control.

Low Filter Wavelen

Advanced Texture Application. Specifies the wavelength of the lower cutoff point between waviness and roughness data when the Low Filter control is set to Fixed. When a value is entered, a corresponding value is output in the Low Filter Freq control.

Lower Light Level Offset

Stitching Application. Specifies the percentage to add to the current measurement light level for the lower surface in a zip stitch measurement.

Lower Overlap (%)

Specifies the overlap of the measured sections in the lower measurement region in a zip stitch measurement. A minimum of 10% is recommended. Requires a motorized z-axis and a programmable stage. See Zip Distance.

Lower Pad Cutoff

ABS Geometry Applications. Defines the separation of pad and ABS data. Specifies the vertical height of a cutoff plane above the ABS that defines an analysis region.

If Pad Location is set to Above, the data below the Lower Pad Cutoff is considered ABS; if set to Below, data below the Lower Pad Cutoff is considered Pad data. The data between the Lower and Upper Pad Cutoff values will not be included in either the Pad or the ABS region. If Remove Pads is On, pad regions will be missing from the Slider Map (ABS) plot. If non-pad data is missing from the ABS data, adjust the Pad Cutoff values. Default is 0. See also Upper Pad Cutoff and Pad Location.

Lower Seq File

Specifies the filename of the stitching sequence file to use for the lower surface when the Use Lower Seq File control is On.

Lower Size X

Specifies the size of the lower stitched image in the x-axis, in a zip stitch measurement. Requires a motorized z-axis and a programmable stage. See Zip Distance.

Lower Size Y

Specifies the size of the lower stitched image in the y-axis, in a zip stitch measurement. Requires a motorized z-axis and a programmable stage. See Zip Distance.

Mask Data button

Opens the Mask Editor, which is used to define sub-areas within the test part. See the section dealing with the Mask Editor.

As part of the manipulate feature, it applies any existing mask to the current data.

Mask Mode

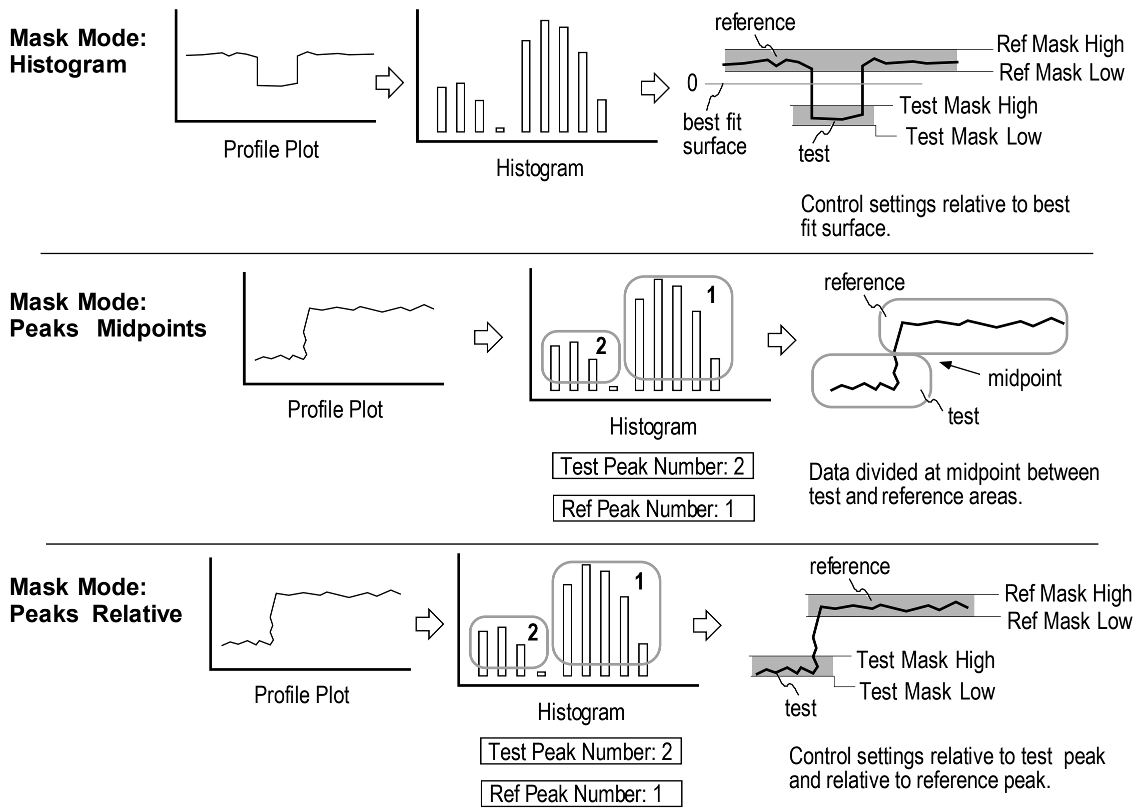
Selects the method used to define test and reference masks; located in the Test+Reference data window. Settings are Editor, Histogram, Peaks Midpoints, and Peaks Relative. When Mask Mode is *Editor*, the Mask Editor test and reference mask definitions are used.

The other mask modes are used to generate test and reference masks based on the part data itself; this helps overcome problems aligning regions on the part to predefined masks. Use the Histogram plot in the Test+Reference data window to help determine settings for the related controls. When Mask Mode is *Histogram*, test and reference masks are generated based on the data from the part relative to zero (the best fit surface specified by the Remove control). When Mask Mode is *Peaks Midpoints*, test and reference masks are generated based on the data from the part halfway between the specified test peak and reference peak. When Mask Mode is *Peaks Relative*, test and reference masks are generated based on the data from the part, relative to the specified test peak and relative to the specified reference peak.

The following table summarizes the controls related to Mask Mode:

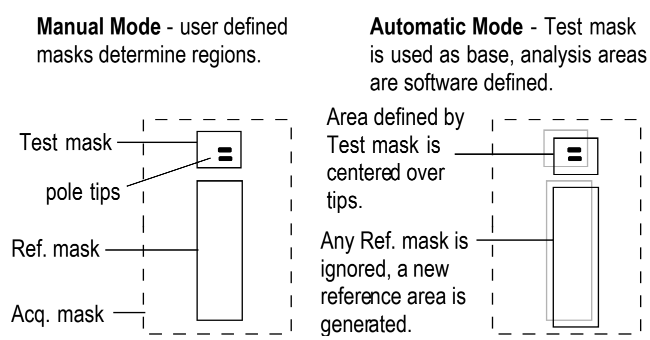
Control	***Function***	***Applicable Mask Mode***
Histogram Filter Window Size Histogram Threshold (%)	Condition (smooth and remove noise) the histogram prior to looking for peaks.	Histogram Peaks Midpoints Peaks Relative
Test Peak Number Reference Peak Number Expected Peak Number	Assign test and reference areas to the peaks in the histogram. The software numbers peak areas from highest to lowest.	Peaks Midpoints Peaks Relative
Test Mask Low/Test Mask High Test Mask Mode Ref Mask Low/Ref Mask High Ref Mask Mode	Specify cutoff locations in the histogram data. Determine what peak data is used to define the test and reference areas.	Histogram Peaks Relative
Test Sigma Filter Ref Sigma Filter	Cleanup data after it is segmented into test and reference areas to improve repeatability.	Histogram Peaks Midpoints Peaks Relative

Histogram Masking Function



Mask Mode (PTR)

PTR Applications. Selects how pole tip test and reference areas are determined. Settings are Manual or Automatic. When set to *Manual*, these areas are defined by test and reference masks created with the Mask Editor.



When set to *Automatic*, the test mask from the Mask Editor is centered around the pole tip region (once identified), and a reference area is created using the settings of the Reference Mask Distance and Reference Mask Height controls.

Note: When using Automatic masks, intensity plots show the original mask locations, while phase plots show the actual analysis areas. The Automatic mask mode may increase measurement repeatability because the same relative measurement area is used on each head.

When set to *Defined*, the recession test mask is defined by user entries in the Defined Test Width, Top Recession Gap, Top Recession Height, Bottom Recession Gap, and Bottom Recession Height controls. This test mask is centered around the pole tips, and the reference mask is created based on the Reference Mask Distance and Reference Mask Height controls. The Etch Area analysis is not available when Mask Mode is set to Defined.

Mask Spacing

Corner Cube Application. The width in camera pixels of space between the adjacent mask figures created by the Auto Mask feature. The spaces between masks are necessary to eliminate facet intersections and their reflections from the analysis.

Masks File

Specifies the name of a mask file to load automatically when the Auto Load Masks control is On. The mask file must exist prior to entering its name in the Masks File control. The name must be 14 characters or less, and usually ends with ".mas".

Max Area Size

Maximum Area Size specifies the largest contiguous number of data points in a valid data region. It is useful for eliminating the effect of large data areas that are not meant to be included in the measurement, without the need of defining a mask.

Max Peaks/Valleys

Advanced Texture Application. Specifies the maximum number of peaks or valleys for the software to find. Part of the peaks/valleys analysis.

Max Peaks/Valleys Area

Advanced Texture Application. Specifies the maximum size of a data area for it to be considered as a valid peak or valley. Part of the peaks/valleys analysis.

Max Sat Pts

Maximum Saturation Points specifies the number of saturated camera pixels allowed by the AGC function. Settings: 0 to 9999, default value is 4. The AGC (Automatic Gain Control) function tries to adjust the light intensity from the instrument as high as possible without saturation. This produces the largest dynamic range. Max Sat Pts allows a specified number of pixels to become saturated. The most useful settings range from 0 to 20. If you have to set the control higher to acquire data, the instrument may have a faulty camera.

Max Summits

Advanced Texture Application. Specifies the maximum number of summits to find. Part of the summits analysis.

Measure button

Causes the instrument to acquire measurement data based on the current control settings and perform an analysis of the obtained data. The F1 key is equivalent to clicking the Measure button.

Measurement Id

An identifier for a measurement. The value identifies the measurement when it is part of a larger context, such as one of many measurements in stats or patterns.

MetroScript button

Runs a MetroScript file. To enter the name of a MetroScript file to run, position the pointer over the MetroScript button, press the right mouse button and select the File command. Using the keyboard, enter a file name, and then press [Enter]. Use the Name command to label the button with a descriptive name linking it to the MetroScript file.

Middle Diameter

Three Zone Radius Scale Application. Specifies the middle diameter of the part with three radii, which is being measured. Enter the outside diameter of the area defined by the middle mask.

Middle Masks File

Three Zone Radius Scale Application. Specifies the name of the mask file defining the middle zone of a part with three radii. The masks defined by the middle mask file included with the application should be adjusted to match your specific part.

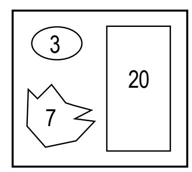
Middle Zone button

Three Zone Radius Scale Application. Initiates a measurement of the middle zone of a part with three different radii.

Min Area Size

Minimum Area Size specifies the smallest acceptable number of contiguous data points in a valid region of data. Settings: 7 to 9999999, default is 20. Decrease to allow smaller areas. Increase to accept larger areas and reject smaller. It is useful for eliminating the effect of isolated data areas that are not meant to be included in the measurement, without the need of defining a mask.

In the example shown here there are three regions of data. A Min Area Size of 7 would exclude the data area consisting of 3 data points. By increasing the value, it could exclude other larger areas which modulate but are not of interest, because of their small size.



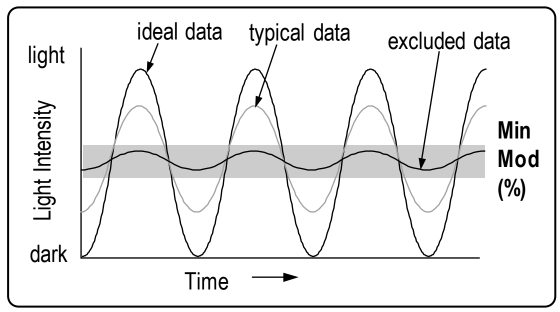
Min Area Size is not the same as Min Mod Pts. Min Mod Pts specifies the minimum number of data points required for a valid data set. Min Area Size specifies the minimum size of a valid measurement area. (An area is an island of data separated by bad data.)

Min Mod (%)

Specifies the minimum modulation necessary for a valid data point. Decrease to accept areas with poor fringe contrast or low reflectivity. Increase to exclude unwanted data points. Settings: 0.0 to 100.0.

Full modulation is represented internally in the instrument as an intensity range from 0 to 1023; when modulation occurs over less than a minimum portion (or percent) of this range, the data is considered invalid. During a measurement, the light intensity at any given camera pixel varies (or modulates) from light to dark as the phase of the interference pattern is shifted. The minimum modulation control sets the acceptable intensity range or minimum modulation necessary for data.

The drawing represents the modulation of three data points over time. Each sine wave is the signal from a given camera pixel when the PZT's are ramping. Ideal modulation is when the light intensity of each data point varies from zero to maximum. Typically, the light intensity from each data point does not have ideal contrast. When the modulation is insufficient, the data point is excluded.



Modulation relates to the signal-to-noise ratio and repeatability. The greater the modulation of each data point, the higher the signal-to-noise ratio and the better the repeatability. As the modulation decreases, the lower the signal-to-noise ratio and worse the repeatability, and thus the harder it is to obtain usable data from the test part.

Increase the minimum modulation percent (>15%) if you desire to exclude unwanted data points, such as with very smooth surfaces with high contrast fringes. Decrease the percentage (<15%) to include more data points, with the added penalty of decreasing the signal-to-noise ratio. Rough surfaces, surfaces with high slopes, or surfaces producing low fringe contrast fringes, will have points that do not modulate as well; thus a lower percentage will allow more points to pass as valid data points.

Min Mod Pts

Minimum Modulation Points specifies the minimum number of data points, which pass the Min Mod (%) criteria, that make up a valid data set. For data to be analyzed by the system, it must be made up of this minimum number of data points. Settings: 0 to 9999, default is 50.

Min Mod Pts is different than Min Area Size. Min Area Size specifies the minimum size of a valid measurement area, not the entire data set.

Min Peaks/Valley Area

Advanced Texture Application. Specifies the minimum size of a data area for it to be considered as a valid peak or valley. Part of the peaks/valleys analysis.

Mouse Acceleration

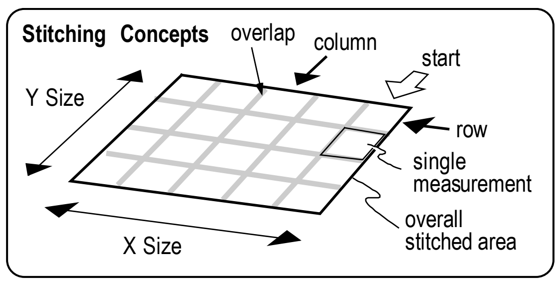
Specifies how fast the screen pointer moves when then the mouse is dragged. It is used in conjunction with the Mouse Threshold control. Settings:1 to 50, default is 2.

Mouse Threshold

Specifies how much the mouse moves before the pointer on the screen accelerates. It is used in conjunction with the Mouse Acceleration control. Settings: 1 (default) to 100.

N Cols

Specifies the number of vertical columns in the stitch stage pattern. Requires a programmable stage.



N Rows

Specifies the number of horizontal rows in the stitch stage pattern. Requires a programmable stage.

Narrow

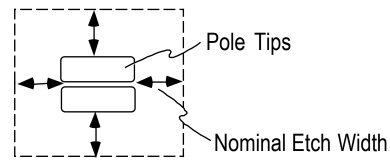
Determines how dark fringes are displayed. Settings are On or Off. When On, the width of the dark fringes is reduced. Part of the Synthetic Fringe window.

Next Bucket button

When the Acquisition Mode control is set to Phase, the instrument acquires multiple "buckets" of intensity data for the phase algorithm. The Next Bucket button displays the next segment of intensity data in the plots in the Intensity Data window. It is primarily used as a diagnostic tool.

Nominal Etch Width

PTR Applications. Specifies the width of an area around the pole tips to look for the etch region. If the width is set to 0, etch analysis is disabled.



Nominal Length

ABS Geometry Applications. Specifies a nominal dimension along the rails. It is used when calculating TwistHt and Crown. A value of 0 automatically finds the length. In the Left, Right, and Center Rail data windows, a setting greater than 0 is used when calculating crown for the individual rails.

Nominal Pole Width

Trimmed PTR Application. Specifies the nominal width in the x-axis of the pole tips. It is used to help find the pole tip region more accurately.

Nominal RadCrv

Specifies the nominal or planned radius of curvature of the spherical part. This value must be entered before making a measurement. Use a negative sign for concave surfaces, convex surfaces are positive. Used when measuring tool offset.

Nominal Step Height

Step Height Application. Specifies the nominal step height of the step height standard being measured. Use the value that is marked on the Step Height Standard. Click the control to enter a value.

Nominal Width

ABS Geometry Applications. Specifies the width of the data to use when calculating Camber results and TwistHt (Coef). A value of 0 uses all of the data.

Normalize

For Profile plots. When On, all slices in a profile plot are adjusted to relate to one another. Linear slices shift so the first valid data point is at zero on the x-axis. Circular slices are made the same length with x-axis in degrees.

nPTR Points

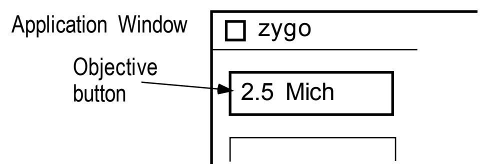
PTR Applications. Specifies the desired number of points to use when calculating nPTR.

Number of Poles

PTR Applications. Selects the number of poles; ensures that appropriate calculations are applied. Settings are 1, 2, or 3. For standard pole tips use 2; for typical MR heads use 3.

Objective button

Selects the objective used for the next measurement in microscope applications. This button is permanent; it can not be moved or deleted.



To select an objective, click on the Objective button with the left mouse button until the name in the button matches the objective you have selected on the instrument. It will only select designated objectives.

Omega 2 Cutoff

ABS Geometry Applications. Specifies the location of the Omega 2 cutoff. Range ± 20 µm, default is 0.

Omega 2 Cutoff Mode

ABS Geometry Applications. When On, all data below the setting in the Omega 2 Cutoff control is deleted after finding the hogout region. Only applicable for AAB 2 slider type.

Outer Diameter

Three Zone Radius Scale Application. Specifies the outer diameter of the part with three radii, which is being measured. Enter the outside diameter of the area defined by the outer mask.

Outer Flyable Radius

Disk Flatness Application. Defines the radius of the outer extent of disk at which the head flies over the disk during use.

Outer Masks File

Three Zone Radius Scale Application. Specifies the name of the mask file defining the outer zone of a part with three radii. The masks defined by the outer mask file included with the application should be adjusted to match your specific part.

Outer Radius

Stitching Application. Specifies the radius of a circular area in which there is data. Applicable when the Type control is set to Annulus.

Outer Rails Trim

ABS Geometry Applications. Specifies number of pixel layers to remove from edges of the two outer rails. The Outer Rails Trim Mode control specifies where the trim is performed, either to All edges or Outside edges.

Outer Rails Trim Mode

ABS Geometry Applications. Selects the edges where the number of pixel layers entered in the Outer Rails Trim control are trimmed. Settings are All or Outside.

Outer Zone button

Three Zone Radius Scale Application. Initiates a measurement of the outer zone of a part with three different radii.

Overlap (%)

Specifies the overlap of the columns and rows in the stitched image. 15 to 20% is recommended, 10% is the minimum. When the Type control is Start & End Pos or the X & Y Dimension, it is the minimum overlap percent.

P1/P2 Separation (%)

PTR Application. Specifies how the top pole (P1) is separated from the middle pole (P2) of an MR head. The value entered in the control is the percentage of data assigned to the top pole, the rest of the data is assigned to the middle pole or split between the middle and bottom poles. The Number of Poles control must be set to 3. Range 0 - 99. When set to 0, the current or previous algorithm is used to separate the poles.

P2/P3 Separation (%)

PTR Application. Specifies how the middle pole (P2) is separated from the bottom pole (P3) of an MR head. The value entered in the control is the percentage of data assigned to the middle pole, the rest of the data is assigned to the bottom pole. Applies only when the Number of Poles control is set to 3. Range 0 - 99.

Pad Fit Control

ABS Geometry Applications. Determines the data and the fit used to identify pads along the ABS regions. Selections are: Plane, Sphere, Cylinder (default), Plane 2 Rail, Sphere 2 Rail, or Cylinder 2 Rail. Plane, Sphere, and Cylinder use all ABS regions for the fit and identify pads on all ABS areas. Plane 2 Rail, Sphere 2 Rail, and Cylinder 2 Rail use the left and right ABS regions for the fit and only identify pad regions along the left and right ABS.

Pad Location

ABS Geometry Applications. Specifies the relationship of the pad regions with the ABS areas. Selections are: Above/Inside, Above/Outside, Below/Inside, or Below/Outside. Above refers to the pad area as that above the setting of the Upper Pad Cutoff control. Below refers to the pad area as that below the setting of the Lower Pad Cutoff control. Inside indicates that the pad area is surrounded by the ABS region. Outside indicates the pad area surrounds the ABS. Data between the Upper Pad Cutoff and Lower Pad Cutoff control values is not included in either region.

Pad Trim

ABS Geometry Applications. Trims data to make the pad data area smaller. Specifies the number of pixel layers to remove around the outside of valid pad regions. Range: 0 to 5, default 0. See also Remove Pads control.

Part Diameter

Radius Scale Application. Specifies the diameter of the part whose radius is being measured. If an acquisition mask is used, enter the diameter of the area defined by the mask. If a mask is not used, enter the diameter of the test surface over which the fringe pattern occurs.

Specifies the nominal part diameter of the part being measured. This is a required entry. Part of the ISO 10110-5 window.

Part Num

Use to enter a number for item being tested. Text and numbers may be entered.

Part Radius

GPI Application. Specifies the radius of curvature of the test part. This control is used in conjunction with the Spherical Distortion Correction control. Part Radius has no effect if Spherical Distortion Correction control is turned off. Access Part Radius via New Control→Distortion Correction.

Part Ser Num

Use to enter the serial number of the test part. The Part Ser Num control has three modes of operation: Normal, Auto-Increment, and Prompt. To enter a serial number, click on the box with the left mouse button, type a number with the keyboard and press [Enter].

The mode of operation of the Part Ser Num control is selected with the Mode command from the control's menu. The current mode of operation is indicated by an asterisk (*). When the Mode is *Normal*, the data is saved under the specified serial number. When the Mode is *Prompt*, the software asks you to enter a serial number before each measurement.

When the Mode is *Auto-Increment*, the serial number is incremented by one for the next measurement. Only the right-most 15 digits are incremented until a non-digit character is found. For example: "1234" increments to "1235"; "Test-01-10" increments to "Test-01-11"; "Test-12X" is unchanged because the entry ends with a letter. One digit in the serial number provides for ten increments, two digits for 100 increments, and three digits for 1000. When the maximum increment is reach, digits roll over; 999 becomes 000.

Part Thickness

PHom Application. Specifies the thickness of the test part. An entry is required to calculate Homogeneity. Change the measurement units with the Units command from the control's menu.

Pattern File

Specifies the name of a pattern file to load automatically when the Auto Load Pattern control is set to On. The pattern file must exist prior to entering its name in the control. The name must be 14 characters or less, and usually ends with ".pat".

Pattern Number

A user-specified identifier for a pattern position.

Phase Avg Pause

When On, the instrument is paused between multiple phase averages. To continue, the operator clicks an on-screen button. Phase Avg Pause is primarily used when making a system error file. It is only functional if the Phase Avgs control has an entry greater than 1.

Phase Avgs

Specifies the number of phase averages performed during measurements; averaging improves repeatability. Values from 0 to 1024 can be entered. Averaging increases processing time.

Averaging is used to improve the instrument measurement repeatability by increasing the signal-to-noise ratio of the data acquisition system. MetroPro has both intensity averaging and phase averaging. Both averaging techniques can be used together. Averaging increases the time required to analyze data. The time is dependent on the computer speed, the complexity of the data, and the number of data points.

Drift and vibration in the interferometer cavity can limit the effectiveness of averaging. But drift is less of a factor in phase averaging than intensity averaging, since sets of data are acquired in segments of 100-200 microseconds and then averaged; the amount of drift is minimal during such a small interval. The sensitivity of phase averaging to drift is approximately 10 times to 120 times less than intensity averaging.

Phase Correction

Selects the phase correction mode, which adjusts for phase changes due to parts consisting of dissimilar materials. Applicable only when the Acquisition Mode control is set to Phase. Settings are None, Offset, or n and k. Other Control boxes used with this control are: Ref Region k, Ref Region n, Test Region k, Test Region n, Ref Region Offset, and Test Region Offset.

The accuracy of phase measuring interferometers is limited when the measured test part consists of materials with dissimilar optical properties. The dissimilar optical properties cause relative phase shift error in the measured vertical heights of the dissimilar materials. Light reflected from glass or any homogeneous surface has a constant phase change and does not require correction.

None means that no correction is used. Normally, most measurements do not require phase correction because the part is made of a uniform material.

Offset uses values entered in the Ref Region Offset and Test Region Offset controls to correct for phase shift errors. An overview of this technique is: measure the test part; over-coat the part with an opaque specular material, such as aluminum; remeasure the same part; compare the first results to the second; and determine the offset value, which is the average difference between the coated and uncoated results. These offset correction values are applied to future measurements; they adjust the relative vertical position of dissimilar areas to more accurately represent the part.

n and k uses the index of refraction values entered in the Ref Region k, Ref Region n, Test Region k, and Test Region n Control boxes to correct for phase shift errors. The optical constants of a material are referred to as "n" and "k". The index of refraction is *n*; the absorption coefficient is *k*. It can be difficult to determine the correct n and k values. The optical constants vary depending on the material, the wavelength of light, and the numerical aperture of the objective. The values also vary depending on the material, how it is deposited, and what it is deposited on. For these reasons, offset correction is often preferred over n and k correction.

Phase correction may be necessary when thin film effects are present. The optical thickness (τ) of a thin film is given by: $\tau = nd$ Where n is the index of refraction of the film material and d is the thickness of the film. Light which reflects off the bottom of the film travels two times the optical thickness farther than the light reflected from the top of the film. If $2*\tau$ is larger than the interference depth of the objective, the thin film will not affect the measurement. If $2*\tau$ is smaller than the interference depth, the light reflected from the bottom of the film could add to or subtract from the light reflected from the top of the film.

When either Offset or n and k correction is used, Test and Reference masks must be defined to coincide with the dissimilar test part areas. See the Mask Editor section for details on defining and using masks.

Phase Hogout

ABS Geometry Applications. Turns on/off phase measurement hogout identification and hogout tilt results. If the Taper Location control is 0 (zero), then the crossbar and/or taper area is included in the hogout area for analysis. This is only applicable to AAB 1, AAB 1 (Wide), Proximity, and Proximity 3 slider types. This is a measurement control; therefore you must re-measure after changing this control.

Phase Res

Selects the resolution of the calculation of phase values. When the Acquisition Mode control is set to Phase, it also affects the number of buckets acquired. The Settings are Normal or High.

Phase Res	*Counts per Fringe*	*Phase Acquisition Buckets*
Normal	4096	7
High	32768	13

High provides higher resolution, but lower total range of heights. Normal provides a higher range of heights but lower resolution. Normal is the suggested settings for interferometers. High is the suggested setting for microscopes; though it should be set to Normal if the test part is curved, when there are many fringes, or when very fast processing is required.

Pole Tip Cut End Offset

ABS Geometry Applications. Specifies the dimension from the end of the slider to the pole tip. This area is removed from the ABS analysis and used to calculate Trailing Edge Height and Angle.

Pole Tip Delete %

PTR Applications. After identifying the pole tips, areas smaller than this % of the total pole tip area are not considered part of the pole tips. These areas are considered part of the etch region if they are within the area defined by the Nominal Etch Width control, or part of the baselayer area if they are outside the etch area. The size is specified as a percent of the total pole tip area; the recommended setting is 10.

Pole Tip Intensity Cutoff

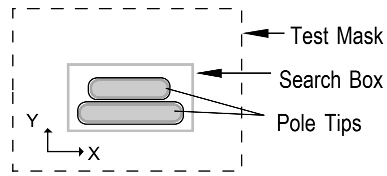
PTR Applications. Specifies an intensity cutoff value from 0 to 1023. Typical values range from 50 to 150. Any intensity data below this value is considered outside the valid pole tip region. Applicable when the Pole Tip Search control is set to Intensity Data. Lower the value to include more pole tip data, raise the value to exclude more data.

Pole Tip Phase Cutoff

PTR Applications. Specifies a phase cutoff value; always a negative number. Typical values range from -0.8 to -1.2 µin. The value establishes a cutoff plane below the baselayer, data above this plane is considered outside the valid pole tip region. Applicable when the Pole Tip Search control is set to Phase Data 1 or Phase Data 2. Lower the value to exclude more pole tip data, raise the value to include more data.

Pole Tip Region Size X

PTR Applications. The dimension across the rail of a "search box" used to find the pole tips. Enter a size about 10% longer than the tips. For MR heads, enter a value to the extent of the pole tips you want to include in the PTR calculation.



Search box should be 10% larger than pole tips and < 2/3 size of PTR Test Mask.

Pole Tip Region Size Y

PTR Applications. The dimension along the rail of a "search box" used to find the pole tips. Enter a size about 10% larger than the height of the tips.

Pole Tip Reject

PTR Applications. Specifies what pole tip data points to reject when using phase correction. Phase correction shifts the pole tip area upward. Pole Tip Reject specifies how much of the shifted data to reject. The default setting of -1.0 accepts all pole tip points. A value greater than or equal to 0 is multiplied times the rms of the baselayer to obtain a cutoff value; data points higher than this value are eliminated. Applicable when the Phase Correction control is set to Offset.

Pole Tip Search

PTR Applications. Selects the type of data searched and mode used to find the pole tips. Settings are Intensity Data, Phase Data 1, or Phase Data 2. The software locates the pole tips by systematically moving a "search box" around the data in the PTR Test mask. Use Intensity Data for production inspection and Phase Data when measuring coated heads for deriving offset values. Phase Data 1 looks for one contiguous region, Phase Data 2 looks for two distinct pole tips.

Post-log Command

Used to enter a command for performing external processing functions of report files. For example, a command can output the report file to a printer or to another computer.

Pre-Connect Filter

Filters data before the connect process to help eliminate edge effects. It is used primarily with two wavelength measurements. Settings: 0 to 100, default is 0. A value of 60 or higher is recommended. When filtering is active, more processing time is required and data points may be eliminated.

An edge effect occurs along a vertical step in a part where there is very steep pixel-to-pixel slope greater than half the wavelength of the light source. The Pre-Connect Filter removes ambiguous edge effects before data points are joined together in a map representing the part, otherwise the ambiguous data may adversely affect results.

Pressure (Torr)

Specifies the pressure of the radius slide test environment in Torrs. A Torr is a unit of pressure equal to 1/760 atmosphere or 1 mm Hg. Range: 0 to 9999, default 760. The Index of Air is recalculated as values are entered. Click the Reset Env button to reset the control to the default setting.

Prev Bucket button

When the Acquisition Mode control is set to Phase, the instrument acquires multiple "buckets" of intensity data for the phase algorithm. The Prev Bucket button displays the previous segment of intensity data in the plots in the Intensity Data window. It is primarily used as a diagnostic tool.

Print Report button

Prints the contents of the Report window to a printer connected to the computer when clicked on with the left mouse button.

Printing

Enables the auto printing of the contents of the Report window as text, after each measurement. When Off, the report is not printed at the end of each measurement. But selectively, you can print the report by clicking the Print Report button. When On, a report is printed automatically after each measurement. When the next measurement is made, another report is output.

Proximity Filter

ABS Geometry Applications. Selects the type of filter used to determine ABS regions when the Slider Type is set to Proximity or Proximity 3. Settings are Slope or Acceleration (default).

Proximity Length

ABS Geometry Applications. Specifies the height of the proximity area, which is the distance from the top of the slider and to the bottom of the proximity pad. A single Pole Tip Cut End Offset area is defined on the center rail for calculating Trailing Edge Height and Angle. An entry is required for Proximity slider types; all other slider types ignore this control. For Proximity 3 sliders, a single row of pixels is deleted in the plot only to identify where the Proximity Length is located on the center rail. See also Proximity Overlap.

Proximity Overlap

ABS Geometry Applications. Set to On when the proximity pad data extends between the side ABS regions. If Off (default), the overlapping data is deleted from the proximity pad. Applicable when the Slider Type is Proximity and Proximity 3.

PSF Size

Selects the resolution of the array used in the computation of PSF analysis. Settings: 64, 128, or 256. Because the PSF computation uses a two-dimensional Fast Fourier Transform, a setting of 64 yields the fastest results, but the plot is relatively coarse. Conversely, a setting of 256 yields the most detailed plot, but takes longer to create.

PTR (%)

Trimmed PTR Application and PTR Applications. Specifies how much data of the pole tip region to use in calculating the PTR (%) result. When set to 100 (%), PTR and PTR (%) results are the same.

PTR (%) 1,2,3

PTR Applications. Specifies the percentage of data from each pole tip to use when calculating PTR (%) 1, 2, and 3 results.

PZT Cal

Piezoelectric Transducers Calibration enables automatic adjustment of modulation magnitude during data acquisition. If the PZT Cal control is On, the modulation of the instrument piezoelectric transducers (PZT's) is adjusted during data acquisition to obtain the correct phase relationships among the numerous readings of light level data.

When PZT Cal is On, the current modulation value, specified with the PZT Gain control, is used as a starting point and adjusted if necessary. If PZT Cal is Off, the PZT Gain value is used but is not adjusted. PZT Cal is most accurate when there are several (4 to 5) fringes across the measured area. Under most measurement conditions, it is preferable to have ramp calibration on.

PZT calibration is very stable when used with a single microscope objective or interferometer transmission element. If you are measuring a large batch of similar parts and want the maximum processing speed, turn the PZT Cal control to Off after the first measurement is completed.

PZT Gain

Piezoelectric Transducers Gain specifies the modulation amplitude value used during data acquisition. The higher the value, the greater the PZT movement. Settings: 0 to 4095, default about 1600, set at factory. Under normal circumstances it is not necessary to change the PZT Gain value. There are certain interferometer setups that require one-half the normal PZT motion; this can be set by dividing the PZT Gain by two.

If the PZT Cal control is On, the modulation value is used as a starting point and adjusted if necessary to produce the correct phase differences. If PZT Cal is Off, the modulation value is used but not adjusted.

PZT Scale Factor

Specifies the scale of PZT movement; it is used in special applications to scale the PZT movement up or down to achieve the required one fringe of phase modulation. Settings: 0.125 to 2.0, default is 1.000.

The Corner Cube application uses a PZT Scale Factor of 0.5 when measuring a corner cube in the double-pass configuration.

RadCrv Leading Edge Offset

ABS Geometry Applications. Specifies the distance from the leading edge of the ABS *not* to include in the restricted radius of curvature calculations. The default is 0.

RadCrv Trailing Edge Offset

ABS Geometry Applications. Specifies the distance from the trailing edge of the ABS *not* to include in the restricted radius of curvature calculations. The default is 0.

Radius

Specifies the radius in pixels of a generated Zernike data set. An entry of -1 makes the radius as large as possible based on the Camera Size X and Camera Size Y controls.

Radius (measured)

Specifies the actual measured radius of curvature of the part being measured. This radius is supplied from some other means, such as the Radius Scale Application. If using this control, do not enter a value in the Radius (Nominal) control. Part of the ISO 10110-5 window.

Radius (nominal)

Specifies the nominal radius of curvature of the part being measured. If using this control, do not enter a value in the Radius (Measured) control. Part of the ISO 10110-5 window.

Rail Width

ABS Geometry Applications. Specifies the dimension in the x-axis of the left and right rails. If entered, the Auto Focus and Tilt functions use this value along with the Slider Width control to determine the surface to focus and tilt to, rather than utilizing the Hogout Width control. An entry is required when Slider Type is Three Rails (Defined) to determine the left, right, and center ABS regions.

Read button

Click to obtain measurement data from the ZMI system on screen. Click the mouse button (anywhere) to cancel the distance display. Part of the DMI Test window; used with the radius scale option.

Ref Freq

Specifies a MTF reference frequency for a plano wavefront, or when the f-number is equal to zero. Range 0 to 1. The Ref MTF results are the modulation values at this reference frequency.

Ref Mask High

Specifies the higher height limit used in defining the reference mask. When Mask Mode is Histogram, the limit is in relation to zero (the best fit surface specified by the Remove control). When Mask Mode is Peaks Relative, the limit is in relation to the center of the reference peak area. This control along with the Ref Mask Low and Ref Mask Mode determine the reference mask area. See Mask Mode.

Ref Mask Low

Specifies the lower height limit used in defining the reference mask. When Mask Mode is Histogram, the limit is in relation to zero (the best fit surface specified by the Remove control). When Mask Mode is Peaks Relative, the limit is in relation to the center of the reference peak area. This control along with the Ref Mask High and Ref Mask Mode determine the reference mask area. See Mask Mode.

Ref Mask Mode

Determines how the Ref Mask High and Ref Mask Low controls are applied to the data when creating the reference mask. Applicable when the Mask Mode control is set to Histogram or Peaks Relative. Settings are Unfill or Fill. When Fill, the data points above Ref Mask High and below Ref Mask Low are deleted. When Unfill, the data points between Ref Mask Low and Ref Mask High are deleted.

Ref Pt 1

For profile plots. Specifies the starting point of the reference segment along the x-axis. Requires an entry in the Ref Pt 2 control. The Use Ref Pts control must be On.

Ref Pt 2

For profile plots. Specifies the ending point of the reference segment along the x-axis. Requires an entry in the Ref Pt 1 control. The Use Ref Pts control must be On.

Ref Region k

Ref Region k (Reference Region k) specifies the imaginary part of index of refraction constant of an area inside a Reference mask. The value is used along with the values in the Ref Region n, Test Region k, and Test Region n controls to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to n and k.

Ref Region n

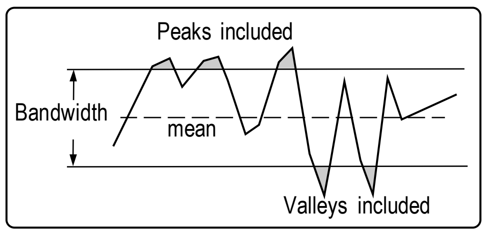
Ref Region n (Reference Region n) is a numeric Control box used to enter the real part of the index of refraction of an area inside a Reference mask. The value is used along with the values in the Ref Region k, Test Region k, and Test Region n controls to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to n and k.

Ref Region Offset

Ref Region Offset (Reference Region Offset) is a numeric control used enter an offset compensation value for an area inside a Reference mask. The value is used along with the value in the Test Region Offset control to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to Offset.

Reference Band

Advanced Texture Application. Specifies a band for locating peaks and valleys. The band is centered around the mean plane of the data. The upper edge of the band is the reference value for finding peaks, and the lower edge is the reference for finding valleys. Part of the peaks/valleys analysis.



Reference Mask Distance

PTR Applications. The distance below the relocated Test mask to place the Reference mask when the Mask Mode is set to Automatic. The distance should be large enough to position the area on the ABS.

Reference Mask From

PTR Applications. Selects where the reference mask is reference to, when the Mask Mode is set to Automatic or Defined. Settings are Test Mask (default) or Pole Tips.

Reference Mask Length

PTR Applications. The height of the Reference mask created when the Mask Mode is set to Automatic.

Reference Peak Number

Specifies which histogram peak from the histogram data to use as the reference area. This control is used in the Test+Reference data window to define the reference region. Applicable when the Mask Mode control is set to Peaks Midpoints or Peaks Relative. See Expected Peak Number.

Reference Sigma Clip

Applies a sigma filter to the reference area to remove spurious data when the Mask Mode control is set to Histogram, Peaks Midpoints, or Peaks Relative. If a data point height is greater than the entered value times the rms from the reference surface (specified by the Remove control), it is removed. It is used for data clean-up after segmenting into test and reference areas.

Refractive Index

Specifies the refractive index of the part being measured. The index of refraction is the ratio of the velocity of light in a vacuum to the velocity of light in a refractive material for a given wavelength.

Angle Measurement Application. Specifies the refractive index of the part being measured. It is preset in the Wedge (Trans) and 90 deg Prism Int setup to 1.50. You must enter the actual refractive index of the test optic; 1.50 is simply a default software entry.

Corner Cube Application. Specifies the refractive index of the corner cube material, if the corner cube is a solid piece of glass. If the cube is constructed from three mirrored planes, enter the refractive index of air. For example, the Refractive Index for BK-7 is 1.51633; the refractive index of air at STP is 1.0002714. This value is used for the calculation of the dihedral angles of the corner cube.

PHom Application. Specifies the refractive index of the test part. An entry is required so a scale factor for measuring surface 2 can be determined.

Relative Cutoff

Advanced Texture Application. Specifies the cutoff based on a percentage of the highest summit, when the Cutoff Mode control is set to Relative. Only summits with a height greater than a calculated height are analyzed. This calculated height is equal to the maximum summit height minus the specified percentage of the range of summit heights. A value of 100 includes all summits in the analysis. Part of the summits analysis.

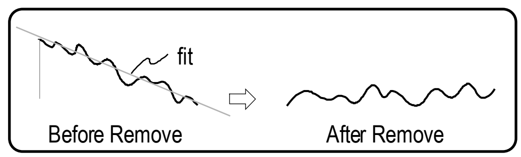
Relative Humidity (%)

Specifies the relative humidity of the radius slide test environment in percent. Range: 0 to 100, default 50. The Index of Air is recalculated as values are entered. Click the Reset Env button to reset the control to the default setting.

Remove (*interferometers*)

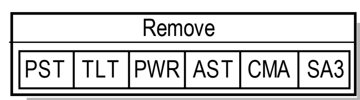
Specifies the overall surface shape(s) to subtract from the data during analysis. If the overall shape is not removed, it may dominate the results making it difficult to determine the actual quality of the surface or wavefront. When overall surface shape is subtracted, MetroPro analyzes the difference between a mathematical surface and the actual surface. Note that as used in this description, "surface" means either the surface or the transmitted wavefront of the object being tested.

As shown here, removing plane (or tilt) causes this tilted data to be displayed flat, allowing the vertical scale to be expanded, thus revealing much greater detail about the surface.



Remove performs a least-squares fit of a function to the data. The least-squares fit minimizes the rms difference between the selected "remove" shapes and the actual data by determining the optimal mathematical coefficients for the function. These coefficients are then used to generate a mathematical surface which is subtracted from the data, thus producing a residual map of the difference between the best fit surface and the original data.

The interferometer Remove control contains six buttons, each corresponding to a particular shape.



To select the surface you want to remove, click on the button that corresponds to the particular shape that you want to remove. The interferometer Remove control has four modes of operation that vary the shapes to remove. Use the Mode command from the control's menu to select Normal, Zernike, Cylinder, or Sphere. The button selections are explained below.

Mode	*Selections*
Normal	PST TLT PWR AST
Zernike	PST TLT PWR AST CMA SA3
Cylinder	PST TLT PWX PWY TWS
Sphere	FRS (Fixed Rad Sphere)

Note: You may select any combination of shapes you want; however, be aware that Zernike polynomials are required for some combinations of remove surfaces. Zernikes are calculated by MetroPro when TLT, PWR, or AST is selected with any lower-order terms unselected, or when CMA or SA3 is selected.

Remove - Normal Mode

PST or piston compensates for any z-axis offset. *TLT* or tilt compensates for any residual tilt. It causes a slanted sample to appear flat. For most measurements, remove plane to compensate for the tilt inherent in the equipment setup and the nulling of fringes. *PWR* or power compensates for spherical surfaces; they appear flat. This allows you to observe surface features instead of the dominant spherical shape. *AST* or astigmatism compensates for astigmatic (cylindrical) surfaces; they appear flat. This allows you to observe surface features instead of the dominant astigmatic shape.

Remove - Zernike Mode

For explanations of PST, TLT, PWR, and AST see Normal mode. *CMA* and *SA3* or Coma and Spherical Aberration is usually used when testing lens systems to view residual wavefront errors after removing known aberrations. The residual errors are usually an indication of misalignment or fabrication errors of the elements in the optical system. The Mode command must be set to Zernike.

Remove - Cylinder Mode

For explanations of PST and TLT see Normal mode. *PWX* or power in the x-axis, compensates for cylindrical surfaces. *PWY* or power in the y-axis, compensates for cylindrical surfaces. In general, if moving the part towards or away from the interferometer causes vertical fringes, select PWX. If this motion creates horizontal fringes, select PWY. TWS or twist removes the residual clocking error of the part relative to the reference. Twist is also called “fan” by opticians because of the characteristic fan shaped fringes. Small misalignments of the surface can cause this aberration to appear in the measured wavefront. Removing twist improves measurement repeatability, though it also removes any twist which is part of the surface. The Mode command must be set to Cylinder.

Remove – Sphere Mode

When Sphere Mode is selected, there is one active button labeled “FRS” (Fixed Radius Sphere). FRS will remove the known value of the radius of a sphere. The sign convention for a convex surface is a positive radius. A convex surface will have a negative radius.

The Remove Control and Results

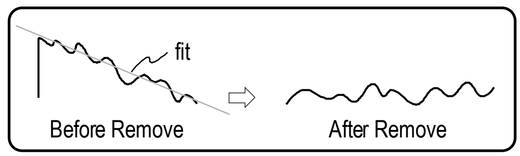
Results calculated *before* Remove include: Power, RadCrv, Sag, Sag X, Sag Y, Tilt X, Tilt Y, TltAng, TltMag, Seidels, Zernikes.

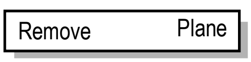
Results calculated *after* Remove include: AvgHgt, H, Peak, PV, Ra, Rku, rms, Rsk, R3z, Rtm, Rz, Valley, Vol Dn, Vol Up, VolNet.

Remove (microscopes)

Specifies the overall surface shape(s) to subtract from the data during analysis. If the overall shape is not removed, it may dominate the results making it difficult to determine the actual quality of the surface. When overall surface shape is subtracted, MetroPro analyzes the difference between a mathematical surface and the actual surface.

As shown here, removing plane causes this tilted data to be displayed flat, allowing the vertical scale to be expanded, thus revealing much greater detail about the surface.





For the microscopes, the Remove control selects the surface to remove, this usually improves the analysis by eliminating form from the results, thus highlighting the surface irregularities. The results are the deviation from the surface you have removed. Settings are Piston, Plane, Sphere, Cylinder, Fixed Rad Sphere, Fixed Angle Cone, Variable Angle Cone, or None.

Piston, plane, sphere, and cylinder are removed by a least squares fit on the data. It calculates the coefficients of the best fit surface and other parameters related to the fit without modifying the data. If you have modified the data with an Acquisition mask, only those points remaining are used in the least squares fit. Piston and plane are an aspect of the interferometer configuration and the sample, while sphere and cylinder are inherent to the sample. Most analyses should be performed with plane removed, while sphere and cylinder should be removed only from samples of certain shapes. When sphere or cylinder is selected, piston and plane are also removed.

Removing *Piston* compensates for any offset in the z-axis after you null the fringes. Removing *Plane* compensates for any residual tilt present after you null the fringes. It causes a slanted sample to appear flat. For most analyses, you should remove plane to compensate for the tilt inherent in the equipment setup and the nulling of fringes. Piston is also removed.

Removing *Sphere* causes spherical samples such as ball bearings to appear flat. This allows you to observe surface roughness features instead of the dominant spherical shape. Piston and Plane are also removed. Removing *Cylinder* causes cylindrical samples such as rods to appear flat. This allows you to observe surface roughness features instead of the dominant cylindrical shape. It can remove two different orthogonal cylinders. Piston and Plane are also removed.

Removing *Fixed Rad Sphere* removes the radius of a sphere whose value is known. The sign convention for a convex surface is a positive radius. A concave surface will have a negative radius. A value must be entered for the Sphere Radius control.

Removing *Fixed Angle Cone* removes a specified cone angle from the data. This value must be entered using the Cone Angle control. An illustration of cone angle is included with the description of the control.

Removing *Var Angle Cone* removes a best fit cone angle from the data. While a cone angle value is not required for this remove routine, entering a valid value in the Cone Angle control can improve processing time.

Select *None* when the surface is not continuous, when the surface has an asymmetrical structure such as a large hole or slope, or when you want to see the tilt.

The Remove Control and Results

Results calculated *before* Remove include: Power, RadCrv, Sag, Sag X, Sag Y, Tilt X, Tilt Y, TltAng, TltMag, Seidels, Zernikes.

Results calculated *after* Remove include: AvgHgt, H, Peak, PV, Ra, Rku, rms, Rsk, R3z, Rtm, Rz, Valley, Vol Dn, Vol Up, VolNet.

Remove (profiles)

For profile plots. Subtracts the selected shape from the all slices; choices are Piston, Line, Circle, and None. Piston compensates for offset in the z-axis. Line compensates for residual tilt. Circle removes a best fit circle from the data. None turns off remove.

Remove (spectrum)

The Remove control in the Spectrum data window subtracts the selected shape form the data; choices are Cylinder, Plane, or Sphere. This control should only be used if surfaces have not been removed with the Remove control in the default data window. Cylinder removes any dominant cylindrical shape so the data appears flat. Plane compensates for any residual tilt present. Sphere removes any dominant spherical shape so the data appears flat.

Remove Fringes

Removes fringes from the data displayed in the Intensity window. It does not affect the results in other Data windows. This control is required for the Pole Tip Recession (PTR) application. Removing fringes only works when the Acquisition Mode Control box is set to Phase.

When *Off*, a Filled plot in the Intensity window displays one frame of light level data similar to the image on the video monitor screen. When *On*, a Filled plot in the Intensity window displays a map of the light intensity without the interference pattern. In effect, the fringes are removed from the intensity data. This is accomplished by averaging a number of frames of intensity data. Processing time is increased.

Remove Pads

ABS Geometry Applications. When On, pads are identified, removed from the ABS and analyzed. Hogout must be identified and removed from data for pad analysis. The default setting is Off.

Remove Reference

ABS Geometry Applications. Specifies what surface to fit and remove to the reference area in a composite magnetic head, before analyzing the data along the slices. Settings are Plane, Sphere, or Cylinder. See A1.

Remove Spikes

Determines if spikes are removed from the data. When On, a 3x3 windowing function uses the setting of the Spike Height control to remove spikes from the data. For example, the rms of the nine data points inside the window is calculated; if there are any points that exceed the multiplier value of the Spike Height control times the rms within that window, they are excluded. Spikes are only removed within the data window where the control is accessed. When Off, spikes are not removed.

Remove Tilt Bias

Activates a remove function associated with movement of the Piezoelectric Transducers (PZT's). The physical process of PZT movement during data acquisition introduces into the phase data a slight tilt bias that is unrelated to the fringe orientation. This control allows the removal of this tilt bias during a measurement before analysis.

Tilt bias normally has no affect on results because the Remove control is usually set to remove overall tilt. Set Remove Tilt Bias to *On* in situations when removal of overall tilt from the data set is not appropriate. An example is measuring a corner cube in the double-pass configuration.

Reset button

Sets the system parameters back to those of the current saved application and clears memory (RAM) occupied by data.

Clicking the Reset button also deletes the displayed data set, clears all windows and results, resets Control boxes to their original settings, and resets any units changed in the Result boxes to those of the “master” units. It does not affect the windows, changing their size, shape, or location.

Reset Cal button

Step Height Application. Click to undo the step calibration or any previous step calibration.

Reset Env button

Sets all the environmental Control boxes (Temperature, Pressure, and Relative Humidity) back to their “standard” settings. That is, Temperature is set to 20.0°C, Pressure is set to 760 Torr, and Relative Humidity is set to 50%.

Reset MC button

Initializes the motion control software and communication to Zygo Motion Controller. After the button is clicked, programmable stage home positions must be found again.

Reset Zernikes button

Changes the settings in the Center X, Center Y, Radius, and Coef x Zernike controls to factory default settings. It is used when generating data.

Rotate

Three Flat Application. Specifies the flat you plan to rotate 180 degrees for the BR / CR measurement. Settings are B or C; these refer to the flats used in the test. You must physically rotate the flat. A bayonet mounted Transmission Flat (B) is easily rotated; to rotate a test Flat (C), an indexing device is needed.

Rotate Data button

Redisplays the current data set at the entered angle. Part of MetroPro’s manipulate features.

Rough Blend Reject

Edge Blend Application. Selects if scanned rows are used in calculating blend results. Settings are On or Off. When On, any scanned row of data that has a downward slope is rejected. When Off, all scanned rows are used. Set this control to Off when the Blend Depth Limit is close to the roughness of the ABS (approximately ≤ 0.15 µin.).

Run Align Pattern Script

This control is used in conjunction with the Align Pattern Script File control and the Align Pattern button. When this control is set to on, it runs the script (specified with Align Pattern Script File) at each pattern alignment site. This is part of the alignment procedure that is activated when the Align Pattern button is clicked. Applicable to systems that have the programmable stage option.

Run Pattern button

Activates the stage to run the data in the current pattern file when clicked on with the left mouse button. It runs either the current pattern in the Pattern Editor, or those listed in the SC Pattern List control. Applicable only to systems with programmable stages.

Sample

Specifies an interval for sampling the rows and columns of the height map when calculating the slope map. It reduces the resolution of the slope analysis. It affects the plots and results displayed in the slope data window. Available in slope data windows only.

Save Data button

Opens the File Handler, which is used to specify a data file name and save the file to the hard drive. A data file contains measurement information only, it can be loaded into different applications and reanalyzed. Raw or unprocessed data is saved with the Save Data button in the Control window; processed measurement data is saved with the Save Data button in the Data window.

To save your data click the Save Data button. In the File Handler, click the "Current Selection" box , enter a name for the settings file, ending with ".dat", and then press [Enter]. Click the Done button to close the File Handler.

Synthetic Fringe Map Data window. Saves fringe data as it has been manipulated in the Synthetic Fringe map Data window.

Save Report button

Opens the File Handler, which is used to save the current report file to the hard disk. The Save Report button saves only one report file; to save multiple report files use the Logging control.

To save your report click the Save Report button. In the File Handler, click the "Current Selection" box , enter a name for the file, ending with ".rep", and then press [Enter]. Click the Done button to close the File Handler.

Save Settings button

Opens the File Handler, which is used to save the current configuration of control settings to the hard disk. Normally, the settings of controls return to factory default settings when an application is closed and reopened.

To save your control settings click the Save Settings button. In the File Handler, click the "Current Selection" box , enter a name for the settings file, ending with ".set", and then press [Enter]. Click the Done button to close the File Handler.

Save Zernikes button

Opens the File Handler, which is used to save the current Zernike file to the hard disk. Saved Zernike data does not preserve the settings of the Radius, Center X, or Center Y controls.

To save your data click the Save Zernikes button. In the File Handler, click the "Current Selection" box , enter a name for the file, ending with ".zfr", and then press [Enter]. Click the Done button to close the File Handler.

SC Pattern List

Specifies the name of one or more pattern files that are run consecutively when the Run Pattern button is clicked. When the last pattern runs, the software loops back to the first pattern and continues running. Pattern files control the movement of a motorized programmable stage.

One or more pattern files can be specified. Separate each file name with a blank space.

Scale

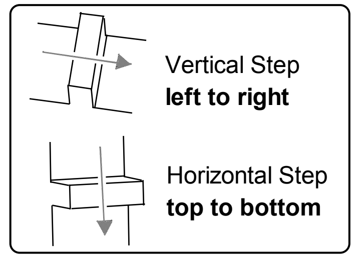
Multiples or divides the number of fringes per wave. Entries <1 divides, entries >1 multiplies. Part of the Synthetic Fringe window.

Scale Data button

Redisplays the current data set at the entered z-axis (height) scale.

Scan Direction

Specifies the way the software scans the step for the Step Height Application. When the step edges are displayed vertically on the video monitor screen, the control should be set to "left to right". When the edges are horizontal, set the control to "top to bottom". Settings: Left to right or top to bottom.



Scan Length

The Scan Length control determines the actual vertical length of the scan made by the scanning microscope's pifoc during a measurement. Settings are: 5 µm, 10 µm, 20 µm, 40 µm, or 100 µm. The longer the scan, the longer the processing time. Set the Scan Length control so the setting shown encompasses the details you are measuring.

Note that the Scan Length selections also display the time in seconds required to perform the scan, and the type of scan. The time varies based on the setting of the Camera Mode control. If there is not an active instrument, the control displays None.

Scan Type

Selects how the microscope objective is moved during the measurement cycle. The settings for this control are: Bipolar, Bipolar 3X Ind, and Phase. Bipolar scan employs a vertical scanning interferometry technique. A Bipolar 3X Ind scan uses the same process but the scan is completed three times faster. In measurement situations in which scan time is critical, Bipolar 3X Ind can be used; however, it is less precise than Bipolar. A Phase scan combines vertical scanning techniques with phase shifting algorithms. Scan Type control settings interact with FDA Res settings as shown below.

Scan Type Choices	*FDA Res Settings*
Bipolar	High,* Normal, Low
Bipolar 3X Ind	Normal,* Low
Phase	Phase 1,* Phase 2

*Default value of FDA Res with corresponding Scan Type selection.

Scanning Seq

Selects whether to traverse the part rows in a serpentine or raster fashion. Settings are Serp or Rast. It is recommended that Rast be used for more accurate stage movement.

Scattering Angle

Specifies the angle of the outgoing light relative to the plane of incidence for the BRDF analysis. Results are calculated based on this angle. It is the polar angle of s-polarized out.

Script File

Specifies the name of the script file automatically run when the application is opened, if the Auto Run Script control is On.

Select Results

Selects which ISO figure specification results are calculated. They can be selected in any combination. Choices are SAG, IRR, RSI, RMSt, RMSi, and RMSa. Part of the ISO 10110-5 window.

Seq File

Name of the file that contains all relative locations of a stitching sequence. When a stitch sequence is run and the Auto Save Seq control is set to On, the relative locations are saved into the file specified by this control. When the Type control is set to Run Sequence, the stitching sequence defined by the file specified, is run. This way multiple stitching sequences may be defined, saved, and loaded.

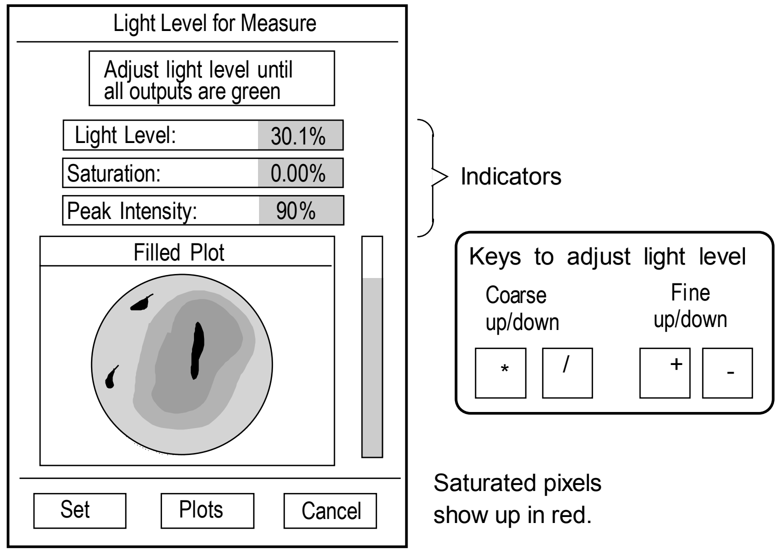
Set Focus Zero button

Prompts the operator for confirmation, then sets the current Z axis position as the new focus zero position. Readout values displayed on screen are relative to this zero position. After a stage pattern is run, the z-axis is returned to this zero position. At startup, the initial z-axis position is considered focus zero position until it is set by clicking this button.

Set Light button

When clicked with the left mouse button, it opens the Light Level window, which is used to manually adjust the measure light level. Same as pressing the F4 key.

Using the keyboard adjust light level until all outputs are green. Then click the Set button.

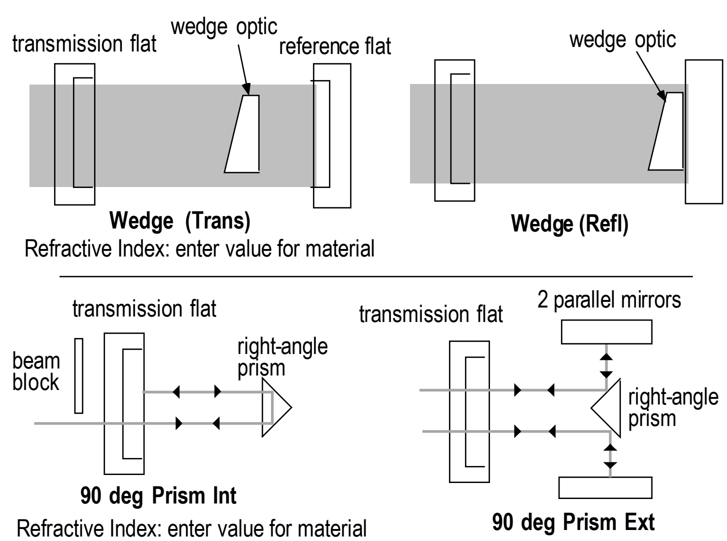


Set Tilt Zero button

This button prompts the operator for confirmation, then sets the current pitch and roll axes positions as the new tilt zero positions. Pitch and roll readout values displayed on screen are relative to this zero position. After a stage pattern is run, the pitch and roll axes return to this zero position. At startup, the initial pitch and roll axes positions are considered tilt zero position until it is set by clicking this button.

Setup Type

Angle Measurement Application. Selects the measurement type you are performing Settings are Wedge (Trans), Wedge (Refl), 90 deg Prism Int, or 90 deg Prism Ext. When this control is changed, the settings of the Intf Scale Factor and PZT Scale Factor controls are automatically changed. The Wedge (Trans) and 90 deg Prism Int settings require a Refractive Index control entry.



Corner Cube Application. Selects the test setup you are using. Settings are Double Pass or Single Pass.

Shape

Selects the actual physical shape of the data you are analyzing in the Spectrum Data window. Settings: Rectangular (default) or Circular. If the incoming data is not of these shapes and windowing is used, create a rectangular or circular mask.

Show 4PtTw

ABS Geometry Applications. The Show 4PtTw control is used to verify the location of the portion selected with the 4PtTw Mode control. This control should be Off when taking measurements.

Show Blend Border

Edge Blend Application. Selects if a black line is displayed in the Filled plot; this line or border shows the actual lateral location of the Blend Depth Limit control. Settings are On or Off.

Show Masks

Selects if masks are displayed on the video monitor screen. When On, masks are displayed on the video monitor screen. When Off, masks are not displayed. If masks are being displayed and you turn Show Masks Off, the existing masks are displayed until you make a measurement or click the Update button in the Video Monitor window.

Side Rail Trim

ABS Geometry Applications. Specifies the number of pixel layers to remove from the rail edges selected with the Side Rail Trim Mode control. The default setting is 0.

Side Rail Trim Mode

ABS Geometry Applications. Selects if pixels are trimmed from the left or right side of both rails. Settings are None, Left, or Right.

Size X

Specifies the size of the stitched image in the x-axis. Requires a programmable stage.

Size Y

Specifies the size of the stitched image in the y-axis. Requires a programmable stage.

Ski Jump Rail

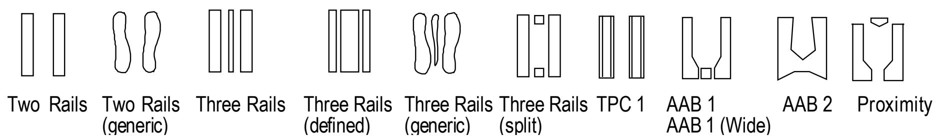
ABS Geometry Applications. Selects which rail has the core region. Settings are Left or Right.

Slide Sequence

Radius Scale Application. Selects the sequence used to perform the radius measurement. Settings are Confocal → Catseye or Catseye → Confocal. Set to match your preferred measurement sequence.

Slider Type

ABS Geometry Applications. Specifies the type of slider being measured. Choices are: Two Rails, Two Rails (Generic), Two Rails (Bisect), Three Rails, Three Rails (Generic), Three Rails (Split), Three Rails (Bisect), Three Rails (Defined), TPC 1, TPC 2, AAB 1, AAB 1 (Wide), AAB 2, Proximity, or Proximity 3.



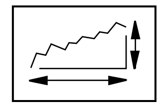
Two Rails and Three Rails are for two and three rail sliders that have straight sides only, with no rough edges or indentations. Two Rails (Generic) and Three Rails (Generic) are for arbitrarily shaped 2 and 3 rail heads; straight edges are not required. Three Rails (Split) is for use with the Maxim and for sliders with center rails that have separate top and bottom pieces, or a top or bottom piece that is adjacent to the side ABS area. Two Rails (Bisect) divides the data in half, assigns the data in each area to left and right ABS regions and uses a preconnect routine for phase measurements to delete the hogout area from the analysis. Three Rails (Bisect) divides the data into thirds and assigns the data in each area to left, center, and right ABS regions. Three Rails (Defined) uses the Rail Width control to define the left and right rails from either edge of the data; the data between the Rail Widths is considered the center rail.

TPC 1 and TPC 2 are for transverse pressure contour sliders. Use TPC 1 first; if it doesn't work, try TPC 2; TPC 2 is for narrow track sliders. AAB 1 and AAB 1 (Wide) are for etched ABS sliders with two ABS areas and a crossbar. AAB 1 (Wide) sliders are similar to AAB 1 heads, but with wider steps on the sides. AAB 2 is for etched ABS sliders with two ABS areas and a center taper area. Proximity is a variation of an etched ABS slider with a central ABS pad above the two rails. Proximity 3 sliders have a third rail with a proximity pad.

Slider Width

ABS Geometry Applications. Specifies the dimension across the x-axis of the slider. This control is only used by microscopes with auto focus or auto tip/tilt options. An entry is required for these options to work.

Slope Units



Selects the master unit system for all slope-based results; settings are English, Metric, Optical, Degree, or Radian. It applies to results in a Slope Data window, such as PV, Peak, and Valley.

For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or µm.

Sort Direction

Advanced Texture Application. Specifies the direction for sorting the Peak/Valley Stats or Summits Stats tables, either Decreasing or Increasing. (From largest to smallest, or from smallest to largest.)

Sort Key

Advanced Texture Application. Specifies which result is used for sorting the Peak/Valley Stats or Summits Stats tables.

Sphere Radius

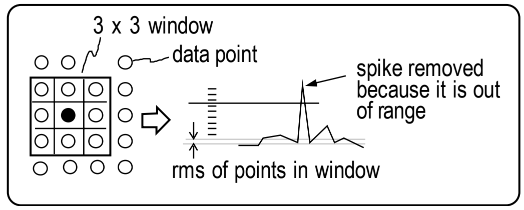
This control specifies the radius of the sphere to be removed. The sign convention is: a convex surface has a positive radius; a concave surface has a negative radius.

Spherical Distortion Correction

GPI Application. When on, the Spherical Distortion routine is applied to the data. Part Radius must also be defined via the Part Radius control and Spherical calibration performed. See the GPI Lateral Calibration section of this manual.

Spike Height (xRms)

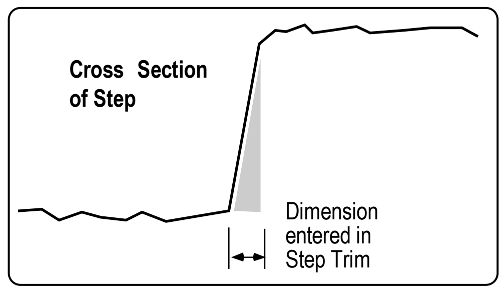
Spike Height is used to remove spurious spikes in the data. An indication of data spikes is a single color and extremely flat Oblique plot. The entry specifies a multiplier applied to the RMS whose resultant specifies a height above which all points are deleted.



The Remove Spikes control must be set to On. For each point, the rms height of the surrounding points is calculated; if the point height is greater than the entered value times the rms it is removed. Or in other words, single data points higher than the spike height are removed.

Step Trim

Specifies the dimension of an area trimmed along the vertical edges of the Step Height Standard. Step Trim has no function except with the Step Height Application included with MetroPro since version 3.0.3. It removes the affect the vertical step has on the step height results.



Stitch button

Invokes a stitch measurement sequence based on the settings of the stitch controls. Requires a programmable stage.

Stitch Diagnostics

Selects if diagnostic information from the stitch algorithm is provided. Settings are On or Off.

Stitch File

Stitching Application. Specifies the name of the final stitched data set.

Stitch Processed Data

Selects whether to pass raw data or processed data to the stitch algorithm. Settings are On or Off. It is recommended that this control be Off. The stitching of processed data is only recommended in rare cases.

Store button

Places the measurement results displayed on screen into temporary memory, which also places these values into Process Stats and Control Charts.

The Store button serves two main purposes. First, it allows you to select the results stored in Control Charts and Process Stats when the Auto Store control is Off. Second, it provides a way to enter existing data into Control Charts and Process Stats.

Store Process Stats

Selects whether to store the stitched image into Process Stats. Settings are On or Off. If On, the final overall stitched measurement results are stored.

Subtract

Subtracts the current generated Zernike wavefront from the current wavefront data. Settings are Off or Gen Zern (default).

Subtract Data button

Opens a text entry box, which is used to specify the name of an existing data file in the current directory. The specified data file is subtracted from the current data.

To cancel the action, press the right mouse button or the ESC key. The manipulated data set must exist in the current directory. You can change directories by clicking the Save Data or Load Data button, and specifying the directory with the File Handler.

Subtract Sys Err

Subtract Sys Err stands for Subtract System Error. When On, it activates a software system error subtract function. The name of the file to subtract from the measurement is specified by the Sys Err File control.

Surface

Three Flat Application. Specifies what surface to calculate and display. Settings are A, B, or C. After a measurement series is complete, the setting can be changed and results redisplayed by clicking the Calculate button.

Two Sphere Application. Specifies what sphere results to calculate and display in the Phase Map window. Settings are Part or TS (Transmission Sphere). After a measurement series is complete, the setting can be changed and results redisplayed by clicking the Calculate button.

Surface 1 button

PHom Application. Click to select the Surface 1 measurement. For the Surface 1 measurement, the beam reflects off the front of the test part.

Surface 2 button

PHom Application. Click to select the Surface 2 measurement. For the Surface 2 measurement, the beam reflects off the back surface of the test part.

Surface Type

Selects the method used to generate data. Part of the Generate function.

Sys Err File

Sys Err File stands for System Error File. It specifies the name of a system reference data file which is subtracted from current measurements when the Subtract Sys Err control is On. The system error or reference file must already exist, or any entry in this control is meaningless.

The reference data file should contain measurement results taken from a "perfect" test part. In theory, this file contains only aberrations inherent in the instrument, these aberrations are then subtracted from measurement to improve accuracy.

System Command button

Windows MetroPro only. Runs a user-entered MS-DOS command. The command is entered with the Command command in the button's menu. For example, it can launch an application or execute a command line.

To enter an MS-DOS command, position the pointer over the System Command button, press the right mouse button and select the Command command. Using the keyboard, enter a system command, and then press [Enter]. Use the Name command to label the button with a descriptive name linking it to the input command. If the command is left blank, it opens a console window when clicked.

Taper Cut Thickness

ABS Geometry Applications. Specifies the number of pixel rows to remove between the ABS and the taper. Use the smallest value that works best. Not applicable to AAB 2.

Taper Location

ABS Geometry Applications. Specifies the dimension from the Pole Tip Cut End Offset to the beginning of the taper. An entry is required when using a microscope with an auto focus option, regardless of the Taper Mode setting.

For Taper Mode Fixed, the data below the Taper Location is removed from the ABS and used to calculate leading edge results. For taper Mode Auto, the Taper Location represents the point below which the software searches for the taper. If set to 0 and Taper Mode is Auto, AAB1 slider types search the lower third of the data for the taper; Three Rail types (defined, generic, bisect, split) search the lower half; AAB2 ignores this control and searches the lower quarter.

Taper Mode

ABS Geometry Applications. Selects the way the slider taper or leading edge step is defined. Settings are None, Auto Cut, or Fixed Cut. Use None when the slider does not have a taper. Auto Cut automatically finds the area and removes it from the analysis. Fixed Cut locates the taper based on the Taper Location control and then removes it. For AAB 2 slider type, it must be set to Auto Cut. See also Taper Location.

Target Range

Specifies the acceptable tolerance limits of the light intensity level used during data acquisition. Settings: 0.00 to 0.99; default value is 0.10. Target Range is part of the Automatic Gain Control (AGC) feedback loop, which tries to maximize the signal-to-noise of the camera data by raising the light intensity to a point just below where any camera pixels become saturated. Target Range sets the acceptable limits to which the light intensity can adjust. See AGC.

The instrument has an intensity range from 0 to 1023, which is output by the electronics and used internally in the AGC feedback loop. Target range specifies the acceptable intensity level before saturation (1023). For example, if the maximum light level is 1023 and the Target Range is 0.010, the acceptable maximum intensity level is 1023 - (1023 x 0.10), or 920.7.

A smaller range causes the software to search longer to find a intensity level which will fall within this range. If the Target Range is too small, the AGC function may not be able to find an acceptable intensity level. A larger Target Range may decrease the signal-to-noise ratio (decreased contrast) but will take slightly less time to find the acceptable intensity level.

TE Distance End

ABS Geometry Applications. Specifies the distance from the TE Distance Start data to use in Trailing Edge Distance result calculations. Must be greater than TE Distance Start and less than the length of the ABS reference data.

TE Distance Fit

ABS Geometry Applications. Specifies the surface to fit to the selected ABS reference area when calculating Trailing Edge Distance results. Selections are Cylinder (default), Sphere, and Plane.

TE Distance Location

ABS Geometry Applications. Specifies where to apply the TE Distance Controls when calculating Trailing Edge Distance results. Selections are Left & Right (default), Center, Center 2, and Center 1. Data between the TE Distance End and the taper is used as reference.

Left & Right calculates trailing edge distance results for the left and right rails using the selected surface fit to its own ABS. Center uses all of the ABS surfaces as a reference and calculates trailing edge distance results on the center ABS. Center 2 uses the left and right ABS for reference and calculates trailing edge results on the center ABS. Center 1 uses the center ABS to the taper as reference and calculates trailing edge results on the center ABS. Users are cautioned against using Center 1 when the center ABS is small and may not have enough data to provide an adequate reference surface. The three Center options are available only for Proximity, Proximity 3, and Three Rail (generic), (bisect), (split) and (defined) Slider Types.

TE Distance Start

ABS Geometry Applications. Specifies the distance from the end of the rail *not* to include in Trailing Edge Distance results.

Temperature (C)

Specifies the temperature of the radius slide test environment in degrees Celsius. Range: 0.0 to 99.0, default 20.0. The Index of Air is recalculated as values are entered. Click the Reset Env button to reset the control to the default setting.

Test Drift button

Click to initiate a drift test of the distance measuring interferometer. This helps to determine the performance of the ZMI system in its present operating environment. Part of the DMI Test window; used with the radius scale option.

Test Mask High

Specifies the higher height limit used in defining the test mask. When Mask Mode is Histogram, the limit is in relation to zero (the best fit surface specified by the Remove control). When Mask Mode is Peaks Relative, the limit is in relation to the center of the test peak area. This control along with the Test Mask Low and Test Mask Mode determine the test mask area. See Mask Mode.

Test Mask Low

Specifies the lower height limit used in defining the test mask. When Mask Mode is Histogram, the limit is in relation to zero (the best fit surface specified by the Remove control). When Mask Mode is Peaks Relative, the limit is in relation to the center of the test peak area. This control along with the Test Mask High and Test Mask Mode determine the test mask area. See Mask Mode.

Test Mask Mode

Determines how the Test Mask High and Test Mask Low controls are applied to the data when creating the test mask. Applicable when the Mask Mode control is set to Histogram or Peaks Relative. Settings are Unfill or Fill. When Fill, the data points above Test Mask High and below Test Mask Low are deleted. When Unfill, the data points between Test Mask Low and Test Mask High are deleted.

Test Peak Number

Specifies which histogram peak from the histogram data to use as the test area. This control is used in the Test+Reference data window to define the test region. Applicable when the Mask Mode control is set to Peaks Midpoints or Peaks Relative. See Expected Peak Number.

Test Region k

Specifies the complex part of the index of refraction of a area inside a Test mask. The value is used along with the values in the Test Region n, Ref Region k, and Ref Region n Control boxes to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to “n and k”.

Test Region n

Specifies the real part of the index of refraction of a area inside a Test mask. The value is used along with the values in the Test Region n, Ref Region k, and Ref Region n Control boxes to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to “n and k”.

Test Region Offset

Specifies an offset compensation value for an area inside a Test mask. The value is used along with the value in the Ref Region Offset Control box to correct for a phase shift condition. The value entered in this control is used only when the *Phase Correction* control is set to “Offset”.

Test Sigma Clip

Applies a sigma filter to the test area to remove spurious data when the Mask Mode control is set to Histogram, Peaks Midpoints, or Peaks Relative. If a data point height is greater than the entered value times the rms from the reference surface (specified by the Remove control), it is removed. It is used for data clean-up after segmenting into test and reference areas.

Test Time (min)

Specifies the time in minutes for the DMI test. Enter a value from 1 to 60 (0.1 minute = 6 seconds). Enter a value that approximates the amount of time it takes to make a measurement. Part of the DMI Test window; used with the radius scale option.

Threshold

Advanced Texture Application. Specifies the minimum height between the central point and the four adjacent points for a data point to be considered as a summit. The higher the value, the fewer and steeper the summits. Part of the summits analysis.

Tilt Direction

Specifies the orientation of the tilt fringes in degrees. Part of the Synthetic Fringe window.

Tilt Fringes

Specifies the number of fringes to add to the cavity. Part of the Synthetic Fringe window.

Tool Offset Sign

Changes the sign of the Tool Offset result to accommodate different test setups or lathe polarity. Settings are Unchanged or Changed. Used when measuring tool offset.

Top Recession Gap

PTR Applications. When the Mask Mode is set to Defined, it defines the height of an area above the pole tips that is *not* included in the recession test mask.

Top Recession Height

PTR Applications. When the Mask Mode is set to Defined, it defines the height of an area above the Top Recession Gap to include in the recession test mask.

TPC Cut Thickness

ABS Geometry Applications. When Slider Type is TPC 1 or TPC 2, it specifies the number of pixel rows to remove between the ABS and stepped areas on each side. Use the smallest value that works best.

Trailing Edge Fit

ABS Geometry Applications. Specifies the surface to fit to the selected ABS reference area when calculating trailing edge results. Selections are Cylinder (default), Sphere, and Plane.

Trailing Edge Location

ABS Geometry Applications. Specifies where to apply the Pole Tip Cut End Offset when calculating Trailing Edge results. Selections are Left & Right (default), Center, Center 2, and Center 1.

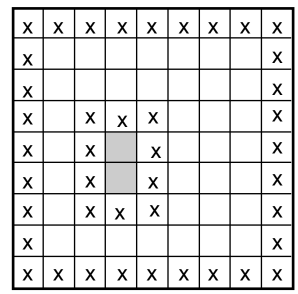
Left & Right calculates trailing edge results for the left and right rails using the selected surface fit to its own ABS (i.e. only the left ABS data is used for calculating the left trailing edge information.). Center uses all of the ABS surfaces as a reference and calculates trailing edge results on the center ABS. Center 2 uses only the left and right ABS for reference and calculates trailing edge results on the center ABS. Center 1 uses only the center ABS as a reference and calculates trailing edge results on the center ABS. Users are cautioned against using Center 1 when the center ABS is small and does not have enough data to provide an adequate reference surface. The three Center options are available only for Slider Type: Proximity, Proximity 3, and Three Rail (generic), (bisect), (split), and (defined).

Transmission button

PHom Application. Click to select the Transmission measurement. For the Transmission measurement, the beam travels through the test part and reflects off the Reference Flat.

Trim

Specifies the number of pixel layers removed from edges and around isolated obscurations. It is useful for removing bad data points from the measurement, such as those caused by diffraction at edges. From one to ten pixel layers can be removed. The action of the Trim control is controlled by the Trim Mode control.



A Trim of 1 is represented by the x's

The trim function is illustrated here. A sample data set of 9 x 9 pixels is shown. The shaded area represents an obscuration. A trim of 1 is shown by the X's.

The Trim control is available in both Control and Data windows. Trim in a Control window removes bad data points right after data is acquired, but before phase processing. Trimming in the Control window may be required if you measure a part with multiple discontinuous areas with substantial edge diffraction. Trim in a Data window removes bad data points after data is acquired and converted to phase values, but before it is analyzed and results are displayed. The advantage of trimming in the Data window is that you can change the trim value and reanalyze without remeasuring.

Trim Data button

Applies the entry in the Trim control to the current data.

Trim Mode

Selects how data is trimmed. The Trim Mode control is available in both control and data windows; the control works in union with the Trim control in the same window. Settings are All or Outside.

All trims pixel layers at the edges of all data including outside edges and edges around internal holes or obscurations. *Outside* trims pixel layers at the outside edges only and not around internal holes. This is useful for removing diffraction edge effects without trimming holes in the data due to dropouts from poor modulation or nonfunctional camera pixels.

Trim Pole 1,2,3

PTR Applications. Specifies the number of pixel layers to trim from individual pole tips after the overall trim in the Pole Tip Maps window, and before calculating any results in the Pole Tip Map window.

Trim PTR Search

Trimmed PTR Application. Selects the data and method used to establish the different trimmed PTR regions. Settings are Phase Data (default) or Intensity Data. Intensity Data utilizes the Unetched Pole (%) and Etched Pole Cutoff controls.

TS f-number

Radius Scale Applications. Specifies the f-number of the transmission sphere used in the radius measurement. This entry is critical for obtaining precise radius measurements. Zygo prints the exact f-number of transmission spheres on the element's cell.

Tst Pt 1

For profile plots. Specifies the starting point of the test segment along the x-axis. Requires an entry in the Tst Pt 2 control. The Use Tst Pts control must be On.

Tst Pt 2

For profile plots. Specifies the ending point of the test segment along the x-axis. Requires an entry in the Tst Pt 1 control. The Use Tst Pts control must be On.

Two Wavelength

When On, activates two wavelength analysis for instruments with multi-wavelength capability. When On, data is acquired twice; once using the primary wavelength source, and again using the secondary wavelength source. These two wavelengths are then combined into a synthetic wavelength. When Off, data is acquired once with the primary source.

Two wavelength measurements are sensitive to mechanical vibration and edge effects or high to low transitions that fall on a single pixel. Use the Intens Avgs control to minimize the affect of mechanical vibration. Use the Pre-Connect Filter control to minimize edge effects.

Type

Three Flat Application.   Selects the measurement type. Settings are 3 Measurements or 4 Measurements. Three measurements provide a vertical profile; a fourth measurement also provides a horizontal profile.

Stitching Application.   Selects the type of stitch measurement. Stitching makes several measurements of the test part as it is moved by a motorized stage and then combines the multiple data sets into one. The settings are Manual Position, Column & Row, X & Y Size, Start & End Position, Annulus, Run Sequence, and Align Stage.

Manual Position. The user teaches the software the location of all measurement positions. Useful for measuring odd shaped parts, like an S-curve. It is the user's responsibility to ensure that the overlap is sufficient between measurement positions.

Column & Row. The stitched area is determined by the number of rows and columns. Requires entries in N Cols, N Rows, and Overlap (%) controls. The pattern always starts in the upper right.

X & Y Size. The stitched area is determined by entered dimensions. Useful when the size of the measurement area is known. The number of rows and columns to cover the area is automatically calculated. Requires entries in Size X, Size Y, and Overlap (%) controls. The pattern always starts in the upper right.

Start & End Position. The user teaches the software the starting position (upper right) and the ending position (lower left) of the stitched area. The number of measurements needed is automatically calculated. Requires an entry in the Overlap (%) control.

Annulus. The stitched area is circular or ring shaped. The measurement locations are automatically determined. Requires entries in the Inner Radius, Outer Radius, and Overlap (%) controls.

Run Sequence. The stitching sequence defined by the Seq File control is run at the current position.

Align Stage. Used when checking stage alignment. Two measurements of adjacent areas are taken and stitched together. Stage alignment is critical to stitching.

Undo button

Removes the last stored measurement values from temporary memory, which also removes these values from Process Stats and Control Charts. Each click removes one set of measurement values until the temporary memory is empty.

Unetched Pole (%)

Trimmed PTR Application. When the Trim PTR Search control is set to Intensity Data, this control determines how much of the entire pole area (etched and unetched) is defined as the unetched pole region. The percent is applied to the highest/brightest points in the intensity data to determine the unetched pole region. This control is initially set to 50; values may range from 0 to 99.9. To establish the correct setting, look at the pole region in the Intensity plot to determine the amount of area that is the unetched pole.

Unix Command button

UNIX MetroPro only. Runs a user-entered HP-UX command. The command is entered with the Command command in the button's menu.

To enter an HP-UX command, position the pointer over the Unix Command button, press the right mouse button and select the Command command. Using the keyboard, enter an HP-UX command, and then press [Enter]. Use the Name command to label the button with a descriptive name linking it to the input command.

An example of an HP-UX command is: `echo update_spc > spcpipe`.
This command sends the message "update_spc" to a named pipe called "spcpipe". The piped message could be heard by a spreadsheet program, which in turn could issue an update command to read the MetroPro report file.

Unset Focus Zero button

Prompts the operator for confirmation, then erases the focus zero position.

Unset Tilt Zero button

This button prompts the operator for confirmation, then cancels the use of the tilt zero positions when running a pattern.

Update button

Updates the video monitor screen with the contents of the Video Monitor window.

Upper Light Level Offset

Stitching Application. Specifies the percentage to add to the current measurement light level for the upper surface in a zip stitch measurement.

Upper Offset X

Specifies the dimension in the x-axis that the upper right corner of the lower stitched area is offset from the upper right corner of the upper stitched area. One of many controls used when making a zip stitch measurement. See Zip Distance.

Upper Offset Y

Specifies the dimension in the y-axis that the upper right corner of the lower stitched area is offset from the upper right corner of the upper stitched area. One of many controls used when making a zip stitch measurement. See Zip Distance.

Upper Overlap (%)

Specifies the overlap of the measured sections in the upper measurement region, in a zip stitch measurement. A minimum of 10% is recommended. Requires a motorized z-axis and a programmable stage. See Zip Distance.

Upper Pad Cutoff

ABS Geometry Applications. Defines the separation of pad and ABS data. Specifies the vertical height of a cutoff plane, above the ABS that defines an analysis region. If Pad Location is set to Above, the data above the Upper Pad Cutoff is considered Pad data; if set to Below, data above the upper Pad Cutoff is considered ABS data. The data between the Upper and Lower Pad Cutoff values will not be included in either the Pad or the ABS region. See also Lower Pad Cutoff and Pad Location.

Upper PTR (%)

PTR Application. Specifies how much of the highest data of the pole tip region to use in calculating the Upper PTR (%) result.

Upper PTR (%) 1,2,3

PTR Application. Specifies the percentage of the highest data of each pole tip to use when calculating the corresponding Upper PTR (%) 1, 2, and 3 results.

Upper Seq File

Stitching Application. Specifies the filename of the stitching sequence file to use for the lower surface when the Use Upper Seq File control is On.

Upper Size X

Specifies the size of the upper stitched image in the x-axis, in a zip stitch measurement. Requires a motorized z-axis and a programmable stage. See Zip Distance.

Upper Size Y

Specifies the size of the upper stitched image in the y-axis, in a zip stitch measurement. Requires a motorized z-axis and a programmable stage. See Zip Distance.

Use Lower Seq File

Stitching Application. Specifies whether the locations to measure for the lower surface, are specified from a stitching sequence file, or from the Lower X and Y Sizes. Settings are On or Off.

Use Ref Pts

For profile plots. When On, the Ref Pt 1 and Ref Pt 2 controls are active; they specify where the fit is done.

Use Tst Pts

For profile plots. When On, the Tst Pt 1 and Tst Pt 2 controls are active; they specify over what area the profile results are calculated.

Use Upper Seq File

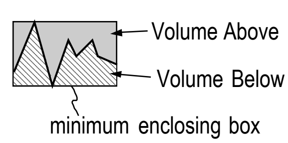
Stitching Application. Specifies whether the locations to measure for the upper surface, are specified from a stitching sequence file, or from the Lower X and Y Sizes. Settings are On or Off.

View Pattern Pos button

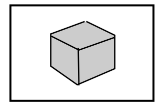
Opens the Position Status window, which shows the current location of the pattern and can drive the stage to a location. Applicable only to systems with programmable stages.

Volume Type

Advanced Texture Application. Specifies where the RVolume result is calculated. Settings are Above Surface or Below Surface.



Volume Units



Selects the master unit system for all volume based results; settings are English or Metric. It applies to Volume results in a Test+Reference Data window, such as Up Vol.

For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or µm.

Wavelength

ISO 10110-5 window. Selects the wavelength of the output results for the ISO 10110-5 window. This defaults to 546.07 nm by the ISO 10110-5 specification and corresponds to the green emission line of mercury.

BRDF window. Specifies the wavelength of the output data. It is used to display results as if the measurement was performed at a wavelength other than the instrument's wavelength.

Wavelength Fold

Selects how two wavelength data is analyzed. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

When On, it combines synthetic wavelength data with the primary wavelength data to produce data with less noise; use this setting for measuring smooth surfaces. When Off, synthetic wavelength data is used; this is useful when measuring rough parts near the roughness limits.

Wavelength Select

Specifies which Wavelength-In controls are used and the order of acquisition. The first number specifies the wavelength for viewing and the reference wavelength, if making multiple wavelength measurements with folding. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

The entry can be a sequence of up to four digits (1, 2, 3, 4) separated by commas. When "1", wavelength 1 is used for the single-wavelength measurement and viewing. When "2", wavelength 2 is used.

Wavelength-In

Specifies the wavelength of the light source used in the instrument. It is used to enter the laser wavelength when another type of laser is used. Settings: 0.25 to 10.6 μm, default 0.6328 μm. Do not confuse with the Wavelength-In X controls.

Wavelength-In 1

Specifies the wavelength of the $\lambda 1$ filter for a phase microscope. The wavelength of the filter is printed on the instrument's filter tray. This control is applicable only when the Two Wavelength control is On.

Wavelength-In 2

Specifies the wavelength of the $\lambda 2$ filter for a phase microscope. The wavelength of the filter is printed on the instrument's filter tray. This control is applicable only when the Two Wavelength control is On.

Wavelength-In 3

Specifies the wavelength of a third light source. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

Wavelength-In 4

Specifies the wavelength of a forth light source. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

Wavelength-Out

Specifies the wavelength of the data displayed within an application. It is used to display results as if the measurement was performed at a wavelength other than 0.6328 μm. Wavelength-Out scales the data in terms of the wavelength entered. Settings: 0.25 to 10.6 μm, default 0.6328 μm.

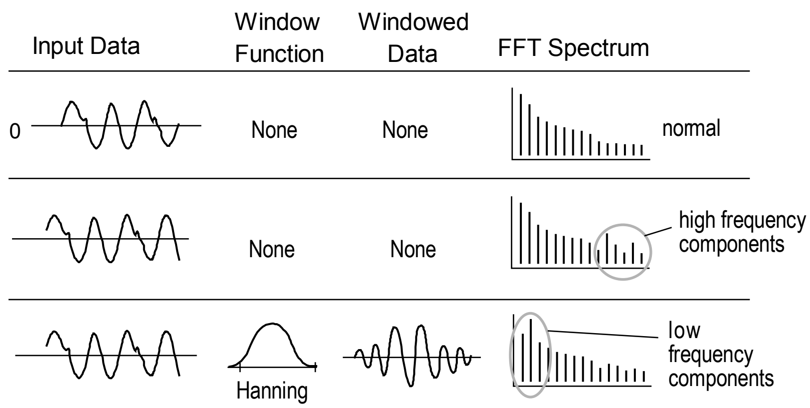
Wavelength-Out is useful to see how an optic performs at another wavelength. It affects only results that use waves as the measurement unit. It does not affect PSF and MTF results.

Window

Selects windowing functions to minimize the effects of spatial-domain truncation in the Spectrum data window. Settings are None, Hamming, or Hanning. The Spectrum Data window performs a Fast Fourier Transform (FFT) on the surface data, breaking it into its frequency components. The FFT algorithm is based upon the assumption that the frequency data is periodic in space. Because this is not usually the case, the windowing function multiplies the input data by a function forcing the sample period to or near to zero at the ends.

Windowing improves the FFT analysis of data that is not periodic; however, the input data is modified and the FFT spectrum peaks are broadened somewhat. Generally, windowing is needed on a test part with pronounced low frequency content, and not needed on a fairly random test part.

Hanning and Hamming are variations of the windowing function. The Hanning window forces the sample period to zero; the Hamming window, near to zero. A one dimensional representation of windowing is shown here for simplicity.



Window Size

Specifies the maximum number of result values that can be stored in temporary memory. It determines the x-axis on Control Charts and number of measurements that can be displayed in Process Stats. Settings:0 to 999, the default setting is 5.

Zernike Sample

Specifies the number of data points used in the Zernike calculation; it also reduces processing time. Selecting 1 uses every data point; selecting 2 uses approximately one-quarter of the data points; 3 uses approximately one-ninth of the data points; and 4 uses approximately one-sixteenth of the data points. However, no matter what number is selected, the data points on the x and y axes and diagonally through the center are always used. The fewer the data points sampled, the less accurate the Zernike result.

This drawing illustrates the effect of the Zernike Sample control. The box represents a sample data set. Points with X's are always selected. The bold X marks the center of the data. Selecting 1 chooses all points. Selecting 2 includes points with X's and 2's. Selecting 3 includes points with X's and 3's.

The proper setting for the Zernike Sample control is determined by the user. A simple way to check the effect is to make a series of Zernike calculations at different settings and cross compare results.

X		2	3	2		X		2	3	2		X
	X					X					X	
2		X		2		X		2		X		2
3			X			X			X			3
2		2		X		X		X		2		2
					X	X	X					
X	X	X	X	X	X	**X**	X	X	X	X	X	X
					X	X	X					
2		2		X		X		X		2		2
3			X			X			X			3
2		X		2		X		2		X		2
	X					X					X	
X		2	3	2		X		2	3	2		X

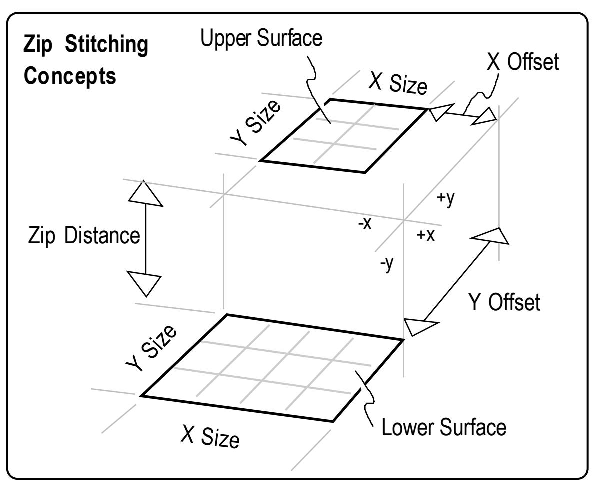
Zernike Terms

In a data window, it specifies how many Zernike terms are analyzed and displayed in the “Zernikes” specialized window. In the control window, it specifies how many terms are used when generating a Zernike wavefront. Settings: none, 3, 4, 9, 16, 25, 36, or 37 (terms). You must specify that at least 9 terms be analyzed if you want to display Seidel coefficients results.

Zip Distance

Specifies the vertical distance between the upper and lower surface areas or measurement regions in a zip stitch measurement. A zip stitch measurement consists of two groups of measurements separated by a vertical distance.

When the Phase Res control is set to High, the vertical range is limited to 20 millimeters. Requires a motorized z-axis and a programmable stage.



Zip File

Stitching Application. Specifies the name of the final zip stitch data set.

Zip Scan button

Invokes a zip scan measurement sequence. Zip scan is two measurements taken in the same location, without stage movement in the x and y axes, but with vertical movement in the z-axis. The vertical dimension is specified by the Zip Distance control.

Zip Stitch button

Invokes a zip stitch measurement sequence based on settings of the zip stitch controls.

Results and Attributes

Section 3

MetroPro provides countless results to characterize your test part. They are listed here under the result's name.

This section provides an alphabetical listing of MetroPro results and attributes. Where applicable, specific applications are listed. Refer to the result or attribute of interest by name in this section.

Results

Result boxes display calculated numeric values. If a limit has not been set, result boxes are normally black with white characters. If limits are set with the Limits command, the box will be red when an output exceeds the limit, or green when the value is within the limits. Results are created with the New Result command from the data window menu.

> **Note:** If the software cannot calculate a result, the result box remains blank. Usually, this occurs because the instrument is not calibrated.
>
> If a result displays a series of asterisks (*******), it means the box is not large enough to display all the digits. To correct this, increase the number of decimal places with the result's menu Value Format → Decimal Places command, or increase the width of the result with the Value Format →Width command.

Use the Result's menu to modify the box.

Units select the measurement unit.

Limits set high and/or low limits for the result.

Adjustment adjust the final numeric result.

Move relocate the result.

Name change the result name and get information.

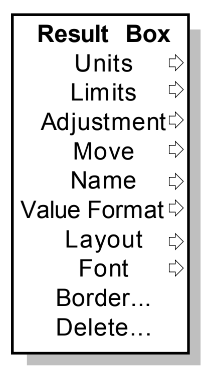
Value Format select the result width and decimals.

Layout select the way information is displayed.

Font select the type style.

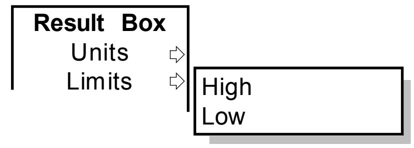
Border change the line width around the result.

Delete erase the result from the screen.



actual menus will vary

Limits Command



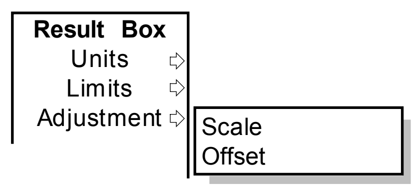
The Limits command allows you to specify what is an acceptable value for a result. If limits are specified, the result is green if the value is acceptable and red if the value exceeds a limit.

The command is accessed with the result's menu. To enter a value, select the command, type in a value, and press [Enter].

The High selection specifies the high limit; if the result exceeds this value it is red in color. The Low selection specifies the low limit; if the result is smaller than this value it is red. Both High and Low limits can be used together. Note that 0 (zero) is a valid entry.

Use the result's menu Units command to change the measurement units. To remove user limits, select the Limits command, delete all numbers, and press [Enter].

Adjustment Command



The Adjustment command allows you to change or adjust numbers displayed within most results with a scale (multiplier) factor and an offset (add or subtract) value.

The command is accessed with the result's menu. To enter a value, select the command, type in a value and press [Enter].

Because the numeric result is modified, it is denoted by the result name being highlighted in yellow. Both scale and offset values can be used in combination. Entering a scale of 0 (zero) will make the result 0. After an adjustment value is entered, the effect may be seen by clicking the Analyze button. Note that adjusting a numeric result does not change original or saved data.

Layout

The Layout command enables you to specify the format for displaying result data. There are some formats that display results on two or three lines. The chart below shows the format for each layout type. It may be necessary to move the result box to completely display a two or three line result format.

Format	Example
Name Value Units	PV 7.570 um
Name Value Units P/F	PV 7.570 um P*
Name Value Units [lo, hi]	PV 7.570 um [7.550, 7.588]**
Name / Value Units	PV 7.570 um
Name / Value / Units	PV 7.570 um
Name Value	PV 7.570
Name Value P/F	PV 7.570 P*
Name Value [lo, hi]	PV 7.570 [7.550, 7.588]**
Name / Value	PV 7.570
Value / Units	7.570 um
Value	7.570

* This format is useful for immediate feedback on pass/fail status for a result when reviewing a report offline.

** Lo represents the low limit for the result, and hi represents the high limit for the result. If this format has been selected, and a high or low limit has not been set, a – is displayed.

Attributes

Attribute boxes display information about the measurement, such as: what a control was set to, what time the measurement was taken, and the current status of the measurement. Attribute boxes are black. Attributes are created with the New Attribute command. The menus for attributes are similar to those for results.

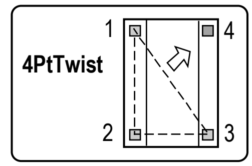
Only unique attributes are described in this section. Most attributes are simply an image of the control when the measurement was made; for more information on these attributes, refer to Section 2.

3/A(B/C)

The SAG, IRR, and RSI results in ISO form. Part of the ISO figure specification (ISO 10110-5).

4PtTwist

ABS Geometry Applications. Four point twist is the distance between the average height of 3 corners and the 4th corner. Refers to the outer rails.



A1

Advanced Texture Application. Material-filled profile peak area. The area of the peaks or amount of material on the surface that will be removed in the run-in period. Part of the bearing ratio analysis. This parameter is calculated from other bearing ratio results:

$$A_1 = \frac{1}{2}(Rpk)(Mr1)$$

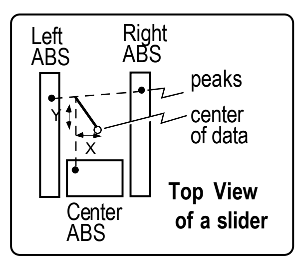
A2

Advanced Texture Application. Lubricant-filled profile valley area. The area of the valleys on the surface that can retain lubricant. Part of the bearing ratio analysis. This parameter is calculated from other bearing ratio results:

$$A_2 = \frac{1}{2}(Rvk)(100 - Mr2)$$

ABS HiPt Ctr Offset X

ABS Geometry Applications. The offset from the center of the data, in the x-axis, to the intercept of the peak of a cylindrical fit to the center rail with a line fitted to the peaks of a cylindrical fit to the left and right (individual) ABS. Applicable when Slider Type is Three Rails, Three Rails (Generic), Three Rails (Bisect), Proximity, or Proximity 3.

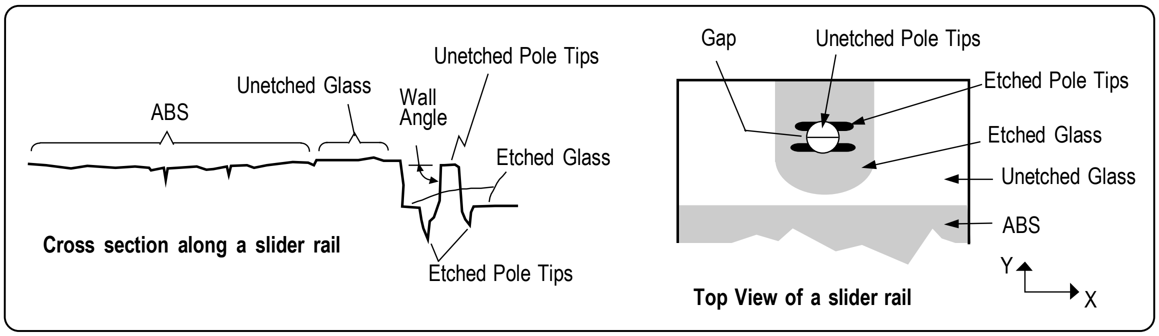


ABS HiPt Ctr Offset Y

ABS Geometry Applications. The offset from the center of the data, in the y-axis, to the intercept of the peak of a cylindrical fit to the center rail with a line fitted to the peaks of a cylindrical fit to the left and right (individual) ABS. Applicable when Slider Type is Three Rails, Three Rails (Generic), Three Rails (Bisect), Proximity, or Proximity 3.

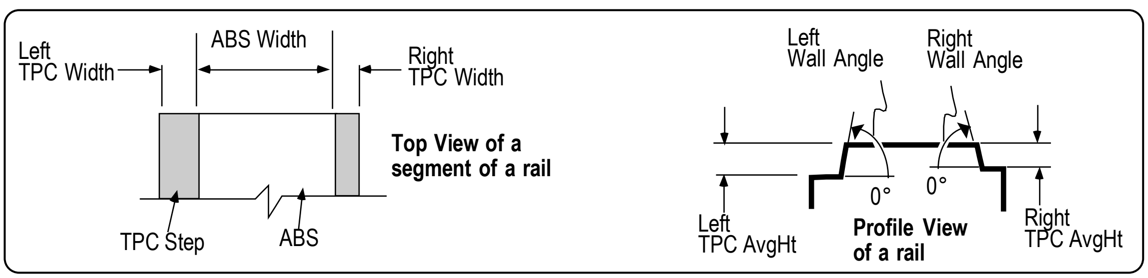
ABS Roughness

Trimmed PTR Application. The roughness of the ABS region. The area of the ABS is specified by the ABS Reference Length control.



ABS Width

Wall Angle Application. The dimension across the ABS or air bearing surface.



Alignment Err

Displays the fiducial actual alignment error in pixels. Attribute only.

Alignment X

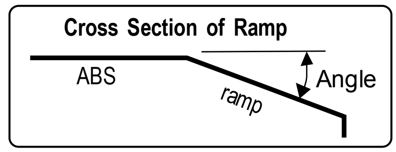
Trimmed PTR Application. An indicator of the alignment of the etched pole in relation to the unetched pole in the X-axis. See ABS Roughness.

Alignment Y

Trimmed PTR Application. An indicator of the alignment of the etched pole in relation to the unetched pole in the Y-axis. See ABS Roughness.

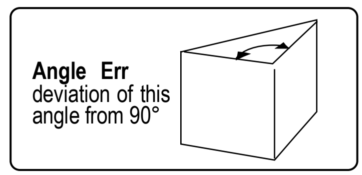
Angle

Taper Flat Application. The angle of the taper flat relative to the air bearing surface.



Angle Err

Angle Measurement Application. Angle Error is the amount a right-angle prism is off from 90 degrees. It also could be called angular deviation. This result is applicable only to prism measurements.



Aperture

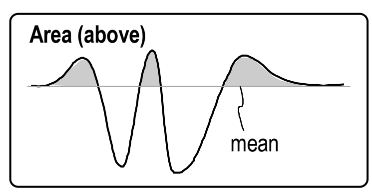
Outputs the setting of the Aperture button at the time the measurement was taken. Attribute only. Applies to microscope applications only.

Area

Advanced Texture Application. The planar area of the peak, valley, or summit region. Part of the peaks/valleys and summits Stats table.

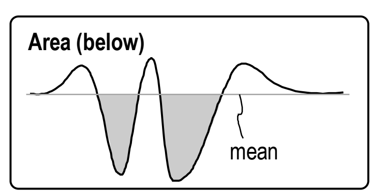
Area (above)

Area (above) is the area of the profile data above the mean. Instrument calibration is required for this result. The mean is the best fit surface to the data.



Area (below)

Area (below) is the area of the profile data below the mean. Instrument calibration is required for this result. The mean is the best fit surface to the data.

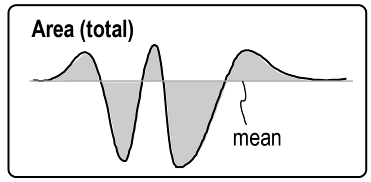


Area (net)

Area (net) is the overall area of the profile data. It is equal to the Area (above) minus the Area (below). Instrument calibration is required for this result.

Area (total)

Area (total) is the sum of the Area (above) and the Area (below) the mean of the profile data. Instrument calibration is required for this result. The mean is the best fit surface to the data.



Aspect

Advanced Texture Application. The Max Ext divided by the Min Ext. Part of the peaks/valleys Stats table.

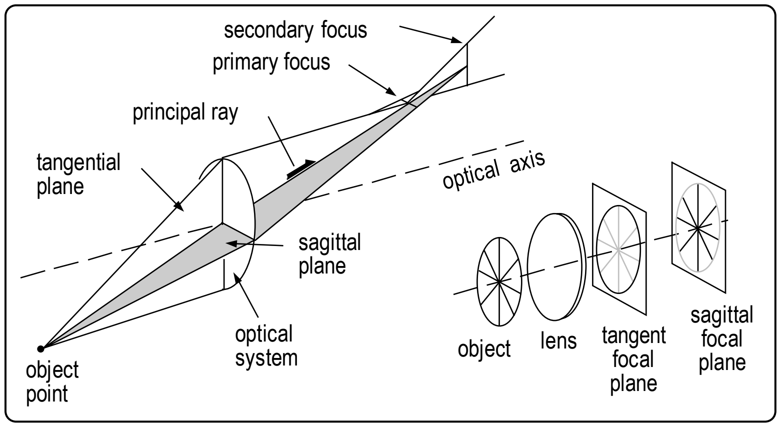
AstAng (Z)

AstAng (Z) (Astigmatism Angle based on Zernikes) is the angle in the instrument coordinate system at which astigmatism occurs. The range of values for AstAng (Z) is ±90°. For an explanation of astigmatism, see AstMag (Z). Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display this result.

$$\text{AstAng} = 0.5 \arctan\left(\frac{z5}{z4}\right)$$

Where z4 is the 4th Zernike term and z5 is the 5th term.

AstMag (Z)



AstMag (Z) (Astigmatism Magnitude based on Zernikes) is a third order wavefront aberration where the rays in two orthogonal axes do not come to focus on the same plane.

A schematic view of an optical system imaging an off axis point is shown to illustrate astigmatism. There are two planes: the tangential plane and the sagittal plane. Rays in the tangential plane come to focus closer to the lens (primary focus) than rays in the sagittal plane (secondary focus). The overall effect of astigmatism is illustrated by the wagon wheel, where the rim and spokes do not come to focus at the same point.

In a perfectly aligned and fabricated optical system, astigmatism is only found at image points off the optical axis. In real optical systems, astigmatism can be found anywhere in the image plane. If aberrations are found on axis they are an indication of fabrication or alignment errors.

$$\mathrm{AstMag} = 2\sqrt{z4^2 + z5^2}$$

Where z4 is the 4th Zernike term and z5 is the 5th term.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display this result.

Auto Save Data Dir

This attribute displays the directory path in which the last auto-saved data file was written. It will only show a value if the Auto Save Data control was On at the time the measurement was made. This attribute is especially helpful if a special code was entered in the Auto Save Data Dir control. Attribute only.

Auto Save Data File

This attribute displays the file name in which the last auto-saved data file was written. It will only show a value after a measurement is made with the Auto Save Data Control set to On. This attribute is helpful if a special code was entered in the Auto Save Data File control. Attribute only.

Auto Seq Count

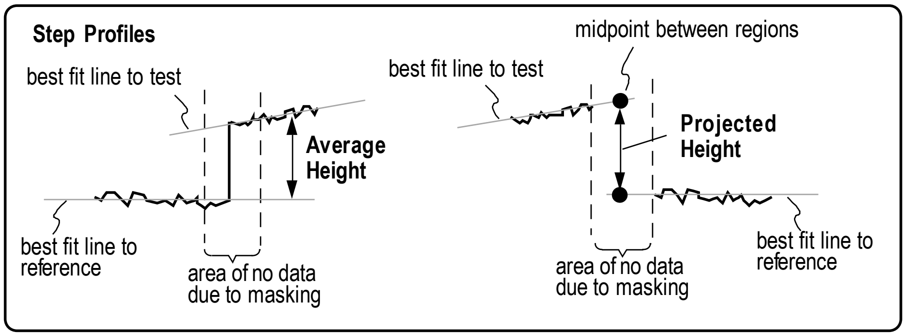
Auto Seq Count (Auto Sequence Count) outputs the actual number of auto sequences performed. Attribute only.

Avg Fit Angle

Step Height Application. Average step angle of all fitted rows. See Avg Fit Step.

Avg Fit Step

Step Height Application. Average step height of all fitted rows.

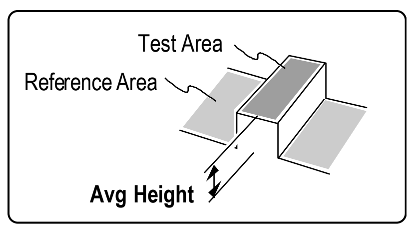


"Fit" step results are based upon lines fit to the test and reference regions. Most fit results are based on the entire area or map data. The Fit Step and Fit Angle results are based on profile data.

"Proj" or projected step results are based upon projections from lines fit to the test and reference regions. Each scan row has points projected from the fit lines to a midpoint of the gap between the regions. These results are used to isolate one side of the step from the other.

Avg Height

Step Height Application. The overall average height of the plane of the test region in relation to the plane of the reference region. It is positive when the test region is above the reference region. See Avg Fit Step.



Avg Proj Angle L/T

Step Height Application. Average projected angle on the left or top of all scanned step rows. See Avg Fit Step.

Avg Proj Angle R/B

Step Height Application. Average projected angle on the right or bottom of all scanned step rows. See Avg Fit Step.

Avg Proj Step L/T

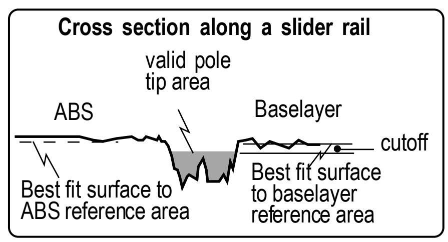
Step Height Application. Average projected height on the Left or Top of all scanned rows of a step. See Avg Fit Step.

Avg Proj Step R/B

Step Height Application. Average projected height on the Right or Bottom of all scanned step rows. See Avg Fit Step.

Avg PTR

PTR Applications. The average recession of the pole tips from the ABS in the valid pole tip area. The valid pole tip area is the region from the cutoff and down.



Avg PTR 1

PTR Applications. The average pole tip recession in an MR head from the ABS to the first pole tip. A blank result indicates that the software could not separate the poles during analysis.

Avg PTR 2

PTR Applications. The average pole tip recession in an MR head from the ABS to the second pole tip. A blank result indicates that the software could not separate the poles during analysis.

Avg PTR 3

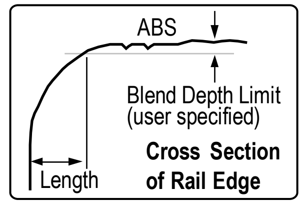
PTR Applications. The average pole tip recession in an MR head from the ABS to the third pole tip. A blank result indicates that the software could not separate the poles during analysis.

AvgBlendDepth

Edge Blend Application. The average blend depth of all scanned rows. The sum of the blend depths divided by the number of blends used.

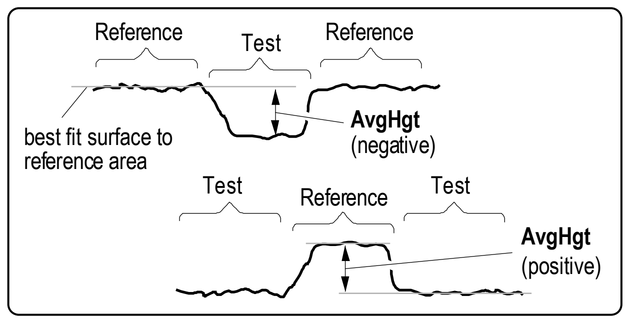
AvgBlendLength

Edge Blend Application. The average blend length of all scanned rows. The sum of the blend lengths divided by the number of blends used.



AvgHgt (Test)

AvgHgt (Average Height) is the average height of a test data area in relation to a reference data area in the instrument's z-axis. It compares an area defined by a Test mask to an area defined by a Reference mask and determines the vertical offset between them. Height refers to direction along the instrument's z-axis.



AvgHgt requires Test and Reference masks to be defined with the Mask Editor. If possible, use a Reference mask on both sides of the test area in order to accurately define the reference plane. When only one reference area is used, the result is generally less reliable. If masks are not used, AvgHgt equals the arithmetic average of the data set.

Ensure that the Remove control is set to remove at least piston or plane; otherwise offset and tilt of the overall surface are reflected in the result.

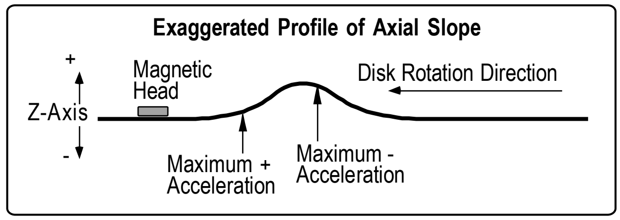
AvgHt

PTR Applications. The average height of the test region in relation to the reference region.

AvgHt (Test)

PTR Applications. The average height of the data in the PTR test region.

Axial Acceleration



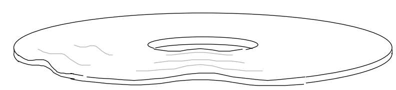
Disk Flatness Application. The rate at which the magnetic head's Z-axis velocity is changing. It is derived from the Axial Velocity calculations and time. The Z Axis acceleration of the head is calculated for each data point in the analyzed arc of the disk. Acceleration data is represented by shading or colors on a filled plot for "flyable" area of the disk's surface, and by numeric values for a circular slice (axial path) around the disk. Both negative and positive acceleration results are provided. Positive acceleration occurs in the direction that would move the head away from the plane of the disk; negative acceleration, toward the plane of the disk.

Axial Acceleration = $k(\omega^2 r^2)\ (d^2y * \cos^2\theta + d^2x * \sin^2\theta)$

Where ω is the angular velocity in rpm, k is a conversion factor depending on the units, r is the radius, d^2y is the second difference of height in the y direction, and d^2x is the second difference of height in the x direction.

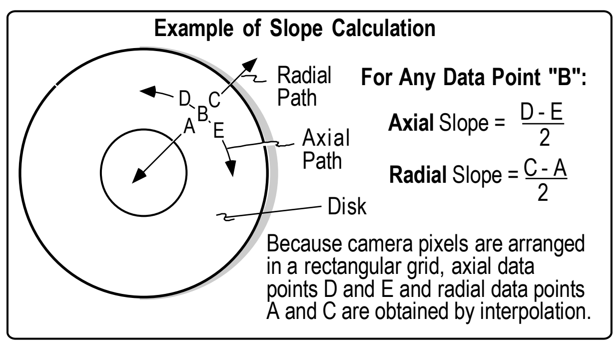
Axial Slope

Disk Flatness Application. Axial slopes are height deviations that are encountered by a magnetic head as the rotating disk passes beneath it. The path traced by the head is coaxial with the rotational center of the disk.



Exaggerated Axial Slopes

The method of calculating slopes on a disk is similar to the method used in the standard MetroPro software slope calculations with one notable exception. Instead of using measured data points in X and Y axes (the way the camera pixels are arranged), data points are interpolated along Radial and Axial paths, as shown.

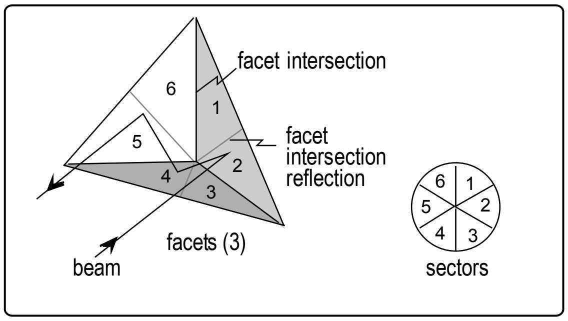


Axial Slope = $dy * \cos\theta + dx * \sin\theta$

Where dy is the first difference of height in the y direction, and dx is the first difference of height in the x direction.

Beam Dev (1) … (6)

Corner Cube Application. Individual beam deviation results for each of the six sectors. Results for all six are displayed when using the single pass setup. With double pass setups, beam deviations for sectors 4, 5, and 6 are not shown as they duplicate the results for sectors 1, 2, and 3.



Blends Measured

Edge Blend Application. The number of scans or pixel rows measured.

Blends Used

Edge Blend Application. The number of valid scans or pixels rows used in determining results.

Bottom Pole Width

Trimmed PTR Application. Length (width in x-axis) of the unetched lower pole. See ABS Roughness.

Calibration f-number

Displays the f-nunber value of the calibration standard used when calibrating for spherical distortion. Attribute only.

Calibration NA

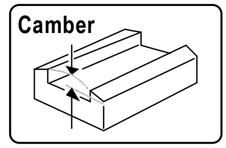
Displays the numerical aperture value for the calibration standard used when calibrating for spherical distortion. Attribute only.

Calibration Radius

Displays the radius of curvature value for the calibration standard used when calibrating for spherical distortion. Attribute only.

Camber

ABS Geometry Applications. The curvature of the rails in the short axis or the sag across the rail(s). Camber can be calculated for both rails or each rail individually. Camber is positive for a convex surface and negative for a concave. The Deskew Data control can be used to adjust this result.



Camber is derived from a best fit cylindrical surface. The equations are:

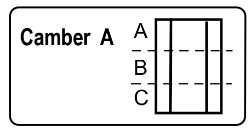
$$Z(X,Y) = C0 + (C1xX) + (C2xY) + (C3xXxY) + (C4xX^2) + (C5xY^2)$$

$$\text{Camber} = -\frac{C4xL^2}{4}$$

Where C*x* are the coefficients derived by fitting the surface, and L is the length of the region in the short axis.

Camber A

ABS Geometry Applications. The curvature of the rails in the short axis or the sag across the rail(s) in the top third of the slider.



Camber B

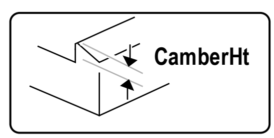
ABS Geometry Applications. The curvature of the rails in the short axis or the sag across the rail(s) in the center third of the slider.

Camber C

ABS Geometry Applications. The curvature of the rails in the short axis or the sag across the rail(s) in the bottom third of the slider.

CamberHt

ABS Geometry Applications. The greatest vertical distance occupied by either outer rail. The Deskew Data control can be used to adjust this result.



Camera Res

It displays the lateral resolving power of each camera pixel with a given calibrated objective or calibrated transmission element. The value is the smallest detail that can be measured laterally. If the objective or transmission element are not calibrated, the output box is blank. Attribute only.

Cat's Eye

Three Zone Radius Scale Application. Shows the status of the cat's eye measurement when measuring a part with three different radii. Attribute only.

Catseye Astigmatism

Radius Scale Application. The amount of residual astigmatism present in the test cavity at the cat's eye position.

Catseye Error

Radius Scale Application. The distance error contributed by the residual power at the cat's eye position.

Catseye Points

Radius Scale Application. The number of data points acquired during the radius measurement when in the cat's eye position.

Catseye Power

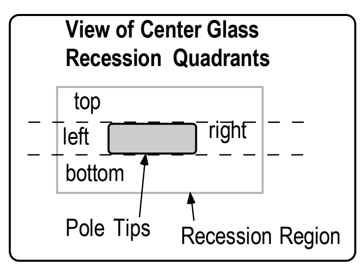
Radius Scale Application. The amount of residual power present in the test cavity at the cat's eye position.

Center Bar AvgHt

ABS Geometry Applications. Average height of the crossbar relative to the best fit plane to the ABS. The crossbar region is the area below the cavity between the ABS. Its width is the same as specified by the Hogout Width control.

Center Bottom Recession

PTR Applications. When the Glass Location control is set to Center, Center All, or Center Split, this result shows the average heights for the bottom quadrant of the recession test mask where data is available.



Center Left Recession

PTR Applications. When the Glass Location control is set to Center, Center All, or Center Split, this result shows the average heights for the left quadrant of the recession test mask where data is available. See Center Bottom Recession.

Center Right Recession

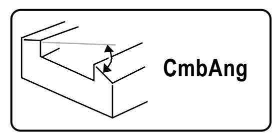
PTR Applications. When the Glass Location control is set to Center, Center All, or Center Split, this result shows the average heights for the right quadrant of the recession test mask where data is available. See Center Bottom Recession.

Center Top Recession

PTR Applications. When the Glass Location control is set to Center, Center All, or Center Split, this result shows the average heights for the top quadrant of the recession test mask where data is available. See Center Bottom Recession.

CmbAng (Avg)

ABS Geometry Applications. The average tilt between the outer rails in the same direction as Camber. The Deskew Data control can be used to adjust this result.



CmbAng (Median)

ABS Geometry Applications. The median tilt between the outer rails in the same direction as Camber.

Cntr Taper AvgHt

ABS Geometry Applications. The height from the center taper to a best fit plane to the ABS.

Cntr Taper Tilt X

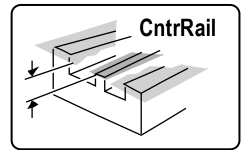
ABS Geometry Applications. The tilt in the X axis of the center taper in relation to a best fit plane to the ABS. The Deskew Data control can be used to adjust this result.

Cntr Taper Tilt Y

ABS Geometry Applications. The tilt in the Y axis of the center taper in relation to a best fit plane to the ABS. The Deskew Data control can be used to adjust this result.

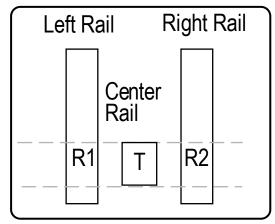
CntrRailAvgHt

ABS Geometry Applications. The average height between the two outer rails and the center rail.



CntrRailAvgHtLocal

ABS Geometry Applications. The height of the center rail in reference to the ABS regions on the outer rails that overlap the center rail in the Y axis. As shown in the drawing, it is the height of a plane fit to "T" relative to a plane fit to areas "R1" and "R2".



CntrRailMaxHt

ABS Geometry Applications. The greatest height between the two outer rails and the center rail. See CntrRailAvgHt.

CntrRailMinHt

ABS Geometry Applications. The shortest height between the two outer rails and the center rail. See CntrRailAvgHt.

CoefVarBlendDepth

Edge Blend Application. The coefficient of variation of all blend depths. It is equal to the standard deviation divided by the average blend depth.

CoefVarBlendLength

Edge Blend Application. The coefficient of variation of all blend lengths. It is equal to the standard deviation divided by the average blend length.

Coef (0 to 36)

Displays the value for Zernike polynomial coefficients created when a Zernike data set was generated.

Coherence Mode

Displays the orientation of the MESA Coherence Mode knob when the measurement was made. Attribute only.

ComAng (Z)

ComAng (Z) (Coma Angle based on Zernikes) is the angle in the instrument coordinate system at which coma occurs. The range of values for ComAng (z) is ±180°. For an explanation of coma, see ComMag (z).

$$\text{ComAng}(Z) = \arctan\left(\frac{z7}{z6}\right)$$

Where z6 is the 6th Zernike term and z7 is the 7th term.

Zernike polynomials are used to calculate Seidels, and at least 9 Zernike terms must be analyzed to display the result.

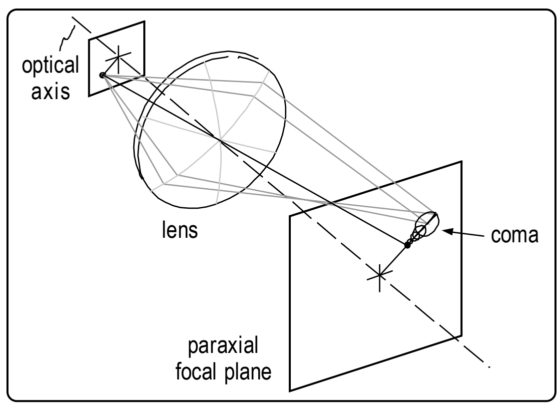
ComMag (Z)

ComMag (Z) (Coma Magnitude based on Zernikes) is a third order wavefront aberration that appears when light is brought to a focus at points off the optical axis. The name coma is Latin for comet, which is the shape of the aberrated image of an off-axis point.

$$\text{ComMag} = 3\sqrt{\left(z6^2 + z7^2\right)}$$

Where z6 is the 6th Zernike term and z7 is the 7th term.

Zernike polynomials are used to calculate Seidels, and at least 9 Zernike terms must be analyzed to display the result.



The imaging of an off-axis point source by a lens with positive transverse coma is shown here. Each cone of rays passing through a circle of the lens surface is imaged as a comatic circle and not a point. The overall image is shaped like a comet. Rays passing through the center of the lens form a point image at the vertex of the cone.

In a perfectly aligned and fabricated optical system, coma is only found at image points off the optical axis. In real optical systems, coma can be found anywhere in the image plane. If aberrations are found on axis they are an indication of fabrication or alignment errors.

In third order aberration theory, coma may be positive or negative. For negative coma, the tail points away from the optical axis and for positive coma, the tail points toward the axis. ComMag as computed in MetroPro is always positive. Its orientation is given by ComAng. This modification of the definition was necessary because the location of the optical axis is unknown to the interferometer.

Cone Angle

Represents the value of the cone angle that was removed from the data set. For fixed angle cone removal, this result will be the value entered in the Cone Angle control. For variable angle cone removal, this result will be the angle of the cone determined during the measurement and removed during analysis.

Confocal Astigmatism

Radius Scale Application. The amount of residual astigmatism present in the test cavity at the confocal position.

Confocal Error

Radius Scale Application. The distance error contributed by the residual power at the confocal position.

Confocal Points

Radius Scale Application. The number of data points acquired during the radius measurement when in the confocal position.

Confocal Power

Radius Scale Application. The amount of residual power present in the test cavity at the confocal position.

Contrast (Ref)

Step Height Application. A number from 0 to 100 representing the contrast between light and dark fringes on a reference area. Applicable only to phase microscopes.

Contrast (Test)

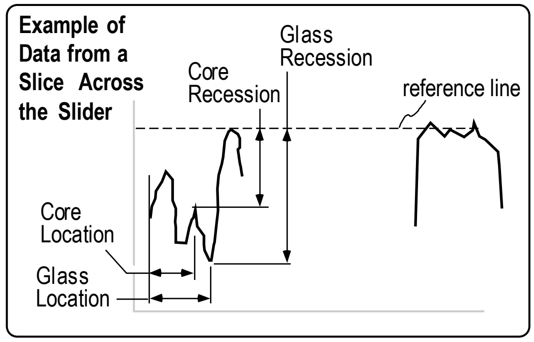
Step Height Application. A number from 0 to 100 representing the contrast between light and dark fringes on a test area. Applicable only to phase microscopes.

Core Location

ABS Geometry Applications. The distance of the core recession peak from the outside edge of the rail. See Core Recession.

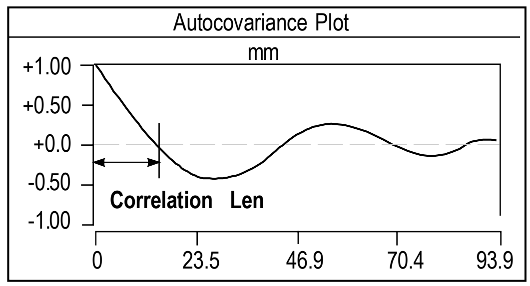
Core Recession

ABS Geometry Applications. The depth from the reference line to the core. The reference line is based on the highest point on the rail containing the core leveled to the mean of points on the other rail.



Correlation Len

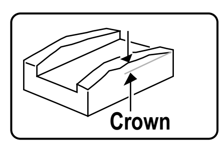
Correlation Len (Length) is the distance or length along the x-axis of the Autocovariance plot where the autocovariance function first crosses zero. It can be thought of as the minimum distance along the cross section of the surface where one point has no relation to the next. In a perfectly random surface, the Correlation Len is zero because no points have any relationship to other points. In a part with a non-random surface, Correlation Len is one quarter of the period of the dominant pattern.



The Correlation Len result is blank if a Filled plot in a corresponding data window does not have a linear slice defined. The instrument must be calibrated for the Correlation Len result to display in units other than pixels. For Zygo microscopes, objectives are factory calibrated; unless they are replaced or switched later. For Zygo interferometers, calibration is required every time the zoom setting is changed.

Crown

ABS Geometry Applications. The curvature of the rails in the long axis or the sag along the rail(s). Crown can be calculated for both rails or each rail individually. Crown is positive for a convex surface and negative for a concave.



Crown is derived from a best fit cylindrical surface. The equations are:

$$Z(X,Y) = C_0 + C_1X + C_2Y + C_3XY + C_4X^2 + C_5Y^2$$

$$\text{Crown} = -\frac{C_5L^2}{4}$$

Where C*x* are the coefficients derived by fitting the surface, and L is the length of the region in the short axis.

Crown 2

ABS Geometry Applications. The curve of the ABS along the left and right rails only. If the slider only has two rails, Crown and Crown 2 are the same. The Deskew Data control can be used to adjust this result.

Custom

This result allows for creation of a new, numeric result not offered through standard MetroPro. Custom is available in a Test or Surface/Wavefront window in Microscope or GPI applications. The value of a custom result is derived from a user-created MetroScript. A unit of measure must be selected and named. None is a selection for unit of measure if there isn't one that applies to the custom result. The Auto Run Script command tells the system to run the script, and the Script File command identifies its location.

Cutoff Freq

Cutoff Freq (frequency) is the maximum spatial frequency that can be resolved by a lens; it is where the theoretical unaberrated MTF goes to zero. The Cutoff Freq result requires an entry in the f-number control. With an optic with a focused wavefront, or an f-number greater than zero, the units are shown in cycles per millimeter (l/mm).

$$\text{Cutoff Freq} = \frac{2\,\text{NA}}{\text{Wavelength - In}} \qquad \text{Where: } \text{NA} = \frac{1}{(2)\,\text{f - number}}$$

Cutoff Freq (afocal)

The maximum angular frequency that can be resolved by a lens; it is where the theoretical unaberrated MTF goes to zero. For afocal wavefronts, set the f-number control to 0 (zero) and enter a dimension in the Exit Pupil Diam control. The units are shown in cycles per arc sec (l/sec).

$$\text{Cutoff Freq (afocal)} = \frac{\text{Exit Pupil Diam}}{\text{Wavelength - In}}$$

Data File

Displays the name of the last saved or loaded data file. Attribute only.

Dihed Ang Err 1-2 or 4-5

Corner Cube Application. The amount that the named facets deviate from being truly perpendicular to one another. The numbers refer to intersections of sectors, for example: 1-2 refers to the intersection of sectors 1 and 2. A positive number indicates that the dihedral angle is greater than 90 degrees, a negative value denotes less than 90 degrees. See Beam Dev 1.

Dihed Ang Err 2-3 or 5-6

Corner Cube Application. The amount that the named facets deviate from being truly perpendicular to one another. The numbers refer to intersections of sectors, for example: 2-3 refers to the intersection of sectors 2 and 3. A positive number indicates that the dihedral angle is greater than 90 degrees, a negative value denotes less than 90 degrees. See Beam Dev 1.

Dihed Ang Err 3-4 or 6-1

Corner Cube Application. The amount that the named facets deviate from being truly perpendicular to one another. The numbers refer to intersections of sectors, for example: 3-4 refers to the intersection of sectors 3 and 4. A positive number indicates that the dihedral angle is greater than 90 degrees, a negative value denotes less than 90 degrees. See Beam Dev 1.

Drift Mean

The arithmetical average of all readings obtained from the distance measuring interferometer. Part of the DMI Test window; used with the radius scale option.

Drift Range

The maximum reading minus the minimum reading obtained from the distance measuring interferometer. Part of the DMI Test window; used with the radius scale option.

Drift Std Dev

The standard deviation or variation of the readings obtained from the distance measuring interferometer. Part of the DMI Test window; used with the radius scale option.

End Offset Error

ABS Geometry Applications. The difference between the first pixel row with a valid data point and the first pixel row with valid data across both rails. A large value may indicate a very non-orthogonal position of the slider or data dropouts near the top of the slider.

Fit Angle

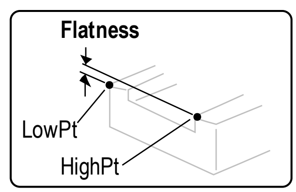
Step Height Application. The angle between the test and reference region of one scan row. It is derived from profile data. See Avg Fit Step.

Fit Step

Step Height Application. The height of the test region in relation to the reference region of one scan row. It is derived from profile data. See Avg Fit Step.

Flatness

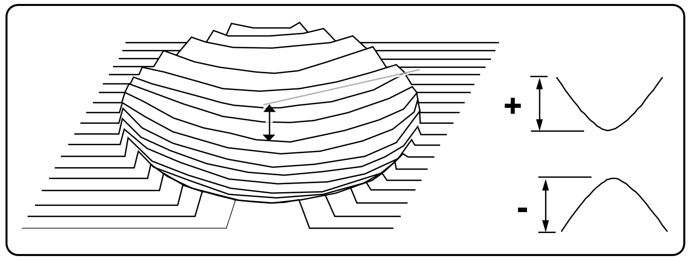
ABS Geometry Applications. The distance between the lowest and highest points of all of the ABS.



Flatness 2

ABS Geometry Applications. The distance between the lowest and highest points of the left and right ABS only. If the slider only has two rails, Flatness and Flatness 2 are the same. See Flatness.

FocMag (Z)



FocMag (Z) (Focus Magnitude based on Zernikes) is a first order wavefront aberration; it is a measure of the sag of the surface or wavefront without distinguishing between the X and Y dimensions. It is the height difference between the center point and the point farthest from the center. FocMag (z) is positive for a concave surface and negative for a convex surface.

$FocMag = 2\,(z3) - 6\,(z8)$ Where z3 is the 3rd Zernike term and z8 is the 8th term.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display the result.

Fringe Centers

Static Fringe Application. Displays the number of fringes found in the static fringe image. Attribute only.

Fringe Contrast

PTR Applications. A number representing the contrast between light and dark fringes. Zero (0) depicts no contrast, 100 depicts perfect contrast. It is used as a focus indicator.

Fringe Contrast (Ref)

A number representing the contrast between the light and dark fringes at the time of acquisition. The result can range from 0 to 100, with 0 depicting no contrast and 100 depicting the perfect contrast. Fringe Contrast (Ref) is the contrast in the area of the test part defined as the Reference mask.

Fringe Contrast (Test)

A number representing the contrast between the light and dark fringes at the time of acquisition. The result can range from 0 to 100, with 0 depicting no contrast and 100 depicting the perfect contrast. Fringe Contrast (Test) is the contrast in the area of the test part defined as the Test mask or the entire part if masks are not used.

The Fringe Contrast (Test) and Fringe Contrast (Ref) results serve together as a focus indicator for the microscope Step Height Application. When both display somewhat equal values it means the objective is properly focused on the step. Values will not be equal if there are dissimilar materials on the top and bottom of the step.

Gap Alignment

Trimmed PTR Application. An indicator of the vertical centration of the gap within the unetched pole tip area. See ABS Roughness.

Gap Band Cyl RMS

Trimmed PTR Application. The rms of the row of pixels immediately above and below the gap. Form is removed from this area before calculating rms. See ABS Roughness.

Glass Location

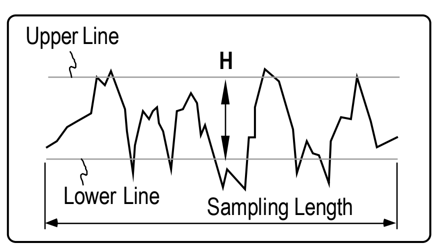
ABS Geometry Applications. The distance of the glass recession peak from the outside edge of the rail. See Core Recession.

Glass Recession

PTR Applications. The average recession of the baselayer or glass area as compared to the ABS area.

H

H or Swedish height is the distance between two reference lines inside the profile. The upper reference line is positioned at a depth which exposes 5% of the data and the lower reference line exposes 90%. Swedish height is less sensitive to data spikes than PV.



Ha

Advanced Texture Application.   The average surface height, or average deviation, of all points from a plane fit to the high frequency data.

Height

Advanced Texture Application. The highest point in a peak, valley, or summit region. Part of the peaks/valleys and summits Stats table.

High Filter Freq

Advanced Texture Application.   Displays the setting of the corresponding Filter Freq control at the time of analysis. Displayed in cycles per millimeter.

High Filter Wavelen

Advanced Texture Application.   Displays the setting of the corresponding Filter Wavelen control at the time of analysis.

HighPt

ABS Geometry Applications.   The highest corner of a plane fitted to the entire ABS. See Flatness.

HighPt 2

ABS Geometry Applications.   The highest corner of a plane fitted to the left and right ABS only. If the slider only has two rails, HighPt and HighPt 2 are the same.

Hmax

Advanced Texture Application.   The maximum height of the high frequency data.

Hogout A AvgHt

ABS Geometry Applications.   The mean height of the top third portion of the hogout region relative to a best fit plane to the ABS.

Hogout A-B AvgHt

ABS Geometry Applications.   The difference between the average height of the top third portion of the hogout region to the middle third portion.

Hogout A-C AvgHt

ABS Geometry Applications. The difference between the average height of the top third portion of the hogout region to the lower third portion.

Hogout AvgHt

ABS Geometry Applications. The mean height of the hogout region relative to a best fit plane to the ABS. The hogout region is the recessed area between the rails.

Hogout B AvgHt

ABS Geometry Applications. The mean height of the middle third portion of the hogout region relative to a best fit plane to the ABS.

Hogout B-C AvgHt

ABS Geometry Applications. The difference between the average height of the middle third portion of the hogout region to the lower third portion.

Hogout C AvgHt

ABS Geometry Applications. The mean height of the lower third portion of the hogout region relative to a best fit plane to the ABS.

Hogout Points

ABS Geometry Applications. Number of valid pixels in the hogout region.

Hogout Ra

ABS Geometry Applications. The average roughness in the hogout region.

Hogout Tilt X

ABS Geometry Applications. The angular tilt in the x-axis of a best fit plane to the hogout region in relation to a best fit plane to the ABS. The Deskew Data control can be used to adjust this result.

Hogout Tilt Y

ABS Geometry Applications. The angular tilt in the y-axis of a best fit plane to the hogout region in relation to a best fit plane to the ABS. The Deskew Data control can be used to adjust this result.

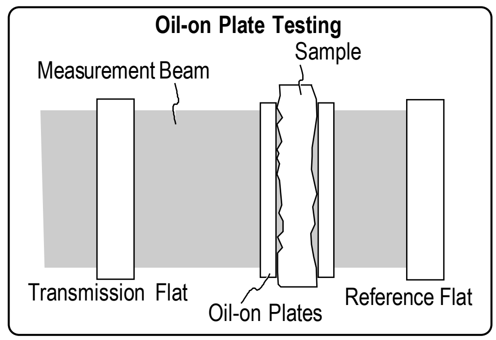
Homogeneity

A measure of the uniformity or purity of an optical material. The lower the Homogeneity, the better the uniformity.

Homogeneity is given by: $\Delta n = [n\ (T - C) - (n-1)\ (S2 - S1)]\ /t$

Where n is the refractive index, t is the part thickness, and T, C, S1, and S2 are the measurements.

It is typically used with large aperture interferometer systems to evaluate material quality before expending time and resources on fabrication. Prior to making a measurement, the thickness of the optical material being tested must be entered in a Part Thickness control. Homogeneity is equal to the PV divided by the part thickness.



The Homogeneity result is commonly used with the oil-on plate testing technique for testing material samples that do not have polished surfaces. Oil-on plate testing is shown here and described below.

Oil-on plates are nominally plane-parallel plates, of which one surface is very flat, and the other surface is corrected to provide good transmitted wavefront quality. The flat surface of the oil-on plate is index matched to the sample under test using an index matching oil with the same index of refraction as the material being tested. The index matching oil serves the dual function of "wetting" the ground surface of the sample to make it transparent, and "filling" the voids in the sample surface.

First, a reference measurement is taken of the cavity consisting of the transmission flat, reference flat, and both oil-on plates oiled together; this measurement is stored as a system error file. The sample is then inserted in the cavity, using the index matching oil between the sample and the plates, and a second measurement is made. The reference measurement is then subtracted from the second measurement to provide corrected data on the sample only.

Homogeneity RMS

The root-mean-square deviation of all points from a plane fit to the test part surface.

Hq

Advanced Texture Application. The root-mean-square deviation of all points from a plane fit to the high frequency data.

Ia

Advanced Texture Application. The average surface height, or average deviation, of all points from a plane fit to the input data.

IArea

Advanced Texture Application. The planar area occupied by the input data excluding the effects of height variations.

Imax

Advanced Texture Application. The maximum height of the input data.

Index of Air

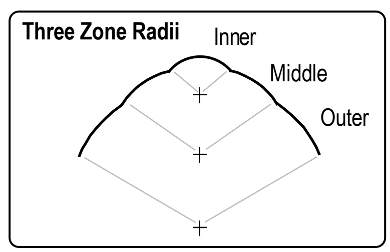
Outputs the refractive index of air every time a new value is entered in the Temperature, Pressure, or Relative Humidity controls. This feature is for use with the Radius Slide Application; it enables MetroPro to compensate for any changes in the wavelength of the laser beam of the Zygo 2/20 or ZMI Laser Heads due to environmental conditions.

Inner Flyable Radius

Disk Flatness Application. The radius of the inner mask when the measurement was made.

Inner Radius of Curvature

Three Zone Radius Scale Application. The radius of curvature, of the area defined by the inner mask, of a part with three different radii.



Inner Zone

Three Zone Radius Scale Application. Shows the status of the inner zone measurement when measuring a part with three different radii. Attribute only.

Iq

Advanced Texture Application. The root-mean-square deviation of all points from a plane fit to the input data.

IRR

Irregularity (IRR) is the tolerance of the surface form error which remains after the sagitta error is removed. It is the PV with respect to the best fit reference sphere. Part of the ISO figure specification (ISO 10110-5).

ISizeX

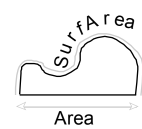
Advanced Texture Application. The largest dimension of the input data set in the x-axis.

ISizeY

Advanced Texture Application. The largest dimension of the input data set in the y-axis.

ISurfArea

Advanced Texture Application. The surface area of the input data. The surface area of the surface including the effects of height variations. This is always greater than or equal to “IArea”.



ISurfAreaRatio

Advanced Texture Application. The surface area ratio of the input data. Equal to (ISurfArea/IArea) -1.

Lap Contour Angle

ABS Geometry Applications. The angle of the cylinder surface relative to the Slider Angle.

Last Reading

The last value obtained from the distance measuring interferometer. Part of the DMI Test window; used with the radius scale option.

Left TPC AvgHt

Wall Angle Application. The average height between a plane fit to the ABS and a plane fit to TPC step to the left of the ABS. See ABS Width.

Left TPC Width

Wall Angle Application. The dimension across the TPC step to the left of the ABS. See ABS Width.

Left Wall Angle

Wall Angle Application. The angle of the wall between the left TPC step and the ABS. See ABS Width.

Length

ABS Geometry Applications. The average length along all vertical slices of valid data.

Length/Circum

Length/Circum is the dimension of the slice drawn on a Filled plot. For a linear slice, Length is the distance from one end point to the other. For a circular slice, Circum is the circumference of the circle. The Length/Circum result is inappropriate if there is not a slice drawn on a Filled plot. For units other than pixels the instrument must be calibrated.

Limits

Indicates if any result has exceeded a user-set limit. Use the attribute's menu Display As command to change the output from Pass/Fail to Accept/Reject. Copy this box to the Video Monitor window to display it on the video monitor screen. Attribute only.

Limits Status

Displays the status of results with user set limits. Indicates Pass or Fail. If there is one or more results out of range, Fail is displayed. Attribute only.

Log Dir

This attribute displays the directory path in which the report file was written. It is useful in that it shows the actual directory path when the Log Dir control contains special codes. If Log Dir is displayed, it will also be written to the report file. Attribute only.

Log File

This attribute now displays up to 80 columns in width. It is useful in showing the actual log file name when the Log File control contains special codes. If the the Log File attribute is displayed, it will also be written to the report file. Attribute only.

Lopoff Center X

Location in the x axis to the center of the trailing edge data. When Lopoff Delete Pole is Left, Right, or one of the Center options, it is calculated on the selected lopoff area. It is not calculated when Lopoff Delete Pole control is Left & Right or None.

The Lopoff Center X and Lopoff Center Y results work with the Trailing Edge Location control. Trailing Edge Location must be set to one of the Center options and Lopoff Delete Pole must be set to Center to calculate the location on the center rail. Trailing Edge Location must be set to Left & Right and Lopoff Delete Pole must be set to Left or Right to calculate the location on either the left or right rail.

Lopoff Center Y

Location in the y axis to the center of the trailing edge data. When Lopoff Delete Pole is Left, Right, or one of the Center options, it is calculated on the selected lopoff area. It is not calculated when Lopoff Delete Pole control is Left & Right or None. See Lopoff Center X.

Low Filter Freq

Advanced Texture Application. Displays the setting of the corresponding Filter Freq control at the time of analysis. Displayed in cycles per millimeter.

Low Filter Wavelen

Advanced Texture Application. Displays the setting of the corresponding Filter Wavelen control at the time of analysis.

LowPt

ABS Geometry Applications. The lowest corner of a plane fitted to the entire ABS. See Flatness.

LowPt 2

ABS Geometry Applications. The lowest corner of a plane fitted to the left and right ABS only. If the slider only has two rails, LowPt and LowPt 2 are the same.

Max +Acc

Disk Flatness Application. The maximum positive acceleration. Acceleration is the rate at which the magnetic head's z-axis velocity is changing. Positive acceleration occurs when the head moves away from the disk.

Max +Slope

Disk Flatness Application. The maximum positive slope. Positive slope is the angle of an upward hill encountered by the magnetic head as it travels across the disk. Radial slopes are those encounter while traveling in a straight line from the center of the disk to the outside edge. Axial slopes are those encountered while traveling coaxial with the center of the disk.

Max +Vel

Disk Flatness Application. The maximum positive velocity. Velocity is the speed of the magnetic head's movement in the z-axis. Positive velocity is an upward movement. The velocity calculation considers the disk's rotational speed, the radial position of the head, and the steepness of the disk's axial slopes.

Max -Acc

Disk Flatness Application. The maximum negative acceleration. Acceleration is the rate at which the magnetic head's z-axis velocity is changing. Negative acceleration occurs when the head moves toward the disk.

Max Acc

Disk Flatness Application. The maximum acceleration. Acceleration is the rate at which the magnetic head's z-axis velocity is changing. Acceleration occurs when the head moves away from or towards the disk.

Max Beam Deviation

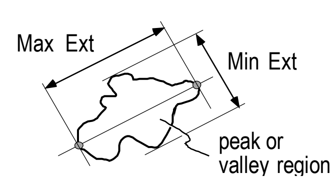
Corner Cube Application. Beam deviation is the angle that a retroreflected ray of light deviates from being parallel to the incident ray of light. This result displays the maximum of the individual sector results. See Beam Dev 1.

Max Etch Depth

PTR Applications. Maximum Etch Depth. Lowest point in the etch region.

Max Ext

Advanced Texture Application. Maximum Extent, the distance between the two most widely separated points in the peak or valley region. Part of the peaks/valleys Stats table.



Max Fit Angle

Step Height Application. Largest single angle of all scanned rows. See Avg Fit Step.

Max Fit Step

Step Height Application. Largest single height of all scanned rows. See Avg Fit Step.

Max Peak Area

Advanced Texture Application. The maximum area of all peaks included in the peak analysis.

Max Peak Height

Advanced Texture Application. The maximum height of all peaks included in the peak analysis.

Max Peak Mean Height

Advanced Texture Application. The maximum mean height of all peaks included in the peak analysis. Mean height is the average value of all pixels in the peak area.

Max Peak Slope

Advanced Texture Application. The maximum slope or angle of all peaks included in the peak analysis. Slope is based on the four pixels surrounding the highest point in the peak.

Max Proj Angle L/T

Step Height Application. The largest projected angle between the test and reference region of one scan row on the left or top of the step. It is derived from profile data. See Avg Fit Step.

Max Proj Angle R/B

Step Height Application. The largest projected angle between the test and reference region of one scan row on the right or bottom of the step. It is derived from profile data. See Avg Fit Step.

Max Proj Step L/T

Step Height Application. The largest projected height between the test and reference region of one scan row on the left or top of the step. It is derived from profile data. See Avg Fit Step.

Max Proj Step R/B

Step Height Application. The largest projected height between the test and reference region of one scan row on the right or bottom of the step. It is derived from profile data. See Avg Fit Step.

Max PTR

PTR Applications. The lowest point from the ABS in the pole tip area.

Max PTR 1

PTR Applications. The highest value of all points in the first pole tip of an MR head. A blank result indicates that the software could not separate the poles during analysis.

Max PTR 2

PTR Applications. The highest value of all points in the second pole tip of an MR head. A blank result indicates that the software could not separate the poles during analysis.

Max PTR 3

PTR Applications. The highest value of all points in the third pole tip of an MR head. A blank result indicates that the software could not separate the poles during analysis.

Max Reading

The maximum value obtained from the distance measuring interferometer during the sample period. Part of the DMI Test window; used with the radius scale option.

Max -Slope

Disk Flatness Application. The maximum negative slope. Negative slope is the angle of a downward hill encountered by the magnetic head as it travels across the disk. Radial slopes are those encounter while traveling in a straight line from the center of the disk to the outside edge. Axial slopes are those encountered while traveling coaxial with the center of the disk.

Max Summit Height

Advanced Texture Application. The maximum height of all summits included in the summit analysis.

Max Summit Mean Height

Advanced Texture Application. The maximum mean height of all summits included in the summit analysis. Mean height is the average value of all pixels in the summit area.

Max Summit RadCurv

Advanced Texture Application. The maximum radius of curvature of all summits included in the summit analysis. Radius of curvature is based on the four adjacent pixels to the summit.

Max Summit Slope

Advanced Texture Application. The maximum slope of all summits included in the summit analysis. Slope is based on the four pixels surrounding the highest point in the summit.

Max Valley Area

Advanced Texture Application. The maximum area of all valleys included in the valley analysis.

Max Valley Height

Advanced Texture Application. The maximum height of all valleys included in the valley analysis.

Max Valley Mean Height

Advanced Texture Application. The maximum mean height of all valleys included in the valley analysis. Mean height is the average value of all pixels in the valley area.

Max Valley Slope

Advanced Texture Application. The maximum slope or angle of all valleys included in the valley analysis. Slope is based on the four pixels surrounding the lowest point in the valley.

Max -Vel

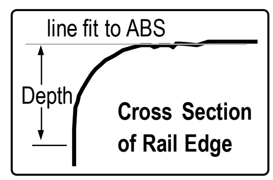
Disk Flatness Application. The maximum negative velocity. Velocity is the speed of the magnetic head's movement in the z-axis. Negative velocity is a downward movement. The velocity calculation considers the disk's rotational speed, the radial position of the head, and the steepness of the disk's axial slopes.

Max Vel

Disk Flatness Application. The maximum velocity. Velocity is the speed of the magnetic head's movement in the z-axis. The velocity calculation considers the disk's rotational speed, the radial position of the head, and the steepness of the disk's axial slopes.

MaxBlendDepth

Edge Blend Application. The largest single blend depth of all scanned rows. The farthest point from the ABS.



MaxBlendLength

Edge Blend Application. The longest single blend length of all scanned rows.

Mean

Advanced Texture Application. The mean height value of all points in a peak, valley, or summit. Part of the peaks/valleys and summits Stats table.

Mean Peak Area

Advanced Texture Application. The arithmetical average area of all peaks included in the peak analysis.

Mean Peak Height

Advanced Texture Application. The arithmetical average height of all peaks included in the peak analysis.

Mean Peak Mean Height

Advanced Texture Application. The arithmetical average mean height of all peaks included in the peak analysis. Mean height is the average value of all pixels in the peak area.

Mean Peak Slope

Advanced Texture Application. The arithmetical average slope of all peaks included in the peak analysis. Slope is based on the four pixels surrounding the highest point in the peak.

Mean Summit Height

Advanced Texture Application. The arithmetical average height of all summits included in the summit analysis.

Mean Summit Mean Height

Advanced Texture Application. The arithmetical average mean height of all summits included in the summit analysis. Mean height is the average value of all pixels in one summit area.

Mean Summit RadCurv

Advanced Texture Application. The arithmetical average radius of curvature of all summits included in the summit analysis. Radius of curvature is based on the four adjacent pixels to the summit.

Mean Summit Slope

Advanced Texture Application. The arithmetical average slope of all summits included in the summit analysis. Slope is based on the four pixels surrounding the highest point in the summit.

Mean Valley Area

Advanced Texture Application. The arithmetical average area of all valleys included in the valley analysis.

Mean Valley Height

Advanced Texture Application. The arithmetical average height of all valleys included in the valley analysis.

Mean Valley Mean Height

Advanced Texture Application. The arithmetical average mean height of all valleys included in the valley analysis. Mean height is the average value of all pixels in the valley area.

Mean Valley Slope

Advanced Texture Application. The arithmetical average slope of all valleys included in the valley analysis. Slope is based on the four pixels surrounding the lowest point in the valley.

Measurement

Three Zone Radius Scale Application, Three Flat Application, and Two Sphere Application. Shows what measurement in a multi-measurement sequence is currently displayed on the screen. Attribute only.

Measurement Status

Displays the measurement number and total number of measurements during a stitching sequence. Attribute only.

Median PTR

PTR Applications. The middle value of all the points in the valid pole tip area.

Median PTR 1

PTR Applications. The middle value of all points in the valid area in an MR head of the first pole tip. A blank result indicates that the software could not separate the poles during analysis.

Median PTR 2

PTR Applications. The middle value of all points in the valid area in an MR head of the second pole tip. A blank result indicates that the software could not separate the poles during analysis.

Median PTR 3

PTR Applications. The middle value of all points in the valid area in an MR head of the third pole tip. A blank result indicates that the software could not separate the poles during analysis.

Middle Radius of Curvature

Three Zone Radius Scale Application. The radius of curvature, of the area defined by the middle mask, of a part with three different radii. See Inner Radius of Curvature.

Middle Zone

Three Zone Radius Scale Application. Shows the status of the middle zone measurement when measuring a part with three different radii. Attribute only.

Min Ext

Advanced Texture Application. Mininum Extent, the sum of two greatest distances at a right angle from a line between two points defining the Max Ext in a peak or valley region. See Max Ext. Part of the peaks/valleys Stats table.

Min Fit Angle

Step Height Application. The smallest single angle of all scanned rows. See Avg Fit Step.

Min Fit Step

Step Height Application. The smallest single height of all scanned rows. See Avg Fit Step.

Min Peak Area

Advanced Texture Application. The minimum area of all peaks included in the peak analysis.

Min Peak Height

Advanced Texture Application. The minimum height of all peaks included in the peak analysis.

Min Peak Mean Height

Advanced Texture Application. The minimum mean height of all peaks included in the peak analysis. Mean height is the average value of all pixels in the peak area.

Min Peak Slope

Advanced Texture Application. The minimum slope or angle of all peaks included in the peak analysis. Slope is based on the four pixels surrounding the highest point in the peak.

Min Proj Angle L/T

Step Height Application. The smallest projected angle between the test and reference region of one scan row on the left or top of the step. It is derived from profile data. See Avg Fit Step.

Min Proj Angle R/B

Step Height Application. The smallest projected angle between the test and reference region of one scan row on the right or bottom of the step. It is derived from profile data. See Avg Fit Step.

Min Proj Step L/T

Step Height Application. The smallest projected height between the test and reference region of one scan row on the left or top of the step. It is derived from profile data. See Avg Fit Step.

Min Proj Step R/B

Step Height Application. The smallest projected height between the test and reference region of one scan row on the right or bottom of the step. It is derived from profile data. See Avg Fit Step.

Min PTR

PTR Applications. The closest point to the ABS from the pole tip area.

Min PTR 1

PTR Applications. The lowest point in an MR head from the ABS to the first pole tip. A blank result indicates that the software could not separate the poles during analysis.

Min PTR 2

PTR Applications. The lowest point in an MR head from the ABS to the second pole tip. A blank result indicates that the software could not separate the poles during analysis.

Min PTR 3

PTR Applications. The lowest point in an MR head from the ABS to the third pole tip. A blank result indicates that the software could not separate the poles during analysis.

Min Reading

The minimum value obtained from the distance measuring interferometer during the sample period. Part of the DMI Test window; used with the radius scale option.

Min Summit Height

Advanced Texture Application. The minimum height of all summits included in the summit analysis.

Min Summit Mean Height

Advanced Texture Application. The minimum mean height of all summits included in the summit analysis. Mean height is the average value of all pixels in the summit area.

Min Summit RadCurv

Advanced Texture Application. The minimum radius of curvature of all summits included in the summit analysis. Radius of curvature is based on the four adjacent pixels to the summit.

Min Summit Slope

Advanced Texture Application. The minimum slope of all summits included in the summit analysis. Slope is based on the four pixels surrounding the highest point in the summit.

Min Valley Area

Advanced Texture Application. The minimum area of all valleys included in the valley analysis.

Min Valley Height

Advanced Texture Application. The minimum height of all valleys included in the valley analysis.

Min Valley Mean Height

Advanced Texture Application. The minimum mean height of all valleys included in the valley analysis. Mean height is the average value of all pixels in the valley area.

Min Valley Slope

Advanced Texture Application. The minimum slope or angle of all valleys included in the valley analysis. Slope is based on the four pixels surrounding the lowest point in the valley.

MinBlendDepth

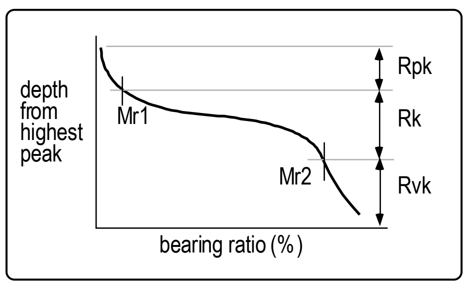
Edge Blend Application. The smallest single blend depth of all scanned rows. The shallowest depth of all the scans.

MinBlendLength

Edge Blend Application. The shortest single blend length of all scan rows.

Mr1

Advanced Texture Application. Material component relative to peaks - The material ratio at which Rpk and Rk meet. It represents the upper limit of the core roughness profile. Part of the bearing ratio analysis.



Mr2

Advanced Texture Application. Material component relative to valleys - The material ratio at which Rvk and Rk meet. It represents the lower limit of the core roughness profile. Part of the bearing ratio analysis. See Mr1.

N Fit Step

Step Height Application. The number of valid scanned rows that have had plane fit and remove. All fit step results are based on this number of rows.

N Proj Steps L/T

Step Height Application. The number of valid projected scanned rows on the left or top of the step. See Avg Fit Step.

N Proj Steps R/B

Step Height Application. The number of valid projected scanned rows on the right or bottom of the step. See Avg Fit Step.

nPTR

PTR Applications. The average recession of the “n” deepest points from the ABS in the pole tip area; “n” is specified by the nPTR Points control.

nPTR Points

PTR Applications. The actual number of points used to calculate nPTR. The blue nPTR Points control specifies the desired number of points to use.

Num Readings

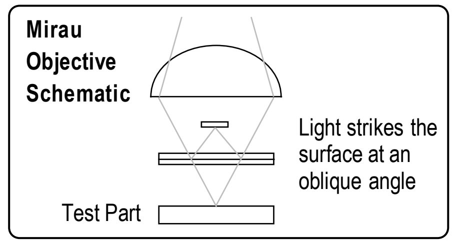
The number of readings from the distance measuring interferometer. Part of the DMI Test window; used with the radius scale option.

Objective

Displays what objective was selected for the measurement or indicates the objective chosen with the Objective button at the time of measurement. Attribute only.

Obliquity Factor

Displays the system calibration factor when using Mirau objectives. MetroPro automatically corrects the height results with an obliquity factor when using Mirau objectives. The Obliquity Factor Attribute box lets you see the scale factor that was used. Fizeau objectives do not require a correction factor because they illuminate normal to the surface. Attribute only.



When using Mirau objectives the test part is illuminated with light oblique (not perpendicular) to the surface. Surface heights measured this way must be multiplied by an appropriate Obliquity Factor to give true surface height. The magnitude of the obliquity factor is a function of the microscope objective numerical aperture and the intensity distribution of the illumination across the pupil of the microscope objective.

The relationship between fringe spacing and the optical path difference when using a Mirau objective is: 1 fringe spacing = $\lambda/2\ [1/\cos(\alpha)]$ Where the term $1/\cos(\alpha)$ is the obliquity factor.

Outer Flyable Radius

Disk Flatness Application. The radius of the outer mask when the measurement was made.

Outer Radius of Curvature

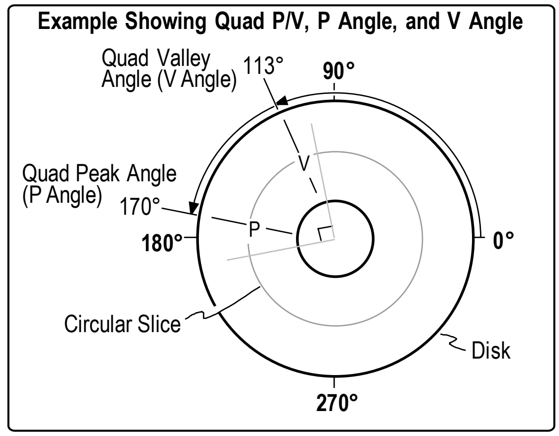
Three Zone Radius Scale Application. The radius of curvature, of the area defined by the outer mask, of a part with three different radii. See Inner Radius of Curvature.

Outer Zone

Three Zone Radius Scale Application. Shows the status of the outer zone measurement when measuring a part with three different radii. Attribute only.

P Angle

Disk Flatness Application. The angle at which the peak (for the quadrant) occurs, referenced to the zero position.



Pad AvgHt (center)

ABS Geometry Applications. The average height of the center pad region from the cylinder fit to the ABS. The Remove Pads control must be set to On.

Pad AvgHt (left)

ABS Geometry Applications. The average height of the left pad region from the cylinder fit to the ABS. The Remove Pads control must be set to On.

Pad AvgHt (right)

ABS Geometry Applications. The average height of the right pad region from the cylinder fit to the ABS. The Remove Pads control must be set to On.

Part f-number

GPI Application. Displays the f-number entered for the test part. Attribute only.

Part NA

GPI Application. Displays the numerical aperture of the test part. Attribute only.

Part Radius

GPI Application. Displays the nominal radius value of the test part. Attribute only.

Pattern Col

Displays the column number position of the current running pattern. Attribute only.

Pattern Coords

Displays the current coordinates of a motorized programmable stage. Attribute only.

Pattern Failed (%)

Displays the percentage of the pattern locations that fail a user set limit on a result.

Pattern Passed (%)

Displays the percentage of the pattern locations that pass a user set limit on a result.

Pattern Position

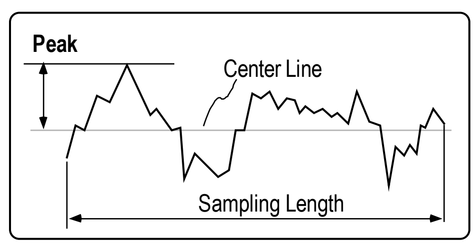
Displays the current ordinal number occupied by a motorized programmable stage in an ordered sequence. Attribute only.

Pattern Row

Displays the row number position of the current running pattern. Attribute only.

Peak

Peak is the maximum distance between the center line and the highest peak point within the sample. The center line is defined as the best fit surface selected with the Remove Control box. Peak is the value of the highest data point. It is also known as Rp.



Peak (1)…(6)

Corner Cube Application. The highest point of each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

Peak (All)

Peak (All) is available only in Test+Reference data windows. It is the highest point in both the test and reference areas. Test and reference areas are defined with the Mask Editor.

Peak (Ref)

Peak (Ref) is available only in Test+Reference data windows. It is the highest point in the area defined by the Reference mask.

Peak (Test)

Peak (Test) is available only in Test+Reference data windows. It is the highest point in the area defined by the Test mask.

Peak Area

Advanced Texture Application. The total area of all the peaks. Part of the peaks/valleys analysis.

Peak Density

Advanced Texture Application. The number of peaks per unit area. Part of the peaks/valleys analysis. Calculated by dividing the number of peaks by the map area.

Peak Loc X

The x-axis location in camera coordinates of the highest point in a profile. For Profile data only.

Peak Loc Y

The y-axis location in camera coordinates of the highest point in a profile. For Profile data only.

Peak Spacing

Advanced Texture Application. The average distance between summits. Part of the peaks/valleys analysis. Calculated as the square root of the map area divided by the number of peaks.

Peaks

Advanced Texture Application. The number of peaks included in the analysis. Part of the peaks/valleys analysis.

Points

Displays the number of valid data points in a particular data set. Also known as pixels, or the number of camera pixels used in the measurement and/or analysis. The number of data points can vary due to the use of masks, data dropout, and the instrument components.

Points (All)

Points (All) is available only in Test+Reference data windows. It is the number of valid data points or pixels in the area defined by the Reference mask and Test mask.

Points (Ref) (%)

PTR Applications. The percentage of good data points located in the PTR reference mask. Generally, it should be 95% or higher.

Points (Test)

Points (Test) is available only in Test+Reference data windows. It is the number of valid data points or pixels in the area defined by the Test mask.

Points (Test) (%)

PTR Applications. The percentage of good data points located in the PTR test mask. Generally, it should be 100%. Data dropout in the test or reference area can be caused by insufficient modulation or defects on the slider.

Points in TIR Spec %

Disk Flatness Application. Indicates the percentage of the disk's surface that is within the predetermined tolerance limit for total indicated runout. When this result box is red, the limit is exceeded and the percentage in the TIR Spec reports the percentage of pixels representing the entire surface of the disk within (or less than) the limit value.

Pole Mill Depth

Trimmed PTR Application. The mean vertical distance between the unetched pole tip and the etched pole tips. See ABS Roughness.

Pole Mill Depth (median)

Trimmed PTR Application. The median vertical distance between the unetched pole tip and the etched pole tips. See ABS Roughness.

Pole to Etched Glass

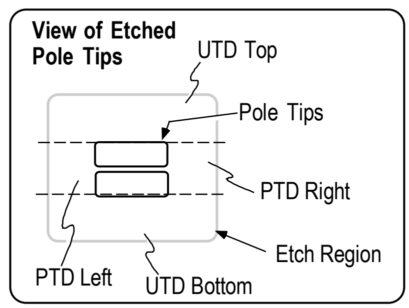
Trimmed PTR Application. The vertical distance from the unetched pole to the etched glass. See ABS Roughness.

Pole to Unetched Glass

Trimmed PTR Application. The vertical distance from the unetched pole to the unetched glass. See ABS Roughness.

Pole Trim Depth L&R

PTR Applications. Pole Trim Depth Left & Right. Average height of the right and left pole tip trimmed areas.



Pole Trim Depth Left

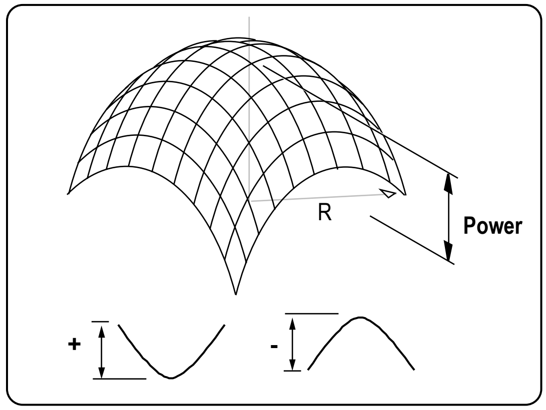
PTR Applications. Pole Trim Depth Left. Average height of the trimmed area on the left of the pole tips. See PTD L&R.

Pole Trim Depth Right

PTR Applications. Pole Trim Depth Right. Average height of the trimmed area on the right of the pole tips. See PTD L&R.

Power

A measure of the curvature of the surface or wavefront without distinguishing between the X and Y dimensions. It is equivalent to the height difference between the center point and the point farthest from the center. The Power result is derived from a best fit spherical surface (see equation). Power is positive for a concave surface and negative for a convex surface.



The equations used to calculate Power are:

$$Z(X,Y) = C_0 + C_1X + C_2Y + C_3(X^2 + Y^2)$$

$$\text{Power} = C_3R^2$$

Where Cx are coefficients derived by fitting the surface, and R is the radius or the distance between the center point and the point farthest from the center.

Proj Angle Lft

Step Height Application. The projected angle between the test and reference region of one scan row on the left or top of the step. It is derived from profile data. See Avg Fit Step.

Proj Angle Rgt

Step Height Application. The projected angle between the test and reference region of one scan row on the right or bottom of the step. It is derived from profile data. See Avg Fit Step.

Proj Step Lft

Step Height Application. The projected height between the test and reference region of one scan row on the left or top of the step. It is derived from profile data. See Avg Fit Step.

Proj Step Rgt

Step Height Application. The projected height between the test and reference region of one scan row on the right or bottom of the step. It is derived from profile data. See Avg Fit Step.

PTR

Trimmed PTR Application. The vertical distance from unetched pole tip region to a reference surface determined by a best fit cylinder to the ABS. See ABS Roughness.

PTR (%)

PTR Applications. The average recession of the PTR (%) deepest points from the ABS in the entire pole area. The PTR (%) control specifies the percentage used in the calculation.

Trimmed PTR Application. The pole tip recession calculated using the data specified by the PTR (%) control.

PTR (%) 1

PTR Applications. The average recession of deepest points from the ABS in the first pole tip in an MR head, as specified by the PTR (%) 1 control. If the result is blank, the software couldn't separate or find the three pole tips.

PTR (%) 2

PTR Applications. The average recession of deepest points from the ABS in the second pole tip in an MR head, as specified by the PTR (%) 2 control. If the result is blank, the software couldn't separate or find the three pole tips.

PTR (%) 3

PTR Applications. The average recession of deepest points from the ABS in the third pole tip in an MR head, as specified by the PTR (%) 3 control. If the result is blank, the software couldn't separate or find the three pole tips.

Pts in PV Spec (%)

Percentage of Points within the Peak-to-Valley specification is the percentage of valid data points within a user specified high limit for the PV result. It is linked to the PV result and displays a percentage result only if a high limit is set on the PV result. When a percentage is displayed, it represents the percentage of data points within the set limit.

Pts in PV Spec (1)…(6) (%)

Corner Cube Application. The percentage of valid data points within a user specified high limit for each of the PV (1)…(6) results. Each is linked to the matching PV result and displays a percentage result only if a high limit is set on the PV result. When a percentage is displayed, it represents the percentage of data points within the set limit.

Pts in PV Spec (All) (%)

Pts in PV Spec (All) (%) is available only in Test+Reference data windows. It is the percentage of valid data points within a user specified high limit for the PV (All) result; it applies to both the reference and test areas. The test and reference areas are defined with the Mask Editor. It is linked to the PV (All) result and displays a percentage only if a high limit is set on the PV result. It represents the percentage of data points within the set limit.

Pts in PV Spec (Ref) (%)

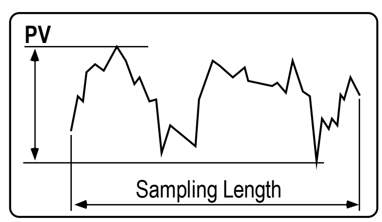
Pts in PV Spec (Ref) (%) is available only in Test+Reference data windows. It is the percentage of valid data points within a user specified high limit for the PV (Ref) result; it applies to the area defined by the Reference mask. It is linked to the PV (Ref) result and displays a percentage only if a high limit is set on the PV result. It represents the percentage of data points within the set limit.

Pts in PV Spec (Test) (%)

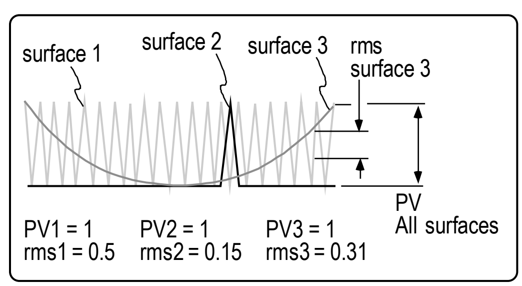
Pts in PV Spec (Test) (%) is available only in Test+Reference data windows. It is the percentage of valid data points within a user specified high limit for the PV (Test) result; it applies to the area defined by the Test mask. It is linked to the PV (Test) result and displays a percentage only if a high limit is set on the PV result. It represents the percentage of data points within the set limit.

PV

PV (Peak-to-Valley) is the distance between the highest and lowest points within the sample. PV is also known as R_t.



When used to quantify roughness, PV is the maximum roughness height. PV is the worst case point-to-point error in the data set. PV compares the two most extreme points on the surface; thus, it is possible for two very different surfaces to have the same PV value. This figure illustrates that different surfaces can have the same PV; three surfaces are superimposed over the top of each other.



PV - continued

When a high limit is set in the PV result, it has a special display function with Filled, Oblique, and 3D plots in the same data window. When the set high limit is exceeded, red areas are displayed in the plots.

Step Height Application. The greatest distance from the top of the step to the bottom of all scanned rows.

PV (1)…(6)

Corner Cube Application. The transmitted wavefront peak-to-valley of each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup. See Beam Dev 1.

PV (All)

PV (All) is available only in Test+Reference data windows. It is the greatest distance between the highest and lowest points in with both the test and reference areas. The test and reference areas are defined with the Mask Editor.

PV (Ref)

PV (Ref) is available only in Test+Reference data windows. It refers to the distance between the highest and lowest points within the area defined by the Reference mask.

PV (Test)

PV (Test) is available only in Test+Reference data windows. It refers to the distance between the highest and lowest points within the area defined by the Test mask.

Pwr X

Pwr X or Power X, is a measure of the curvature of the surface or wavefront in the x-axis. Used when measuring cylindrical surfaces to indicate the amount of power in the measurement, regardless of the setting of the Remove control. Instrument calibration is required. The equations used are:

$$Z(X,Y) = C_0 + C_1X + C_2Y + C_3X^2 + C_4Y^2 + C_5XY$$

$$\text{Pwr X} = C_3X^2$$

Where: Cx are coefficients derived by fitting the surface.

Pwr Y

Pwr Y or Power Y, is a measure of the curvature of the surface or wavefront in the y-axis. Used when measuring cylindrical surfaces to indicate the amount of power in the measurement, regardless of the setting of the Remove control. Instrument calibration is required. The equations used are:

$$Z(X,Y) = C_0 + C_1X + C_2Y + C_3X^2 + C_4Y^2 + C_5XY$$

$$\text{Pwr } Y = C_4Y^2$$

Where: Cx are coefficients derived by fitting the surface.

Quad Peak Angle

Disk Flatness Application. The angle at which the peak occurs, referenced to the zero position. See P Angle.

Quad PV

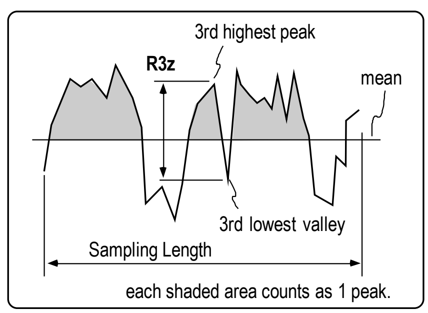
Disk Flatness Application. The largest peak-to-valley departure occurring within any 90 degree segment (quadrant) of a circular slice. The peak and valley of the slice quadrant may or may not be the peak or valley of the entire disk. See P Angle.

Quad Valley Angle

Disk Flatness Application. The angle at which the valley occurs, referenced to the zero position.

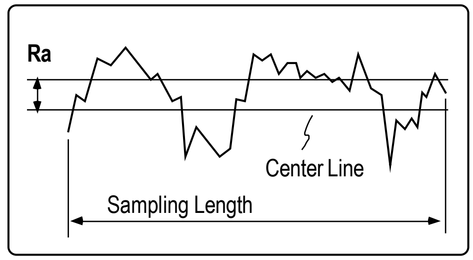
R3z

R3z is the distance between the third highest peak and the third lowest valley within the sampling length. For profile data, a peak is defined as the portion of a surface above the mean line and between center line crossings. For map data, a peak is defined as any island of data protruding up through a plane at the mean of the data. If there are not enough peaks in the data to calculate R3z, the result is blank.



Ra

Ra is the arithmetic average deviation from the center line. The centerline is defined as the best fit surface selected with the Remove control. Since Ra is a roughness parameter, surface figure should be removed from the data with the Remove control for this result to be meaningful.



$$Ra = \frac{y_1 + y_2 + y_3 ... + y_N}{N}$$

Where y_X is the absolute value of each point and N is the number of discrete elements.

Ra (Ref)

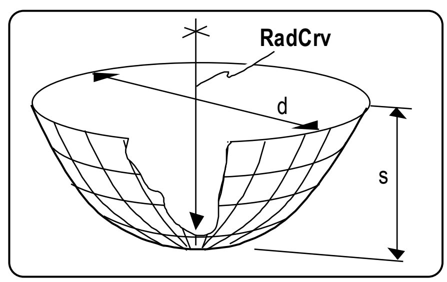
Ra (Ref) is available only in Test+Reference data windows. It is the arithmetic average deviation of all data points from the shape fit to the area defined by the Reference mask.

Ra (Test)

Ra (Test) is available only in Test+Reference data windows. It is the arithmetic average deviation of all data points from the shape fit to the area defined as the Test mask referenced to the shape fit to the reference area.

RadCrv

RadCrv (Radius of Curvature) is the distance from the part being measured to the center of the curvature of the surface. Radius of curvature is for a sphere. It is typically represented in millimeters or inches. A positive value corresponds to a convex surface or wavefront; a negative value corresponds to a concave surface or wavefront.



$$RadCrv = \frac{s}{2} + \frac{(\frac{d}{2})^2}{2S}$$

Where d is the diameter and s is the sag.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

Advanced Texture Application. The radius of curvature of the best-fit sphere to the summit. Part of the summits Stats table.

RadCrv (restrict)

ABS Geometry Applications. Radius of curvature of the ABS within the region specified by the RadCrv Trailing/Leading Edge Offset controls. RadCrv (restrict) is the overall curvature. RadCrv X (restrict) is the curvature in the x-axis; RadCrv Y (restrict) is the curvature in the y-axis.

RadCrv X

ABS Geometry Applications. The radius of curvature of the ABS in the x-axis.

RadCrv X (restrict)

ABS Geometry Applications. The radius of curvature in the x-axis of the ABS within the region specified by the RadCrv Trailing Edge Offset and RadCrv Leading Edge Offset controls.

RadCrv Y

ABS Geometry Applications. The radius of curvature of the ABS in the x-axis.

RadCrv Y (restrict)

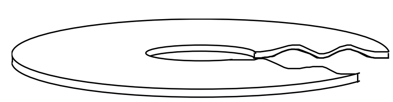
ABS Geometry Applications. The radius of curvature in the y-axis of the ABS within the region specified by the RadCrv Trailing Edge Offset and RadCrv Leading Edge Offset controls.

Rflatness

Advanced Texture Application. A measure of deviation from a flat surface, as based on the roughness data. It is the distance between two parallel planes, obtained by applying a Chebychev fit to the surface data.

Radial Slope

Disk Flatness Application. Slopes that would be encountered while traveling a straight path from the center of the disk to the outside edge.

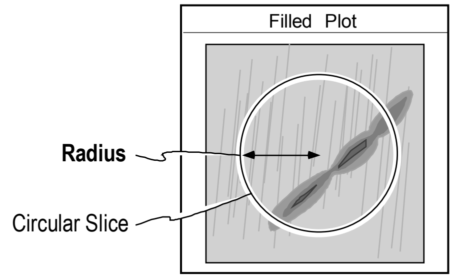


Exaggerated Radial Slopes

Radial Slope = $dx * \cos\theta - dy * \sin\theta$

Where dx is the first difference of height in the x direction, and dy is the first difference in the y direction.

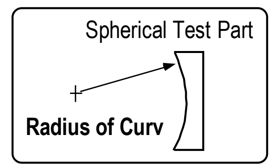
Radius



Radius is the length from the center of a circular slice to its circumference. The Radius result is inappropriate, unless there is a circular slice drawn on a Filled plot.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

Radius of Curv



Radius Slide Application. The radius of curvature of the tested sphere. It is the distance from the surface, or from the best fit spherical equivalent, to the center of curvature.

Rail Area Difference (%)

ABS Geometry Applications. Indicates the equality of the left and right ABS rail areas, and serves as a simple check of head geometry. When the result is 0, both rails have equal areas; when greater than 0, one rail has more area.

RArea

Advanced Texture Application. The planar area occupied by the roughness data excluding the effects of height variations.

Ref MTF 0 deg

The modulation value at 0 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

Ref MTF -45 deg

The modulation value at -45 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

Ref MTF 45 deg

The modulation value at 45 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

Ref MTF 90 deg

The modulation value at 90 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

Ref MTF Mean

The average modulation value of the MTF values at 0, 45, 0, and -45 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

Ref RadCrv

PTR Applications. The radius of curvature of the ABS in the PTR reference area.

Ref Tilt Angle

PTR Applications. The deviation or angle of the fringes in the ABS (reference) area from the y-axis. It is an indicator of the tilt or slope in the ABS; if the ABS has too much tilt, all results are suspect. Generally, the tilt angle can range from 3 to 5 degrees.

Removed

Displays the shape(s) or surface(s) removed with the Remove control at the time of the measurement or analysis. The Removed attribute varies per instrument, though the function is identical.

Right TPC AvgHt

Wall Angle Application. The average height between a plane fit to the ABS and a plane fit to TPC step to the right of the ABS. See ABS Width.

Right TPC Width

Wall Angle Application. The dimension across the TPC step to the right of the ABS. See ABS Width.

Right Wall Angle

Wall Angle Application. The angle of the wall between the right TPC step and the ABS. See ABS Width.

Rk

Advanced Texture Application. Core roughness depth. The long term running surface which will influence the performance and life of the bearing. Part of the bearing ratio analysis. See Mr1.

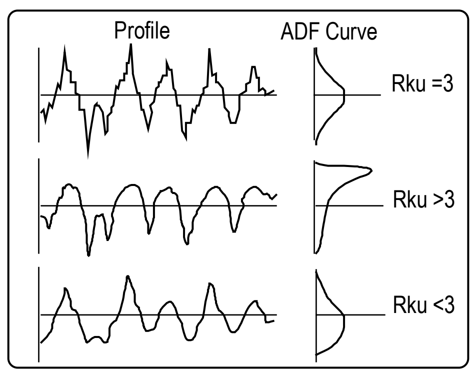
Rku

Rku or Kurtosis is the measure of the sharpness of the ADF (Amplitude Density Function) curve and of the "spikiness" of a surface. Spikiness does not necessarily mean the sharpness of individual peaks and valleys. The sharper the ADF curve, the greater the value. Kurtosis values can range from 0 to 8.

$$Rku = \frac{1}{n\left(R_q\right)^4}\sum_{i=1}^{i=n}\left(Y_i\right)^4$$

Where n is the number of elements Y_i in the profile and R_q is the root-mean-square roughness.

Kurtosis is also a measure of the randomness of profile heights: a perfectly random surface has a kurtosis of 3; the less random and more repetitive the surface, the further the kurtosis value is from 3. Kurtosis is sometimes specified for the control of stress fracture.

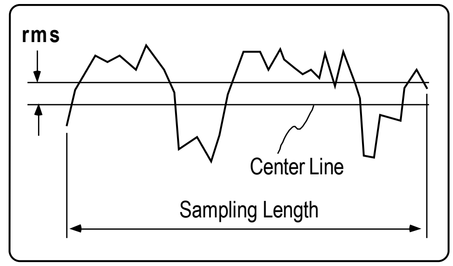


Rmax

Advanced Texture Application. The maximum height of the roughness data. Also known as PV.

rms

Root-Mean-Square or rms is the root-mean-square deviation from the center line. This is a method of calculating an average by squaring each value and then taking the square root of the mean. The center line is defined as the best fit surface selected with the Remove control. It is also known as R_q.



$$\text{rms} = \left(\frac{y_1^2 + y_2^2 + y_3^2 \ldots + y_N^2}{N} \right)^{1/2}$$

Where: Y_x are the height elements along the profile and N is the number of discrete elements.

The rms result is calculated as the standard deviation of the height (or depth) of the test surface relative to the reference at all data points in the data set. Since rms is a roughness parameter, surface figure should be removed from the data with the Remove control for this result to be meaningful.

The rms result is the root-mean-square of surface figure error or transmitted error relative to a reference surface. The rms result is an area weighted statistic; when used for optical components, it more accurately depicts the optical performance of the surface being measured than the PV statistic because it uses all the data in the calculation.

rms (1)...(6)

Corner Cube Application. The transmitted wavefront root-mean-square of each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

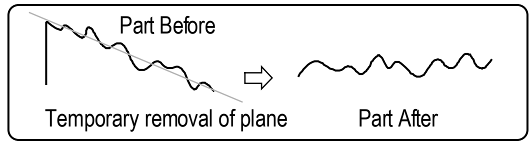
rms (Ref)

rms (Ref) is available only in Test+Reference data windows. It is the root mean-square deviation of all data points from the shape fit to the area defined by the Reference mask.

rms (Test)

rms (Test) is available only in Test+Reference data windows. It is the root mean-square deviation of all data points from the area defined as the Test mask referenced to the shape fit to the reference area.

rms Cyl Residual



rms Cyl Residual (root-mean-square Cylinder Residual) is the residual rms of the test part after cylinder is removed. This result provides a variation of the rms result without changing the Remove control. It is the rms of the test part that is left once the designated surface is removed. The rms Cyl Residual result should match the rms result if cylinder is already removed with the Remove control.

ABS Geometry Applications. The rms of the ABS after a cylinder (Cyl) shape is removed from the data.

Rms Peak Area

Advanced Texture Application. The root-mean-square area of all peaks included in the peak analysis.

Rms Peak Height

Advanced Texture Application. The root-mean-square height of all peaks included in the peak analysis.

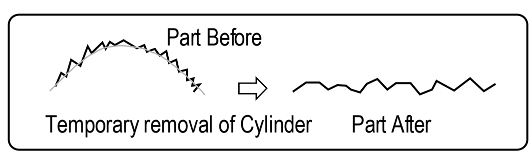
Rms Peak Mean Height

Advanced Texture Application. The root-mean-square mean height of all peaks included in the peak analysis. Mean height is the average value of all pixels in the peak area.

Rms Peak Slope

Advanced Texture Application. The root-mean-square slope of all peaks included in the peak analysis. Slope is based on the four pixels surrounding the highest point in the peak.

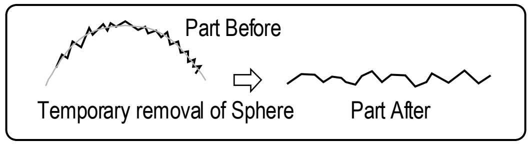
rms Pln Residual



rms Pln Residual (root-mean-square Plane Residual) is the residual rms of the test part after Plane is removed. This result provides a variation of the rms result without changing the Remove control. It's the rms of the test part that is left once the designated surface is removed. The rms Pln Residual result should match the rms result if plane is already removed with the Remove control.

ABS Geometry Applications. The rms of the ABS after a plane (Pln) shape is removed from the data.

rms Sph Residual



rms Sph Residual (root-mean-square Sphere Residual) is the residual rms of the test part after Sphere is removed. This result provides a variation of the rms result without changing the Remove control. It's the rms of the test part that is left once the designated surface is removed. The rms Sph Residual result should match the rms result if sphere is already removed with the Remove control.

ABS Geometry Applications. The rms of the ABS after a sphere (Sph) shape is removed from the data.

Rms Summit Height

Advanced Texture Application. The root-mean-square height of all summits included in the summit analysis.

Rms Summit Mean Height

Advanced Texture Application. The root-mean-square mean height of all summits included in the summit analysis. Mean height is the average value of all pixels in one summit area.

Rms Summit RadCurv

Advanced Texture Application. The root-mean-square radius of curvature of all summits included in the summit analysis. Radius of curvature is based on the four adjacent pixels to the summit.

Rms Summit Slope

Advanced Texture Application. The root-mean-square slope of all summits included in the summit analysis. Slope is based on the four pixels surrounding the highest point in the summit.

Rms Valley Area

Advanced Texture Application. The root-mean-square area of all valleys included in the valley analysis.

Rms Valley Height

Advanced Texture Application. The root-mean-square valley of all valleys included in the valley analysis.

Rms Valley Mean Height

Advanced Texture Application. The root-mean-square mean height of all valleys included in the valley analysis. Mean height is the average value of all pixels in the valley area.

Rms Valley Slope

Advanced Texture Application. The root-mean-square slope of all valleys included in the valley analysis. Slope is based on the four pixels surrounding the lowest point in the valley.

RMSa

Residual rms from the best fit AAS (Approximating Aspheric Surface) after best fit plane and sphere are subtracted. A version of rms error. Part of the ISO figure specification (ISO 10110-5).

RMSi

Residual rms from the best fit sphere after best fit plane is subtracted. A version of RMS error. Part of the ISO figure specification (ISO 10110-5).

RMSt

Residual rms from the best fit plane. A version of RMS error. Part of the ISO figure specification (ISO 10110-5).

Rolloff

ABS Geometry Applications. Another name for Trailing Edge Height. See Trailing Edge Height.

Rpk

Advanced Texture Application. Reduced peak height. The top portion of the surface that will be worn away in the run-in period. Part of the bearing ratio analysis. See Mr1.

Rq

Advanced Texture Application. The root-mean-square deviation of all points from a plane fit to the test part surface. Also known as rms.

RSI

Rotationally Symmetric Irregularity (RSI) is the tolerance on the rotationally symmetric component of the surface form error after the best fit sphere is subtracted. It is the PV of the Approximating Aspheric Surface (AAS). Part of the ISO figure specification (ISO 10110-5).

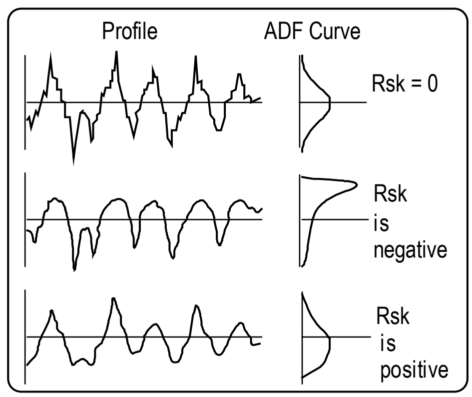
Rsk

Rsk or skewness is a measure of the symmetry of the profile about the center line. It will distinguish between asymmetrical profiles of the same Ra and rms.

$$Rsk = \frac{1}{n(R_q)^3} \sum_{i=1}^{i=n} (Y_i)^3$$

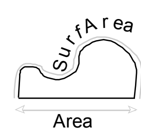
Where n is the number of data points Y_i in the profile and R_q is the root-mean-square roughness.

Negative skew, often specified from -1.6 to -2.0, is used as a criterion for a good bearing surface. Positive skew is sometimes specified for electrical contacts.



RSurfArea

Advanced Texture Application. The surface area of the roughness data. The surface area of the surface including the effects of height variations. This is always greater than or equal to “RArea”.

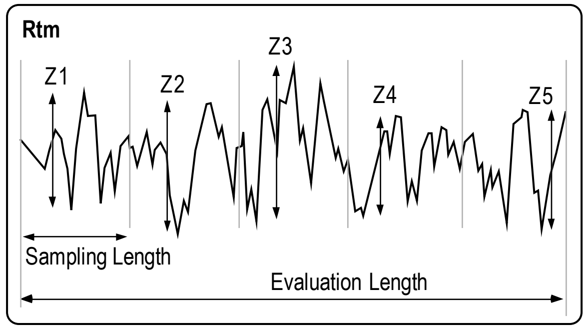


RSurfAreaRatio

Advanced Texture Application. The surface area ratio of the roughness data. Equal to (RSurfArea/RArea) -1.

Rtm

Rtm is the average peak-to-valley roughness determined by the difference between the highest peak and the lowest valley within multiple samples in the evaluation area. In profile data, as shown here, Rtm is based on 5 sampling lengths within the evaluation length. In map data, Rtm is based on 9 sampling areas within the three dimensional evaluation area.



$$Rtm = \frac{(Z1 + Z2 \ldots Zn)}{n}$$

Where Zx is the difference between the highest peak and lowest valley within one sample and n is the number of samples (5 or 9).

Rvk

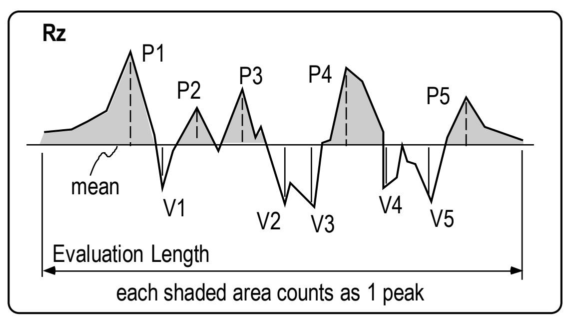
Advanced Texture Application. Reduced valley depth. The lowest part of the surface that retains the lubricant. Part of the bearing ratio analysis. See Mr1.

RVolume

Advanced Texture Application. The volume of the roughness data as specified by the Volume Type control. Part of the bearing ratio analysis.

Rz

Rz is the average distance between the five highest peaks and the five deepest valleys within the evaluation length measured from a line parallel to the center line. Rz is also known as the 10 point height parameter.

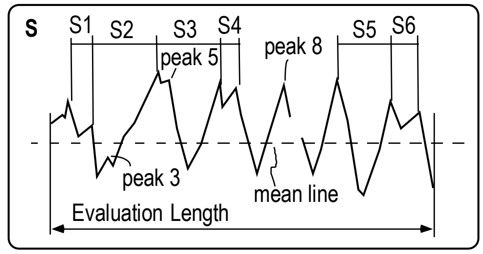


$$Rz = \frac{(P1 + P2 + P3 + P4 + P5) - (V1 + V2 + V3 + V4 + V5)}{5}$$

Where: Px is the peak distance and Vx is the valley distance.

For profile data, a peak is defined as the portion of a surface above the mean line and between center line crossings. For map data, a peak is defined as any island of data protruding up through a plane at the mean of the data. The result is blank if there are not enough peaks and valleys in the data to calculate Rz.

S



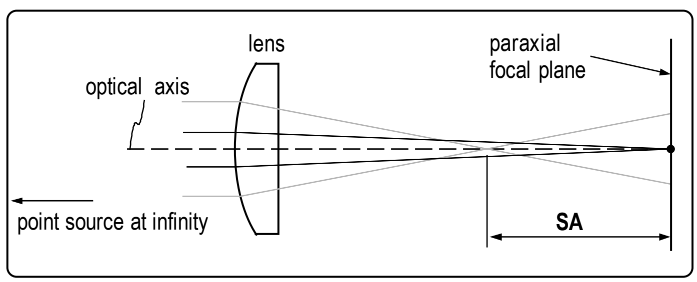
S is the average spacing between local peaks over the evaluation length. A local peak is the highest point between two adjacent minima. A peak is included only if the vertical distance between the peak and its preceding minima is at least 1% of the Rt (the vertical distance from the highest peak to the lowest valley).

S is calculated by summing the peak spacings (horizontal distances between the adjacent local peaks) and dividing by the number of peak spacings. If there are three or more consecutive bad data points, the peak spacing is not included.

In the example above, S is calculated from six peak spacings. Note that peak 3 and peak 5 are not used in the peak spacing because the vertical distance from their preceding minima are less than 1% Rt. Peak 8 is neglected because of bad data points before its seceding peak. S for the above example is calculated by:

$$S = \frac{S_1 + S_2 + S_3 + S_4 + S_5 + S_6}{6}$$

SA (Z)



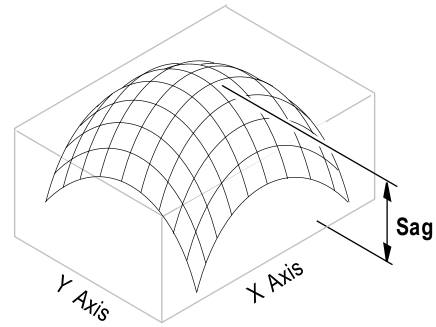
SA (Z) (Spherical Aberration based on Zernikes) is a third order wavefront aberration; it is the failure of a lens or lens system to form a perfect image of a point source axial object. When rays from a point on the axis passing through the outer lens zones are focused closer to the lens than rays passing the central zones, the lens has negative spherical aberration; if the outer zones have a longer focal length than the inner zones, the lens has positive spherical aberration.

$SA = 6.0(z8)$ Where z8 is the 8th Zernike term.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display this result.

Sag

Sag is a measure of the curvature of the surface or wavefront without distinguishing between the X and Y dimensions. It is equivalent to the height difference between the center point and the point farthest from the center. The Sag result is derived from a best fit cylindrical surface.



The equations used are:

$$Z(X,Y) = C0 + (C1 \times X) + (C2 \times Y) + (C3 \times X \times Y) + \left(C4 \times X^2\right) + \left(C5 \times Y^2\right)$$

$$Sag = -\frac{(C4 + C5)}{2} \times R^2$$

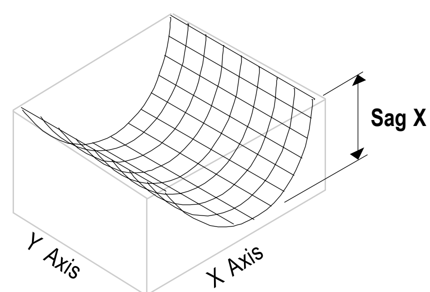
Where: Cx are coefficients derived by fitting the surface, and R is the radius or the distance between the center point and the point farthest from the center.

Sag is negative for a concave surface and positive for a convex surface. The Sag result is intended for measuring circular regions (normally optical components). It may also be used to measure square regions. The Sag result is incorrect when measuring regions of other outlines. Sag is not very meaningful for a surface of arbitrary outline or orientation.

Sagitta error (SAG) is the tolerance on the power or focus of the surface with respect to a reference sphere with the nominal radius of curvature. Part of the ISO figure specification (ISO 10110-5).

Sag X

Sag X is a measure of the curvature of the surface or wavefront in the X dimension only. The Sag X result is derived from a best fit cylindrical surface. Sag X is negative for a concave surface and positive for a convex surface.



The equations used are:

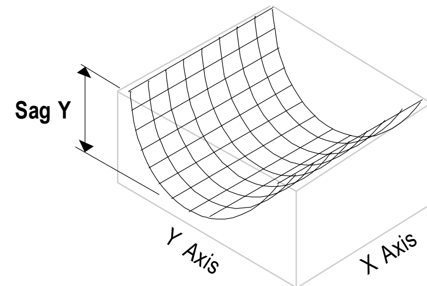
$$Z(X,Y) = C0 + (C1 \times X) + (C2 \times Y) + (C3 \times X \times Y) + \left(C4 \times X^2\right) + \left(C5 \times Y^2\right)$$

$$Sag\ X = -C4 \times R^2$$

Where: Cx are coefficients derived by fitting the surface, and R is the radius of the region in the X dimension (it is not the same R used for Sag).

Sag Y

Sag Y is a measure of the curvature of the surface or wavefront in the Y dimension only. The Sag Y result is derived from a best fit cylindrical surface. Sag Y is negative for a concave surface and positive for a convex surface.



The equations used are:

$$Z(X,Y) = C0 + (C1 \times X) + (C2 \times Y) + (C3 \times X \times Y) + (C4 \times X^2) + (C5 \times Y^2)$$

$$\text{Sag Y} = -C5 \times R^2$$

Where: Cx are coefficients derived by fitting the surface, and R is the radius of the region in the Y dimension (it is not the same R used for Sag).

Scan

Displays the length and type of scan used during the measurement. Applies only to a scanning microscope. Attribute only.

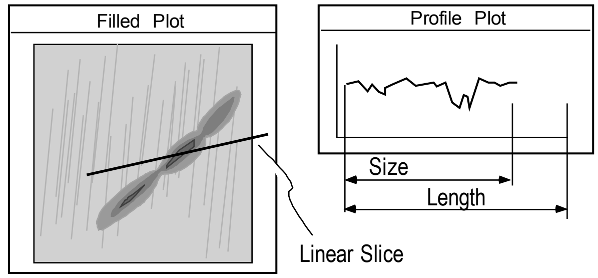
Scan Focus Camera Res

Displays the effective pixel spacing of data obtained during a scanning auto focus or tilt operation. Attribute only.

Shape RMS

Disk Flatness Application. Root mean square deviation of the disk's surface from a reference surface. Since this result is calculated after the Remove function, remove plane from the surface by selecting the Remove control in the Analyze 2 window. The system can report total indicated runout as the deviation from the best fit plane, sphere, or cylinder depending on the selected setting. You must know which surface was fit in order to judge the calculated results properly.

Size

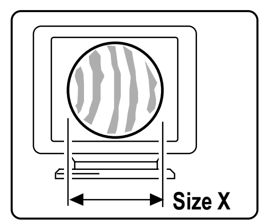


Size is the extent or length of the valid data points of a linear slice. The Size result is similar to Length, however, Length is the dimension of the slice, which can be larger than the dimension of the actual data.

Size is applicable to only profile data windows, it should not be confused with Size X and Size Y, which are applicable to map data windows and have nothing to do with slicing. The Size result is inappropriate, unless there is a linear slice drawn on a Filled plot. If you ask for the Size of a circular slice, the result is blank.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

Size X



Size X is the dimension of the data set in the x-axis of the Video Monitor screen.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

Size X (All)

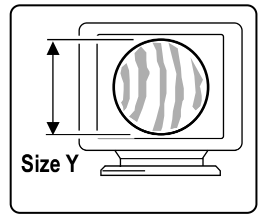
Size X (All) is a special case result available only in Test+Reference data windows. Usually in this data window, just the defined test area is used for results; but in this case, the result applies to the whole data set, both to the test and reference areas. In the Test+Reference data window, Size X (without All) applies to only the test area. The test and reference areas are defined with the Mask Editor.

Size X (Test)

PTR Applications. The dimension of the data in the x-axis as defined by the PTR test mask.

Size Y

Size Y is the dimension of the data set in the y-axis of the Video Monitor screen.



The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

Size Y (All)

Size Y (All) is a special case result available only in Test+Reference data windows. Usually in this data window, just the defined test area is used for results; but in this case, the result applies to the whole data set, both to the test and reference areas. In the Test+Reference data window, Size Y (without All) applies to only the test area. The test and reference areas are defined with the Mask Editor.

Size Y (Test)

PTR Applications. The dimension of the data in the y-axis as defined by the PTR test mask.

Ski Jump 1

ABS Geometry Applications. The highest data point in the ski jump analysis along slice one.

Ski Jump 2

ABS Geometry Applications. The highest data point in the ski jump analysis along slice two.

Slide Distance

Radius Scale Application. Shows the actual distance the mount holding the optic traveled between the confocal and cat's eye positions.

Slider Angle

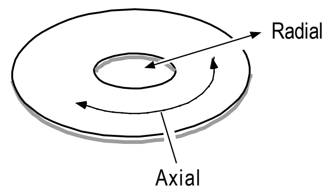
ABS Geometry Applications. Angle of the slider from horizontal (0 degrees). When Slider Type is Two Rails, Three Rails, or TPC, the left edge of the slider is used to determine its rotation. AAB slider types use the top of the slider for alignment. Generic slider types use the setting of the Align To control.

Slope

Advanced Texture Application. The average of the absolute value of the slopes (1st derivatives) in the peak, valley, or summit region. Part of the peaks/valleys and summits Stats table.

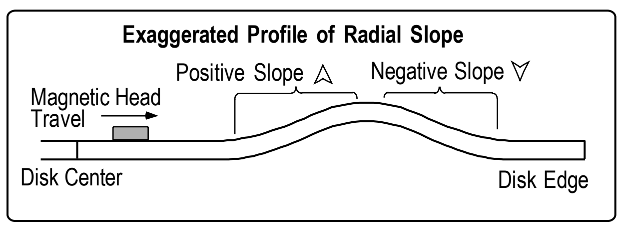
Slope

Disk Flatness Application. The tilt of a surface at any given point on the disk's surface. Slopes are calculated in the axial and radial dimensions as opposed to the X and Y dimensions in standard MetroPro software.

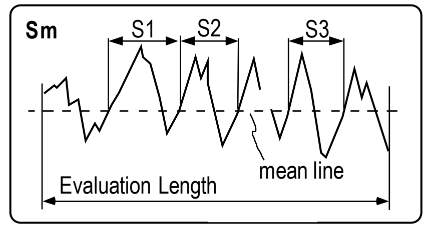


Slope Direction

Disk Flatness Application. The direction of the slope, positive or negative, is determined from the magnetic head's point of view. For radial slopes, the slope direction is specified as if the head were traveling outward from the center of the disk.



Sm



Sm is the average spacing between peaks at the mean line over the evaluation length. A peak is the highest point between an upwards and downwards crossing of a mean line. Sm is calculated by summing the peak spacings (horizontal distances between the upward mean crossings) and dividing by the number of peak spacings. If there are two or more consecutive bad data points before the downward mean line crossing, the peak spacing is not included.

In the example here, Sm is calculated from three peak spacings. The first and last peaks are not included because they don't include complete mean line crossings; the fourth peak is not included because it has missing data points. Sm for the above example is calculated by:

$$Sm = \frac{S_1 + S_2 + S_3}{6}$$

Sphere Radius

Displays the value of the radius of the sphere that was removed. A convex surface has a positive radius. A concave surface has a negative radius. Attribute only.

Sperical Distortion Correction

GPI Application. Identifies whether spherical distortion correction was turned on or off. Attribute only.

Status Msg

Status Message displays the status of the current analysis process. The Status Msg Attribute box is empty if a measurement has not been taken, or if the analysis is complete. Use the Width command in the item's menu to change the size of the Status Msg. Attribute only.

StD Fit Angle

Step Height Application. The standard deviation of all fit angles. It is a measure of the variation of the angles from a mean. The smaller the number, the less the variation. See Avg Fit Step.

StD Fit Step

Step Height Application. The standard deviation of all fit steps. It is a measure of the variation of the heights from a mean. The smaller the number, the less the variation. See Avg Fit Step.

StD Proj Angle L/T

Step Height Application. The standard deviation of all projected angles on the left or top of a step. It is a measure of the variation of the angles from a mean. The smaller the number, the less the variation. See Avg Fit Step.

StD Proj Angle R/B

Step Height Application. The standard deviation of all projected angles on the right or bottom of a step. It is a measure of the variation of the angles from a mean. The smaller the number, the less the variation. See Avg Fit Step.

StD Proj Step L/T

Step Height Application. The standard deviation of all projected step heights on the left or top of a step. It is a measure of the variation of the heights from a mean. The smaller the number, the less the variation. See Avg Fit Step.

StD Proj Step R/B

Step Height Application. The standard deviation of all projected step heights on the right or bottom of a step. It is a measure of the variation of the heights from a mean. The smaller the number, the less the variation. See Avg Fit Step.

StdDevBlendDepth

Edge Blend Application. The standard deviation of all blend depths. It is a measure of the variation of the blend depths from a mean blend depth. The smaller the number, the less the variation.

StdDevBlendLength

Edge Blend Application. The standard deviation of all blend lengths. It is a measure of the variation of the blend lengths from a mean blend length. The smaller the number, the less the variation.

Step Height

Step Height is the height or peak-to-valley measurement of the "current" slice in a corresponding data window Filled plot.

Strehl

Strehl is the ratio of the peak intensity of light in an aberrated point image to the peak intensity of light in an unaberrated point image from a aperture of the same size and shape. It is also known as Strehl Ratio.

Subtracted

Subtracted is an Attribute box which displays the setting of the Subtract control when the measurement or analysis was made.

Summit Density

Advanced Texture Application. The number of summits per unit map area. Part of the summits analysis. Calculated by dividing the number of summits by the map area.

Summit Spacing

Advanced Texture Application. The average distance between summits. Part of the summits analysis. Calculated as the square root of the map area divided by the number of summits.

Summits

Advanced Texture Application. The number of summits included in the analysis. Part of the summits analysis.

Surface Filter

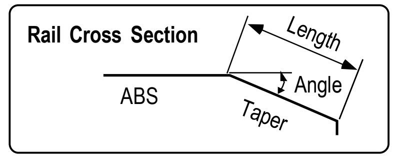
Displays the orientation of the MESA Surface Filter knob when the measurement was made. Attribute only.

Surface Type

Displays the type of surface the ISO results are based on. Part of the ISO 10110-5 window. Attribute only.

Taper Angle

ABS Geometry Applications. The angle of the taper flat relative to the ABS. The Deskew Data control can be used to adjust this result.



Taper Length

ABS Geometry Applications. The average length of tapers on both rails. See Taper Angle.

Taper Length (Raw)

ABS Geometry Applications. The average length of tapers on both rails plus one-half the Taper Cut Thickness. The Taper Cut Thickness control removes pixel rows between the ABS and the taper. This result is an indication of the length of the tapers before they were cut.

TE Distance Angle

ABS Geometry Applications. The average angle of the trailing edge relative to the selected best fit surface to the reference area. TE Distance Location selects the ABS area(s) to use as the reference surface. The TE Distance Fit control determines the surface fit to the ABS. The data between TE Distance Start and TE Distance End is used for the result calculation. When TE Distance Location is Left & Right, the higher of the left and right trailing edge distance angles is reported. TE Distance Start and End must be greater than 0.

TE Distance Height

ABS Geometry Applications. The average height of the trailing edge relative to the selected best fit surface to the reference area. TE Distance Location selects the ABS area(s) to use as the reference surface. The TE Distance Fit control determines the surface fit to the ABS. The data between TE Distance Start and TE Distance End is used for the result calculation. When TE Distance Location is set to Left & Right, the lower of the left and right trailing edge distance heights is reported. Slider Angle (in the field of view) is not accounted for. TE Distance Start and End must be greater than 0.

TE Distance Left Angle

ABS Geometry Applications. When the Trailing Edge Location control is set to Left & Right, this is the average angle of the left trailing edge relative to the left ABS.

TE Distance Left AvgHt

ABS Geometry Applications. When the Trailing Edge Location control is set to Left & Right, this is the average height of the left trailing edge relative to the left ABS.

TE Distance Right Angle

ABS Geometry Applications. When the Trailing Edge Location control is set to Left & Right, this is the average angle of the right trailing edge relative to the right ABS.

TE Distance Right AvgHt

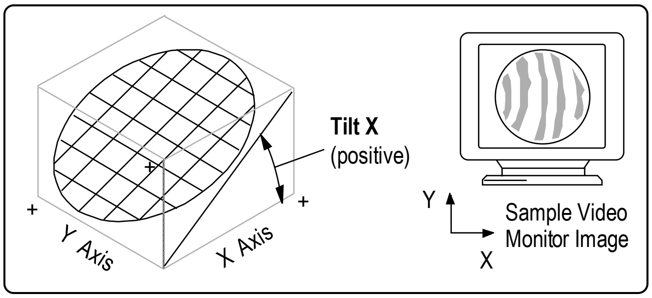
ABS Geometry Applications. When the Trailing Edge Location control is set to Left & Right, this is the average height of the right trailing edge relative to the right ABS.

Test Time (min)

Indicates the elapsed time of the test. Part of the DMI Test window; used with the radius scale option.

Tilt X

Tilt X is the tilt of the part relative to the reference surface in the X direction. Instrument calibration is required for this result.



Tilt X (1)…(6)

Corner Cube Application. The tilt in the x-axis for each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

Tilt X (Ref)

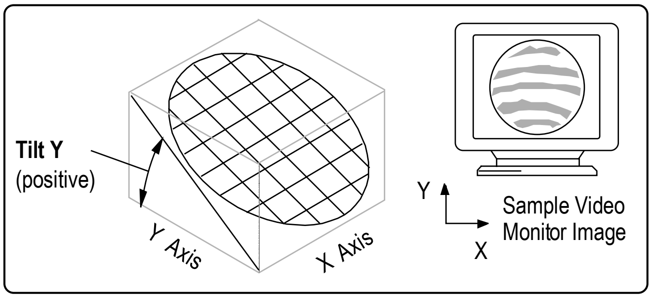
Tilt X (Ref) is the tilt of the part in the X direction of an area defined by a Reference mask. Instrument calibration is required for this result. Used with the Tilt Y (Ref) result as an indicator of instrument null. See Tilt X.

Tilt X (Tst)

Tilt X (Tst) is the tilt of the part relative to the test surface in the X direction. Instrument calibration is required for this result. See Tilt X.

Tilt Y

Tilt Y is the tilt of the part relative to the reference surface in the Y direction. Instrument calibration is required for this result.



Tilt Y (1)…(6)

Corner Cube Application. The tilt in the y-axis for each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

Tilt Y (Ref)

Tilt Y (Ref) is the tilt of the part in the Y direction of an area defined by a Reference mask. Instrument calibration is required for this result. See Tilt Y.

Tilt Y (Tst)

Tilt Y (Tst) is the tilt of the part relative to the test surface in the Y direction. Instrument calibration is required for this result. See Tilt Y.

Time

Displays the date and time of the measurement. The Time Attribute box is empty if a measurement has not yet been taken. When a data file is loaded, the Time box will indicate the date and time of the measurement. Attribute only.

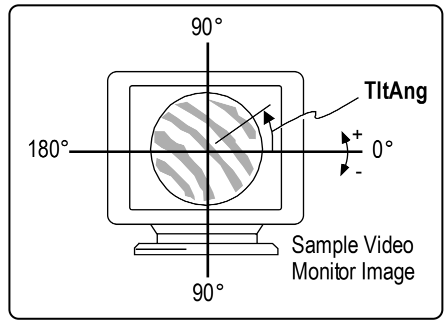
TIR

Disk Flatness Application. Total Indicated Runout; a Peak/Valley result that indicates the difference between the highest and lowest points on the disk's surface relative to a best fit plane.

TltAng

TltAng (Tilt Angle) is the direction of tilt. Visually, this can be seen on the Video Monitor as the direction perpendicular to the fringes. The wavefront is highest at the specified angle. Instrument calibration is required for this result.

$$\text{TltAng} = \text{Tan}^{-1}\left(\frac{\text{Tilt Y}}{\text{Tilt X}}\right)$$



TltAng (1)…(6)

Corner Cube Application. The direction of tilt for each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

TltAng (Ref)

TltAng (Ref) (Tilt Angle Reference) is the direction of tilt in an area defined by a Reference mask. Instrument calibration is required for this result. See TltAng.

TltAng (Z)

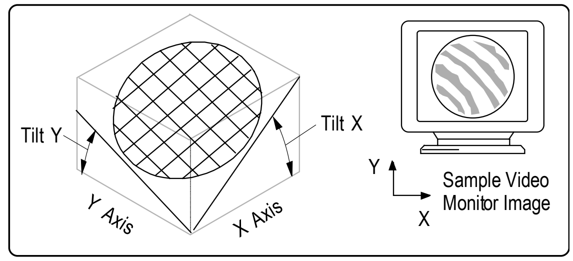
TltAng (Z) (Tilt Angle based on Zernikes) is the direction of tilt. Visually, this can be seen on the Video Monitor as the direction perpendicular to the fringes. TltAng (Z) is typically expressed in degrees and is defined over ±180°. The wavefront is highest at the specified angle. See TltAng.

$$\text{TltAng (Z)} = \arctan\left(\frac{\text{y tilt}}{\text{x tilt}}\right)$$

Where: x tilt = z1 - 2.0 (z6) and y tilt = z2 - 2.0 (z7). z6 and z7 are the corresponding Zernike terms.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display the result.

TltMag



$$\text{TltMag} = \sqrt{\text{Tilt X}^2 + \text{Tilt Y}^2}$$

Tilt refers to the angle of inclination between the reference and test beams of the interferometer. If measuring a surface, tilt is the angle between the reference and test surface. If measuring a transmitted wavefront, tilt is the angle of the beam deviated by the optic. It can be thought of as lying in the plane of the reference surface, or the Video Monitor.

Instrument calibration is required for this result.

Typically, Tilt X, Tilt Y, TltAng, and TltMag results compare data within a Test mask to data within a Reference mask and determine the relative tilt between these two areas on the same part. When using masks, the reference area becomes a zero point, the tilt of the test area is compared to it. Without using masks, the tilt results provide the relative tilt of the interferometer cavity, or the incline of the test part to the reference surface. (As long as tilt is not removed with the Remove control.)

TltMag (1)…(6)

Corner Cube Application. The overall tilt for each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

TltMag (Ref)

TltAng (Ref) (Tilt Magnitude Reference) is the overall tilt of the part in both x and y axes in an area defined by a Reference mask. Instrument calibration is required for this result. See TltMag.

TltMag (Z)

TltMag (Z) (Tilt Magnitude based on Zernikes) is the overall tilt of the part in both x and y axes. TltMag (Z) is expressed in angle units (degrees or radians) and is always positive. Tilt refers to the angle of inclination between the reference and test beams of the interferometer. If measuring a surface, tilt is the angle between the reference and test surface. If measuring a transmitted wavefront, tilt is the angle of the beam deviated by the optic. It can be thought of as lying in the plane of the reference surface, or the Video Monitor. See

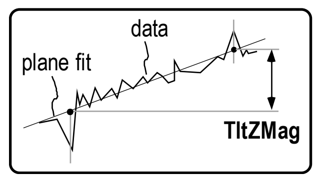
$$\text{TltMag (Z)} = \sqrt{\text{xtilt}^2 + \text{ytilt}^2}$$

Where xtilt = z1 - 2.0 (z6) and ytilt = z2 - 2.0 (z7). z6 and z7 are the corresponding Zernike terms.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display the result.

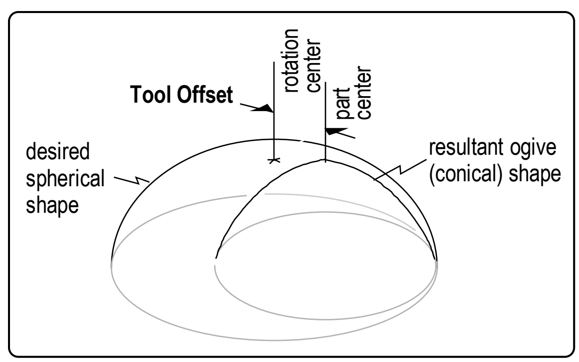
TltZMag

The PV of the plane, fit to the data in the direction of the tilt angle, using the furthest X and Y extent of the data. It is similar to the maximum difference in the Z axis of the data with the noise eliminated. TltZMag is a special case result only available in Test+Reference Data windows; it refers to the whole data set, both the test and reference areas.



Tool Offset

The lateral distance from the physical center of the part to the center of the curve of the arc of the cutting tool, along the horizontal axis of the part. Also known as “ogive”.



Tool Offset is the horizontal decentration, which will actually alter the overall figure of the part. When there is vertical decentration, the tool is denied access to the central region of the spherical part; it does not affect the surface figure significantly. Tool Offset is concerned only with horizontal decentration.

Top of Poles Offset

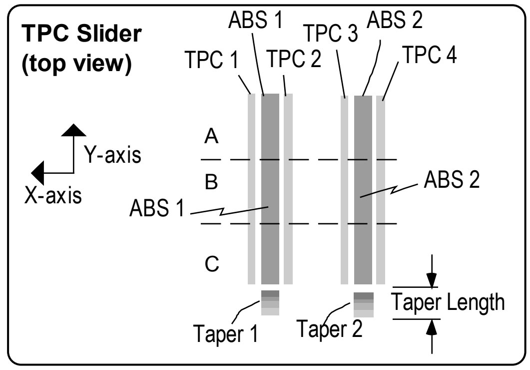
Trimmed PTR Application. The lateral offset between the top of the unetched pole tip and the etched pole area. See ABS Roughness.

Top Pole Width

Trimmed PTR Application. Length (width in x-axis) of the unetched upper pole. See ABS Roughness.

TPC 1 AvgHt

ABS Geometry Applications. The average height between ABS 1 and the TPC 1 step. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider.

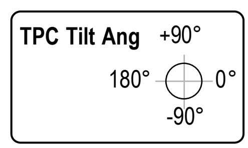


TPC 1 C-A

ABS Geometry Applications. The height difference from one end of TPC 1 step to the other. It is equal to TPC 1C AvgHt minus TPC 1A AvgHt. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1 Tilt Ang

ABS Geometry Applications. The direction of tilt of the TPC step relative to the ABS. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.



TPC 1 Tilt Mag

ABS Geometry Applications. The overall tilt of the TPC step relative to the ABS. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1 Tilt X

ABS Geometry Applications. The tilt of the TPC step relative to the ABS in the x-axis. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1 Tilt Y

ABS Geometry Applications. The tilt of the TPC step relative to the ABS in the y-axis. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1 Width

ABS Geometry Applications. The average width of the TPC 1 step. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1A AvgHt

ABS Geometry Applications. The average height between one rail and one section (A) of the TPC 1 step. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1B AvgHt

ABS Geometry Applications. The average height between one rail and one section (B) of the TPC 1 step. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC 1C AvgHt

ABS Geometry Applications. The average height between one rail and one section (C) the TPC 1 step. TPC 2, TPC 3, and TPC 4 results are similar, but apply to different areas of the slider. See TPC 1 AvgHt.

TPC AvgHt

ABS Geometry Applications. The average height between a plane fit to both ABS surfaces and a plane fit to all TPC steps.

Wall Angle Application. The average height between a plane fit to the ABS and a plane fit to both TPC steps. See ABS Width.

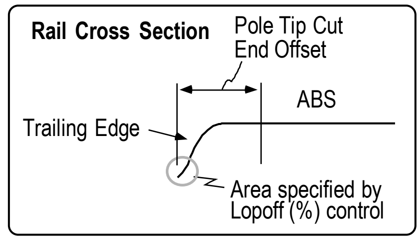
Track Width at Gap

Trimmed PTR Application. The width of the etched pole gap in the X-axis. See ABS Roughness.

Trailing Edge Angle

ABS Geometry Applications. The average angle of the trailing edge relative to the best fit selected surface to the ABS. The Trailing Edge Fit control determines the surface fit to the ABS. When Trailing Edge Location is Left & Right, the higher of the left and right trailing edge angles is reported. Pole Tip Cut End Offset must be greater than 0. See Trailing Edge Height.

Trailing Edge Height



ABS Geometry Applications. The average height of the trailing edge relative to the selected best fit surface to the reference area. Trailing Edge Location selects the ABS area(s) to use as the reference surface. The Trailing Edge Fit control determines the surface fit to the ABS. Lopoff (%) specifies how much of the data to use in the calculation. When Trailing Edge Location is set to Left & Right, the lower of the left and right trailing edge heights is reported. Pole Tip Cut End Offset and Lopoff (%) must be greater than 0. Slider Angle (in the field of view) is not accounted for.

Trimmed

Displays the number of pixel layers removed from the data set during analysis. The number in the black Trimmed attribute box should match the number in the Trim control, except when saved data sets are loaded or when the Trim value has been changed but the data set not reanalyzed. Attribute only.

Twist

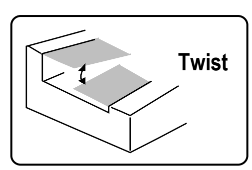
The amount that a cylindrical part is not aligned in the x and y axes. It is also called "fan" by opticians because of the characteristic fan-shaped fringes. Used when measuring cylindrical parts. The equations used are:

$$Z(X,Y) = C_0 + C_1X + C_2Y + C_3X^2 + C_4Y^2 + C_5XY$$

$$Twist = C_5R^2$$

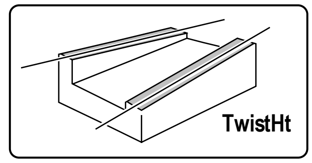
Where Cx are coefficients derived by fitting the surface and R is the radius.

ABS Geometry Applications. The tilt between the outer rails in the same direction as Crown. The Deskew Data control can be used to adjust this result.



TwistHt

ABS Geometry Applications. The greatest deviation along the rails between planes fitted to the outer rails. The Deskew Data control can be used to adjust this result.



TwistHt (Coef)

ABS Geometry Applications. Twist height using the following calculation:

TwistHt (Coef) = (-width) * length * xyCoefficient

Where width is the ABS data width or the Nominal Width if specified, length is the ABS data length or the Nominal Length if specified, and xyCoefficient is the xy coefficient of a cylindrical fit to the ABS data. The Deskew Data control can be used to adjust this result. The Deskew Data control can be used to adjust this result.

Undershoot Trim Depth Bottom

PTR Applications. Undershoot Trim Depth Bottom. Average height of the trimmed area on the bottom of the pole tips. See PTD L&R.

Undershoot Trim Depth T&B

PTR Applications. Undershoot Trim Depth Top & Bottom. Average height of the top and bottom pole tip trimmed areas. See PTD L&R.

Undershoot Trim Depth Top

PTR Applications. Undershoot Trim Depth Top. Average height of the trimmed area on the top of the pole tips. See PTD L&R.

Upper PTR (%)

PTR Application. The average recession of the highest points from the ABS in the entire pole area. The Upper PTR (%) control specifies the percentage used in the calculation.

Upper PTR (%) 1

PTR Applications. The average recession of highest points from the ABS in the top pole tip, as specified by the Upper PTR (%) 1 control. If the result is blank, the software could not separate the pole tip.

Upper PTR (%) 2

PTR Applications. The average recession of highest points from the ABS in the middle pole tip, as specified by the Upper PTR (%) 2 control. If the result is blank, the software could not separate the pole tip.

Upper PTR (%) 3

PTR Applications. The average recession of highest points from the ABS in the bottom pole tip, as specified by the Upper PTR (%) 3 control. If the result is blank, the software could not separate the pole tip.

V Angle

Disk Flatness Application. The angle at which the valley (for the quadrant) occurs, referenced to the zero position. See P Angle.

V1 (Volume 1)

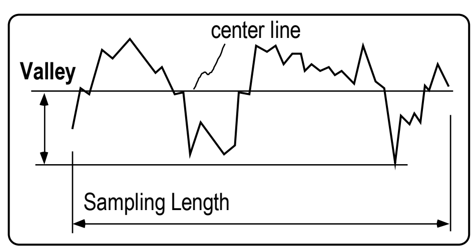
Advanced Texture Application. This result describes the friable area of the surface that could wear off. When manufacturers try to predict the wear dimension(or the bearing area of a surface), this parameter is used to estimate how the surface will change from the existing “as machined” surface.

V2

Advanced Texture Application. Volume 2. This is the valley distribution that predicts the volume of liquid that could be put in this region of the surface.

Valley

Valley is the maximum depth between the center line and the lowest valley within the sample. The center line is defined as the best fit surface selected with the Remove Control box. Valley is the value of the lowest data point. It is also known as R_V.



Valley (1)…(6)

Corner Cube Application. The lowest point of each of the six sectors when using a single pass setup, or only sectors 1 through 3 when using the double pass setup.

Valley (All)

Valley (All) is available only in Phase Test+Reference Data windows. It is the lowest point in the area defined by the both the reference and test areas. The test and reference areas are defined with the Mask Editor.

Valley (Ref)

Valley (Ref) is available only in Test+Reference data windows. It is the lowest point in the area defined by the Reference mask.

Valley (Test)

Valley (Test) is available only in Test+Reference data windows. It is the lowest point in the area defined by the Test mask.

Valley Area

Advanced Texture Application. The total area of all the valleys. Part of the peaks/valleys analysis.

Valley Density

Advanced Texture Application. The number of valleys per unit area. Part of the peaks/valleys analysis. Calculated by dividing the number of valleys by the map area.

Valley Loc X

The x-axis location in camera coordinates of the lowest point in a profile. Profile data only.

Valley Loc Y

The y-axis location in camera coordinates of the lowest point in a profile. Profile data only.

Valley Spacing

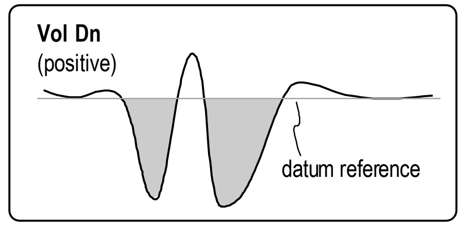
Advanced Texture Application. The average distance between valleys. Part of the peaks/valleys analysis. Calculated as the square root of the map area divided by the number of valleys.

Valleys

Advanced Texture Application. The number of valleys included in the analysis. Part of the peaks/valleys analysis.

Vol Dn

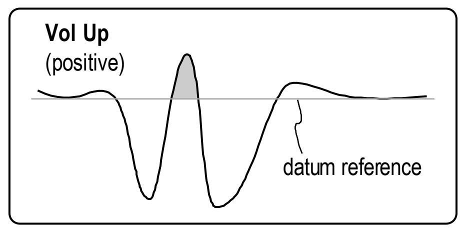
Volume Down is the volume of the test area which is lower than the reference area. Positive Vol Dn can be thought of as the space occupied by pits on the test area; a negative Vol Dn result would protrude above the reference area. See Vol Net.



For proper results, Test and Reference masks must be previously defined with the Mask Editor. Instrument calibration is required for this result.

Vol Up

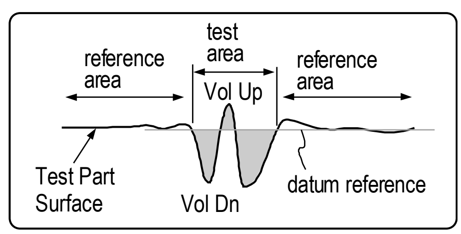
Volume Up is the volume of the test area which is higher than the reference area. Positive Vol Up can be thought of as the space occupied by bumps on the test area; a negative Vol Up result would extend below the reference area. See VolNet.



For proper results, Test and Reference masks must be previously defined with the Mask Editor. Instrument calibration is required for this result.

VolNet

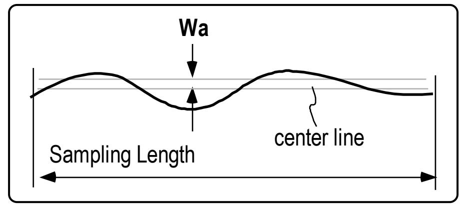
VolNet is the overall volume of the test area. It is equal to the Vol Up minus the Vol Dn. For proper results, Test and Reference masks must be previously defined with the Mask Editor. Instrument calibration is required for this result.



The Vol Up, Vol Dn, and VolNet results require Test and Reference masks to be defined. The reference area defined by the Reference mask establishes a datum reference from which the volume is calculated. The datum reference is derived from a best fit surface to the Reference mask. Volume is the amount of space occupied by the data in the three dimensional test area defined by the Test mask. Volume is calculated by finding the height of each data point multiplied by the area of the pixel.

Wa

Advanced Texture Application. The average surface height, or average deviation, of all points from a plane fit to the waviness data.



Wall Angle

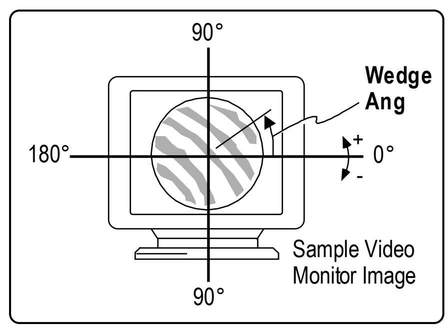
Trimmed PTR Application. The wall angle of the unetched pole tip to the etched area. See ABS Roughness.

WArea

Advanced Texture Application. The planar area occupied by the waviness data excluding the effects of height variations.

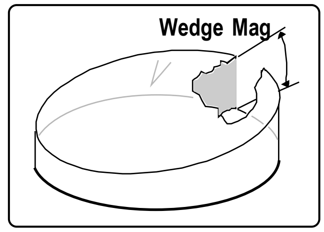
Wedge Ang

Wedge Ang (Angle) is the direction of the wedge. Visually, this can be seen on the Video Monitor as the direction perpendicular to the fringes. The part is thickest at the specified angle. Wedge Ang is typically expressed in degrees and is defined over ±180°. Instrument calibration and an entry in the Refractive Index control are required for this result. See Wedge Mag.



Wedge Mag

Angle Measurement Application. Wedge Mag (Magnitude) is the overall wedge or non-parallelism in the optic. Wedge Mag is a positive number expressed in angle units (degrees or radians). A wedge optical component is an optical element having plane-inclined surfaces. Usually the angle between the faces are inclined toward one another at a very small angle. Instrument calibration and an entry in the Refractive Index control are required for this result.



Wedge X, Wedge Y, Wedge Ang, and Wedge Mag results require the use of Test, Reference, and Acquisition masks. The Test mask is defined as the fringe area of the part; the Reference mask is defined as the surrounding fringe area of the reference flat; and the Acquisition mask is defined as the areas incorporated by the Test and Reference masks. To derive the wedge results, data within the Test mask is compared to data within the Reference mask.

$$\text{Wedge Mag} = \frac{\text{TltMag}}{n - 1}$$

Where n is the refractive index.

Wedge X

Wedge X is the wedge in the part in the X direction; it is a component of Wedge Mag. Wedge X is expressed in angle units (degrees or radians) and can be either positive or negative. Instrument calibration and an entry in the Refractive Index control are required for this result.

$$\text{Wedge X} = \frac{\text{Tilt X}}{n - 1}$$

Where n is the refractive index.

Wedge Y

Wedge Y is the wedge in the part in the Y direction; it is a component of Wedge Mag. Wedge Y is expressed in angle units (degrees or radians) and can be either positive or negative. Instrument calibration and an entry in the Refractive Index control are required for this result.

$$\text{Wedge Y} = \frac{\text{Tilt Y}}{n - 1}$$

Where n is the refractive index.

Width

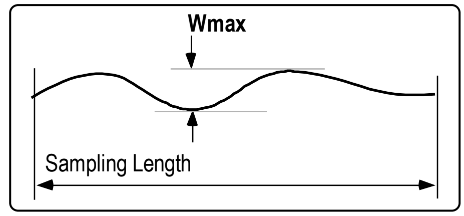
ABS Geometry Applications. The average width along all horizontal slices of valid data.

Within Field Pattern Position

Displays a position within a pattern sequence. Attribute only.

Wmax

Advanced Texture Application. The maximum height of the waviness data. Also known as Wy.

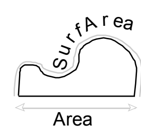


Wq

Advanced Texture Application. The root-mean-square deviation of all points from a plane fit to the waviness data.

WSurfArea

Advanced Texture Application. The surface area of the waviness data. The surface area of the surface including the effects of height variations. This is always greater than or equal to “WArea”.



WSurfAreaRatio

Advanced Texture Application. The surface area ratio of the waviness data. Equal to (WSurfArea/WArea) -1.

X

Advanced Texture Application. The camera X coordinate location of the highest point in peak region, the lowest point in a valley region, or the central point in a summit. Part of the peaks/valleys and summits Stats table.

Y

Advanced Texture Application. The camera Y coordinate location of the highest point in peak region, the lowest point in a valley region, or the central point in a summit. Part of the peaks/valleys and summits Stats table.

Zernike Sampled

Displays the number selected in the Zernike Sample control during the analysis. Attribute only.

Filled Plot and Profile Plot

Section

4

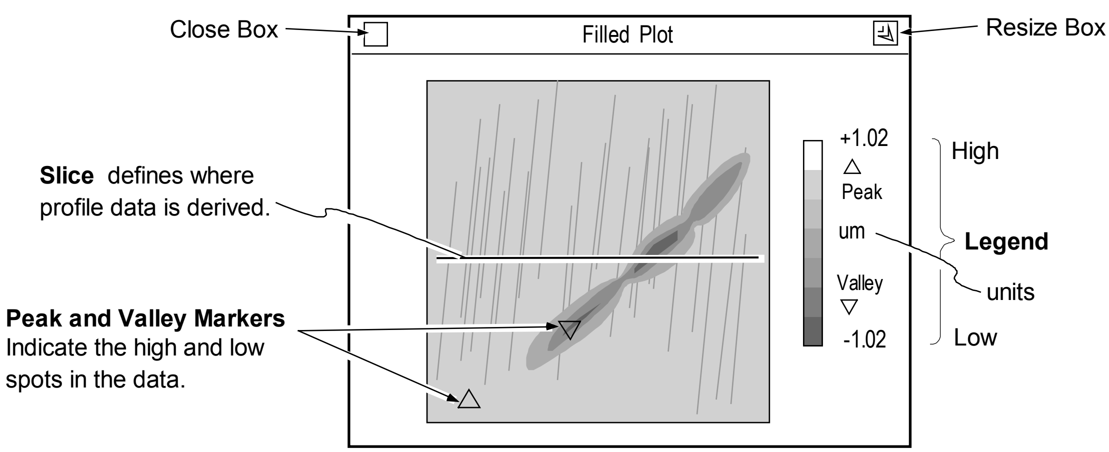
The two most common plots are the Filled Plot and the Profile Plot; they work in tandem.

The Filled plot shows a topographical contour map of the test part surface, providing dimensional information in three axes. The Profile Plot shows data along a slice through a corresponding Filled Plot, providing two dimensional information. The slice may be straight or circular and can be positioned anywhere over the Filled Plot.

Filled Plot

A Filled plot shows different heights in different colors, like a geographical contour map. Technically speaking, it displays surface data as a function of the magnitude as viewed along the instrument's z-axis. Areas with different magnitudes, or height, are represented by different colors, or in a one color plot as different shades. The Filled plot is also used to define slices.

Filled Plots are created in a data window using the New Plot → command. To open the plot Controller, click on the plot with the middle mouse button.



The Filled Plot's Controller

Open the plot controller by positioning the pointer over the filled plot and clicking the middle mouse button.

Buttons: described below.
To activate a button, position the pointer on the button and click the left mouse button.

Hilite Tool: Refer to section later in this chapter.

Z-Axis Fixed Scale Tool: Refer to section later in this chapter.

Specifies the width of the slice. Refer to section later in this chapter.

Used with Circ Ctr and Circ MinPV slice types. Creates a slice of specified radius, centered appropriately. Refer to section later in this chapter.

Filled Plot Controller Buttons

Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the "set" Controller settings.

Set - Makes the current Controller settings the master or "set" display.

Color - Selects the color of the plot. Choices: Bands (15 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum (48 colors), and Neon (a variation of Spectrum).

Hilite - Adds bright green highlights to grey plot contours. Only functional when the Color button set to Greys. HiliteOff turns off highlighting and the hilite tool is disabled. HiliteBar highlights data based on the setting of the hilite tool. HiliteTop highlights data above the hilite tool's setting. HiliteBtm highlights data beneath the hilite tool's setting.

For more information, see "Using the Filled Plot's Hilite Tool".

Limit - Determines if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off displays no limits in the plot. *Note:* To display limits in the plot, high limits must be set in a PV Result box in the same data window.

For more information, see "Displaying Limits in the Filled Plot".

Slice - Selects the type of slice you can draw on the Filled plot. Slice Off turns slicing off.

For other selections, see "Slicing the Filled Plot".

Zoom - Determines how the plot is drawn. When on, the plot fills as much of the window as possible. When off, data is displayed relative to its camera position.

Legends - When on, displays a color key and scale to the right of the plot. The scale denotes magnitude.

ShowPV - When on, marks the highest and lowest points on the plot with triangles.

Note: Not all plot Controllers for Filled plots are identical. For example, an MTF Filled plot Controller is not identical to a phase Filled plot Controller, though both are Filled plots. The MTF Filled plot Controller contains a subset of the features of the Filled plot Controller. The full-featured Filled plot Controller is described herein.

Opening the Plot Controller

1. Position the pointer on the plot window and press the middle mouse button.
2. If this is the first time the controller opened, an outline of the Controller appears. Drag the mouse to position the Controller and release the mouse button. The Controller appears when you let go of the mouse.

Using the Plot Controller

All plot Controller buttons are activated by positioning the pointer over the button and clicking the left mouse button. If there are several choices to a button, repeat click the mouse to cycle through the selections. Click the right mouse button to cycle through choices in the opposite direction. The general procedure is:

1. Click the plot Controller button(s). Some actions occur immediately, others require updating.
2. If necessary, update the plot by clicking the Update button.
3. Store new plot Controller settings by clicking the Set button.

   Note: When a measurement is taken or data is loaded, the plot Controller settings revert or reset to the stored settings.
4. Make other temporary modifications to the plot using the Controller. Revert the Controller settings back to the stored settings by clicking the Reset button.

Permanently Saving Plot Settings

1. After you have changed the plot display with the Controller, you can save these settings by clicking the Set button with the left mouse button. This temporarily preserves changes made with the Controller.
2. To permanently preserve changes made to the plot with the Controller, Plot menu, or Resize box, the application must be saved. To save the application, access the Application Window menu and select the Re-save Application command.

Resizing the Filled Plot

When resizing the window, the plot will automatically resize if the size of the window allows the next incremental plot size to fit and the Zoom button is on. There is no interpolation of the camera data in a Filled plot. The plot is displayed at the nearest integer multiple. For example, one camera pixel may equal one pixel on the color monitor; or one camera pixel may equal four pixels on the color monitor.

1. Click the Zoom button so the zoom function is on.
2. Position the pointer on the window Resize box and press the left mouse button; or, if the title bar is hidden, select the Plot menu's Resize command. Then drag the mouse to resize the window and release the mouse button.

Using Colors in the Filled Plot

Click the plot Controller Color button to change the color of the plot. Suggestions regarding choice of colors are:

- Spectrum shows the greatest detail in the center of plotted height values.
- Neon shows the greatest detail near the top and bottom of plotted height values.
- Greys or Golds help you to see slices; Greys must be used for the Hilite tool and to display limits.

Changing the Plot Units

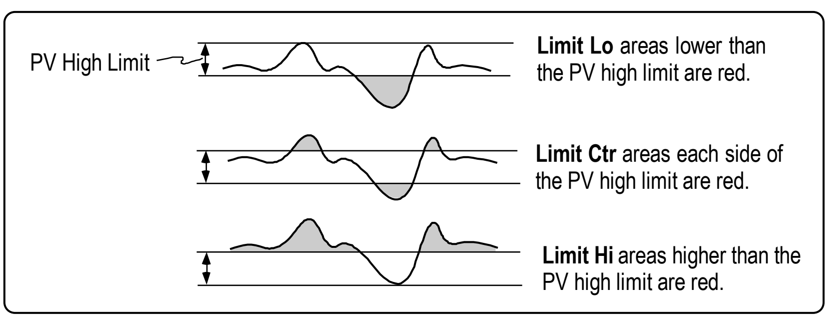
The measurement units for the legend are specified with the Filled Plot menu's Z Units command. The measurement units for the Slice Info box are specified with the Filled Plot menu X-Y Units command. The number of decimal places is set automatically.

Using Peak and Valley Markers

1. Click the plot Controller Show PV button with the left mouse button.
2. Click the Update button. If Legends is on, the legend displays a key to the markers.

Displaying Limits in the Filled Plot

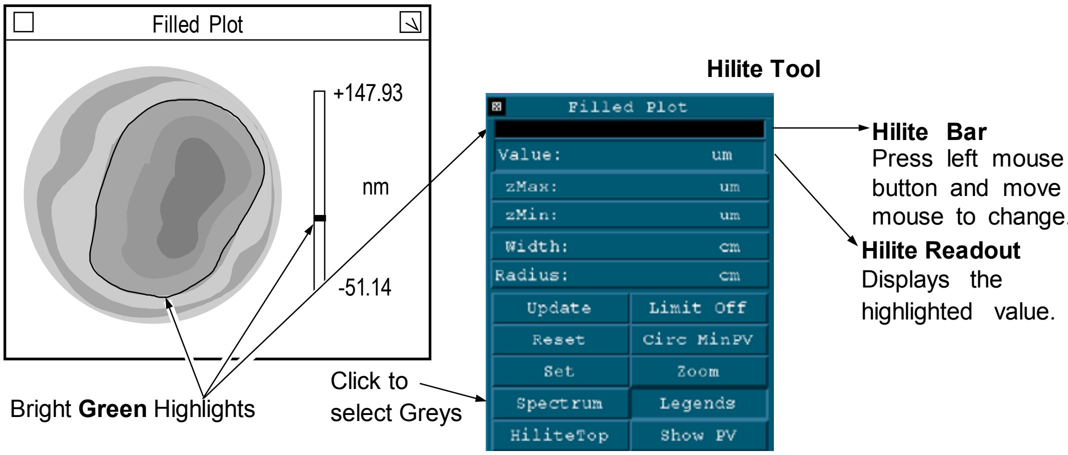
The plot Controller Limit button is used in conjunction with the PV result to display red limits in the Filled plot. The Color button must be set to Greys.



1. Click the plot color to Greys. Click the Limits button to select the limit mode. Then click the Controller's Update button.
2. In the PV result in the same data window, select the Limits → High command from the result's menu. Enter a high limit for the PV result and press [Enter].

Using the Filled Plot's Hilite Tool

The plot Controller Hilite button and the Hilite Tool are used to highlight contours through the Filled plot data. The Color button must be set to Greys.



HiliteBar shows green highlights through the data based on the setting of the hilite bar.

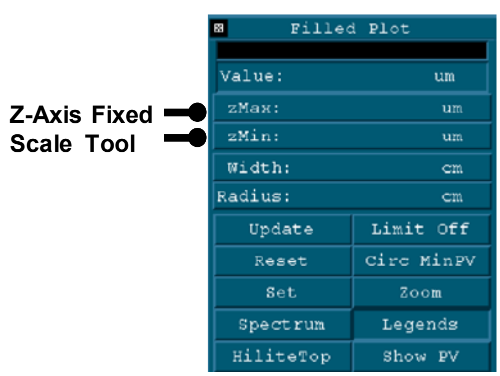
HiliteTop shows green highlights on all data above the position of the hilite bar.

HiliteBtm shows green highlights on all data below the position of the hilite bar.

1. Click the plot color to Greys. Click the Hilite button to select the hilite mode. Then click the Controller's Update button.
2. Position the pointer over the plot Controller Hilite Tool and press the left mouse button. Drag the mouse to move the hilite bar. The corresponding Filled plot and Hilite readout update automatically to the movements of the mouse.

Using the Filled Plot's Z-Axis Fixed Scale Tool

The Fixed Scale Tool enables you to adjust the range (minimum/maxium) values for the display of height data in the filled plot. It is a helpful tool for comparing height data of a similar group of test parts. Use caution with this function as inappropriate values may obscure data by clipping it (height is too small) or compressing it (height is too large). If the plot is blank, it is because the data does not fall within the range of the Z-Axis.



Selecting the Z-Axis Fixed Scale Mode

Position the pointer over the Z-Axis Fixed Scale Tool. Click the right mouse button to change modes.

> **Note:** There must be values entered for this function to operate. Zero (0) is a valid entry.

Entering Values in the Z-Axis Fixed Scale Tool

1. Position the pointer over one of the two boxes in the Z-Axis Fixed Scale Tool.
2. Click the left mouse button, enter a numerica value and pres [Enter]. To erase values, click the left mouse button, delete all characters, the press [Enter].
3. Click the Plot Controller's Update button to redraw the plot.
4. To preserve changes, click the Plot Controller's Set button.

Fixed Scale Mode Combinations

ZMax/ ZMin: Max specifies the upper value. If left blank, ZMax defaults to the peak of the data. Min specifies the lower value. If left blank, ZMin defaults to the valley of the data.

ZMax/ ZRng: Max specifies the upper value. If left blank, ZMax defaults to the peak of the data. Rng specifies the range of the scale. if left blank, the scale expands downward to show the data.

ZMin/ ZRng: Min specifies the lower value. If left blank, ZMin defaults to the valley of the data. Rng specifies the range of the scale. If left blank, the scale expands upward to show the data.

ZCtr/ Rng: Ctr specifies the center of the scale. If left blank, ZCtr defaults to the mean of the data. Rng specifies the range of the scale. If left blank, the scale expands to show the data.

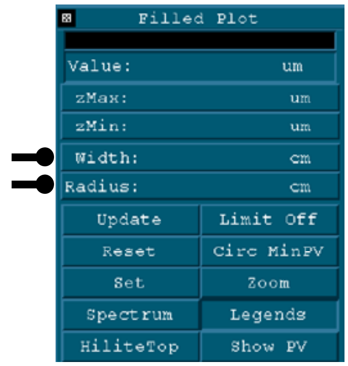
ZMax/ ZRng: Max specifies the upper value. ZMax (blank) defaults to the peak. ZRng (negative) specifies the upper data range to exclude from the plot (when used with ZMax).

Z Min/ ZRng: Min specifies the lower value. ZMin (blank) defaults to the valley. ZRng (negative) specifies the lower data range to exclude from the plot (when used with ZMin).

> **Note:** The Z-Axis Fixed Scale Tool ZRng setting has dual functions. When a positive number is entered, it specifies the overall size of the axis. When a negative number is entered, it invokes an exclude option, which works only with the ZMax and ZMin settings.

Using the Plot Controller's Width and Radius Functions

Width Control



This function is used with the following slice types: Linear, Circular, and Circular Ctr. The typical width of a slice is 1 pixel. A wider slice provides an average of the data over the specified area of interest. The range for a valid entry, in pixels, is from 1 to 320. When entering the value, the current X-Y units for the filled plot are used. The range for a valid entry in real units depends upon the lateral resolution set with the lateral calibration procedure. A label, "Width," and the actual value of the width of the slice appears at the bottom of the filled plot legend. However the slice drawn on the plot does not reflect the width setting.

If multiple slices are drawn, they all use the specified width. The slice width attribute in the Profile Window will be updated. If Lateral Calibration has not been done, the only unit the Slice Width attribute will display in is pixels.

1. With the left mouse button, select either Linear, Circular, or CircCtr as the slice type.
2. Position the pointer over Width and click the left mouse button. Type a value within the valid range and press [Enter]. The Plot Legend will be automatically updated.
3. Draw the slice through the fillled plot.

Note: The width is applied to the slice as follows:
Linear: For each point on the slice, a linear slice normal to the drawn slice is calculated. The length of the normal slice is equal to the value entered in the width control. Each normal slice is centered exactly upon the point at which it is calculated, extending above and below each point on the drawn slice. Each point on the wide slice is the average of the normal slice calculated at that point.
Circular: For each point on the slice, a linear slice radial to the drawn slice is calculated. The length of the radial slice is equal to the value entered in the width control. Each radial slice is centered exactly upon the point at which it is calculated, extending above and below each point on the drawn slice. Each point on the wide slice is the average of the radial slice calculated at that point.

Radius Control

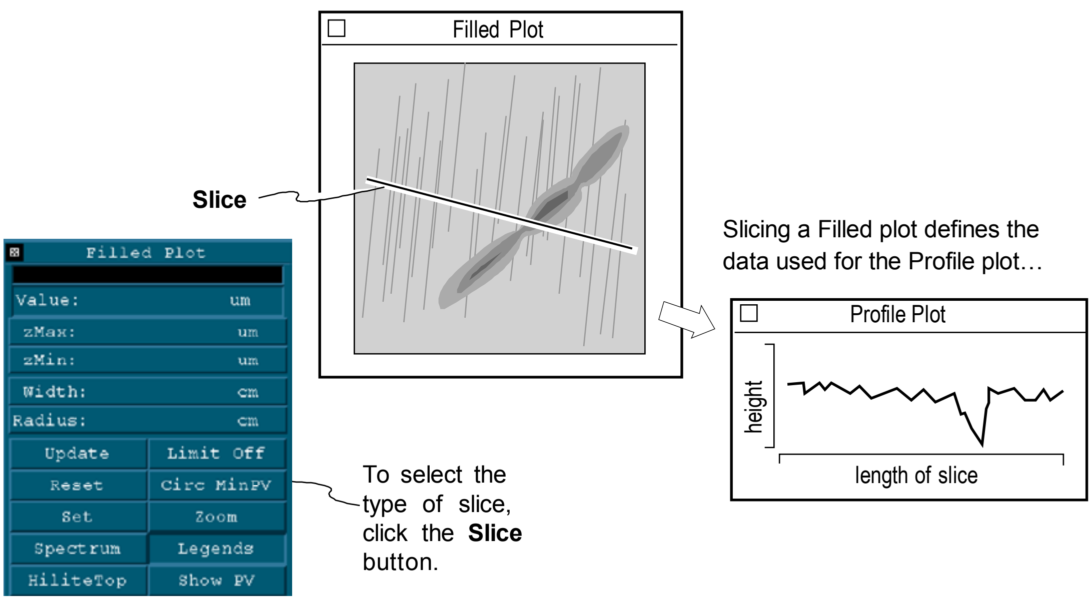
This control makes it possible to enter a specific radius value for the slice. It is used in conjunction with Circ Ctr and Circ MinPV slice types. When you enter a value for this control, a slice is automaticcaly drawn using the specified radius, centered appropriately. Valid entries for this control are between 5 and 8192(pixels). Only one slice can be specified, and the slice cannot be resized using the mouse.

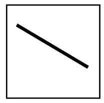
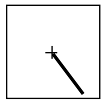
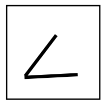
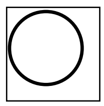
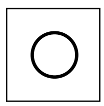
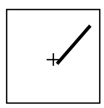
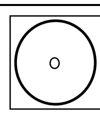
1. With the left mouse button, select either Circ Ctr or Circ MinPV as the slice type.
2. Type a value between 5 and 8192 and press [Enter]. The slice will be drawn automatically.

Slicing the Filled Plot

Drawing a line over the Filled plot is called "slicing". Slicing defines a line or lines from which profile data is derived.

> **Note:** Results related to slices are displayed in a separate corresponding profile data window. For example, the slice is created on the Filled plot in the map Test/Default data window and the slice data is displayed in a Profile plot in a corresponding profile Test/Default data window.

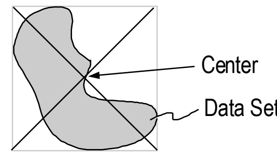


Slice Button	***Example***	***Characteristics***
Linear		Straight line, freely positionable.
Radial Ctr		Straight line, radiates from a fixed center point.
Radial		Straight line, for multiple slices with a common center, center is freely positionable.
Circular		Circular shape, freely positionable.
Circ Ctr		Circular shape with a fixed center point.
AvgRad Ctr		Straight line radiates from a fixed center point that is locked to the center of the data.
Circ MinPV		Fixed, automatically determined center point. Used with spheres and cones. Shifts the center point until it finds the lowest PV value. It searches by increments of 1/16 pixel within a square $\pm$ 3 pixels from the center point used by the CircCtr slice.

Slicing Concepts

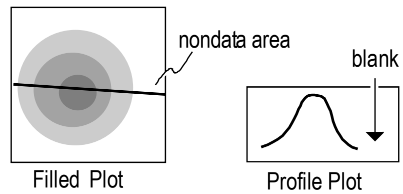
Data Center

The center of the data set is the center of a hypothetical rectangle enclosing the data.



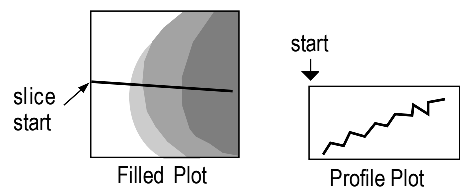
Blank Areas

Portions of the profile plot are blank when the slice is drawn over non-data areas.



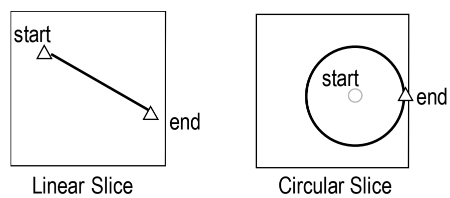
Starting Points

The start of a linear slice is always at the left side of the profile plot, no matter what direction the slice is created.



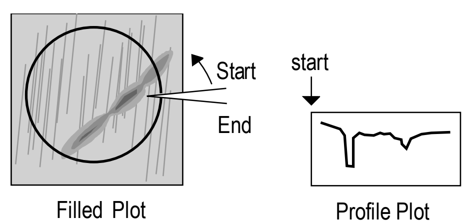
Start and End Points

Slices have start points and end points. These points are marked on the plot.



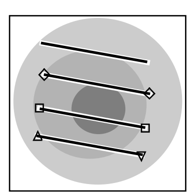
Plotting Circular Slices

The circular slice is automatically cut and unwrapped to create the profile plot.



Labeling Multiple Slices

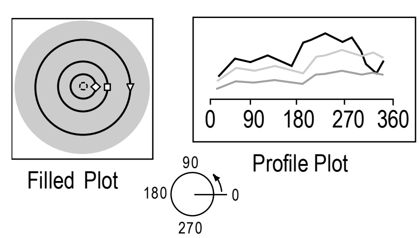
Slices are tagged in reverse order with the last created or current slice labeled with triangles. After the third slice no tags are used.



Creation Order	Tag	Working Order	Color in Profile
1	none	4	red
2	◇	3	blue
3	□	2	cyan
4	▽	1	green

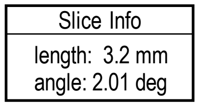
Multiple Circular Slices

Multiple circular slices are normalized to 360 degrees of a circle.



Creating Linear, Radial, or Circular Slices

1. Click the plot Controller's Slice button to select the slice type.
2. Position the pointer over the Filled plot at the start point. Press and hold the left mouse button, move the mouse to where you want the slice to end, then release the mouse button.

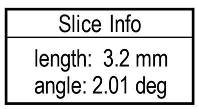


When creating slices, a dynamic Slice Info Box appears; use this data to help you define the slice.

3. To save created slices, click the plot Controller's Set button.

Creating Radial Ctr or Circ Ctr Slices

1. Click the plot Controller's Slice button to select the slice type.
2. Press and hold the left mouse button, move the mouse to where you want the slice to end, then release the mouse button. The start point for these slices is fixed to the center of the data.



When creating slices, a dynamic Slice Info Box appears; use this data to help you define the slice.

3. To save created slices, click the plot Controller's Set button.

Creating Multiple Linear Slices

1. Click the plot Controller's Slice button to select Linear.
2. Position the pointer over the Filled plot at the start point. Press and hold the left mouse button, move the mouse to where you want the slice to end, then release the mouse button.
3. Repeat step 2 to create multiple slices. Or to copy a slice position the pointer near the center of the slice and press and hold the left mouse button. Click the middle mouse button for each duplicate slice. Then release the left mouse button when done.
4. To save created slices, click the plot Controller's Set button.

Creating Multiple Radial, Radial Ctr, Circular, or Circ Ctr Slices

1. Click the plot Controller's Slice button to select slice type.
2. Press and hold the left mouse button. Click the middle mouse button for each slice. Then release the left mouse button when done.
3. To save created slices, click the plot Controller's Set button.

Moving a Linear, Radial, or Circular Slice

1. Position the pointer at the center of the slice.
2. Press and hold the left mouse button, move the mouse to move the slice, then release the mouse button.
3. Or, position the pointer inside the plot window, and press the arrow keys. Hold the [shift] key and press the arrow keys to move in larger increments.

Moving All Slices

1. Position the pointer at the center of one slice.
2. Hold down the [shift] key.
3. Press and hold the left mouse button, move the mouse to move the slice, then release the mouse button.

Changing the Size of a Slice

1. Position the pointer at the end of the slice.
2. Press and hold the left mouse button, move the mouse to change the slice size, then release the mouse button.

Changing the Angle of a Linear or Radial Slice

1. For a linear slice, position the pointer at the end of the slice. For Radial and Radial Ctr slices, position the pointer at the center of the slice.
2. Press and hold the left mouse button, move the mouse to change the slice orientation, then release the mouse button.

Deleting Slices

1. Hold down the [Ctrl] key. Position the pointer over the slice and click the left mouse button.

3. To delete all slices, hold down the [Ctrl] key. Position the pointer over the Filled plot and click the left mouse button.

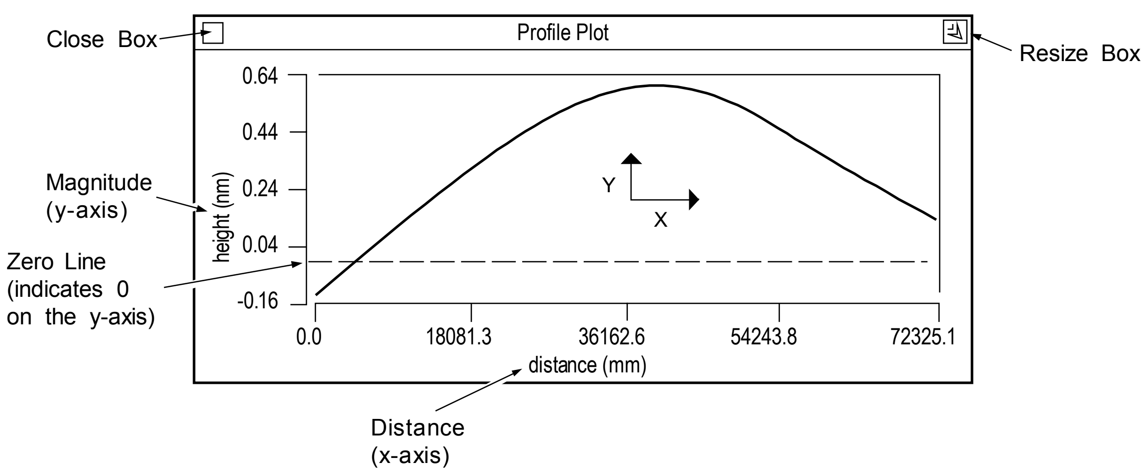
Applicable Slice Editing Actions

Slice Type	*Single Slice* move slice	change size	change angle	*Multiple Slices* move 1 slice	move all	change 1 slice size	change 1 slice angle
Linear	✓	✓	✓	✓	✓	✓	✓
Radial	✓	✓	✓		✓		✓
Radial Ctr		✓	✓				✓
Circular	✓	✓			✓	✓	
Circ Ctr		✓				✓	
Circ MinPV		✓					
AvgRad Ctr		✓					

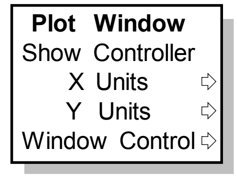
Profile Plot

A Profile plot is a two dimensional display of the data as a cross section through the Filled plot. Data is viewed in two dimensions: distance (x direction) and magnitude (y direction). Distance is determined by the length of the slice, magnitude by the data itself. Notice slices drawn over non-data areas are represented as blank areas on the plot.

The Profile plot is only available in a *profile* data window and is created using the New Plot → Profile Plot command. To open the Controller, click on the plot with the middle mouse button.



The Profile Plot's Menu



Show Controller open the plot controller.

X Units select measurement units for the horizontal or x-axis. If x-axis units are pixels, instrument calibration is required.

Y Units select measurement units for the vertical or y-axis.

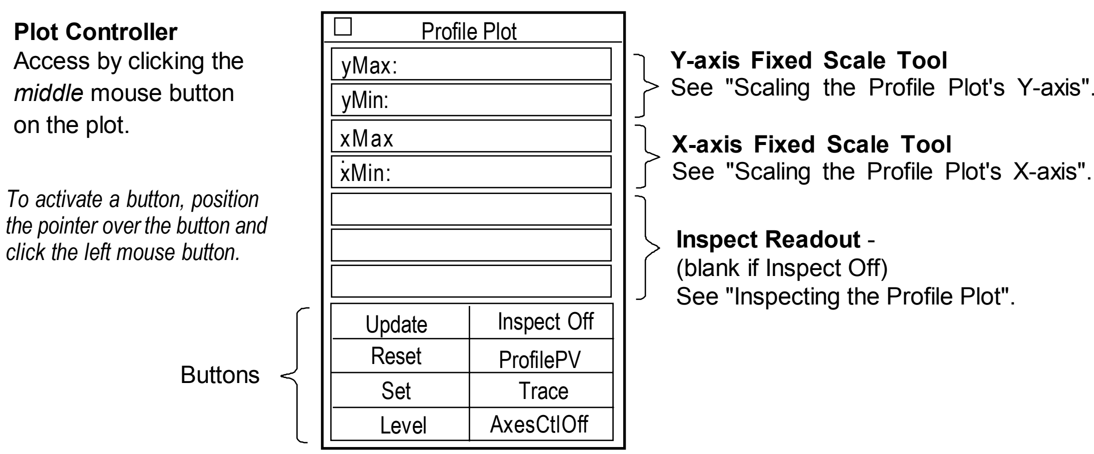
Window Control use to move, resize and delete the window, and to rename or hide the window's title bar.

Displaying the Plot

Note: The Profile plot is blank if there are not slices defined in a corresponding Filled plot.

1. In a corresponding map data window, define a slice through the data within the Filled plot. To create a slice, see "Slicing the Filled Plot".
2. If the profile plot is blank make sure that you are using corresponding map data windows, and that the slice is drawn over an image area in the Filled plot.

The Profile Plot's Controller



Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the "set" Controller settings.

Set - Makes the current Controller settings the master or "set" display.

Level - Works along with inspect feature to temporarily fit and remove the plot area between two crosshairs.

The information in this section is applicable to the Autocovariance, Power Spectrum, Histogram, Bearing Ratio, Encircled Energy, and MTF Profile plots.

Inspect - Turns inspect features on and off. When Inspect Off the readouts and the plot crosshairs are non-functional.

For other selections see "Inspecting the Profile Plot".

PV - Selects automatic scaling of the plot's y-axis. ProfilePV scales the plot to fill the entire area. MapPV scales the plot to the entire data set or Filled plot from which the plot was derived.

Display - Selects how data is displayed. Trace displays data as a line graph. Bar displays data as a series of vertical bars. Scatter displays data as points.

Axes CtlOff - Selects options for the axes scales; opens a secondary button panel.

See "Controlling the Profile Plot's Axes".

Note: This discussion covers using the plot Controller for the Profile plot. Most of this information also pertains to the Autocovariance, Power Spectrum, Amplitude Spectrum, Power Spectral Density, Histogram, Bearing Ratio, Encircled Energy, and MTF Profile plots. Some of the plot Controller's functions are disabled for these other types of two dimensional plots.

Opening the Plot Controller

1. Position the pointer on the plot window and press the middle mouse button.
2. If this is the first time the controller opened, an outline of the Controller appears. Drag the mouse to position the Controller and release the mouse button. The Controller appears when you let go of the mouse.

Using the Plot Controller

All plot Controller buttons are activated by positioning the pointer over the button and clicking the left mouse button. If there are several choices to a button, repeat click the mouse to cycle through the selections. Click the right mouse button to cycle through choices in the opposite direction. The general procedure is:

1. Click the plot Controller button(s). Some actions occur immediately, others require updating.

2. If necessary, update the plot by clicking the Update button.
3. Store new plot Controller settings by clicking the Set button.

    Note: When a measurement is taken or data is loaded, the plot Controller settings revert or reset to the stored settings.

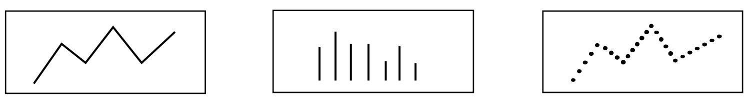
4. Make other temporary modifications to the plot using the Controller. Revert the Controller settings back to the stored settings by clicking the Reset button.

Permanently Saving Plot Settings

1. After you have changed the plot display with the Controller, you can save these settings by clicking the Set button with the left mouse button. This temporarily preserves changes made with the Controller.
2. To permanently preserve changes made to the plot with the Controller, Plot menu, or Resize box, the application must be saved. To save the application, access the Application Window menu and select the Re-save Application command.

Changing the Profile Plot Display

Click the plot Controller's Display button to change the display.



Trace Data as line trace.

Bar Data as vertical bars.

Scatter Data as discrete points.

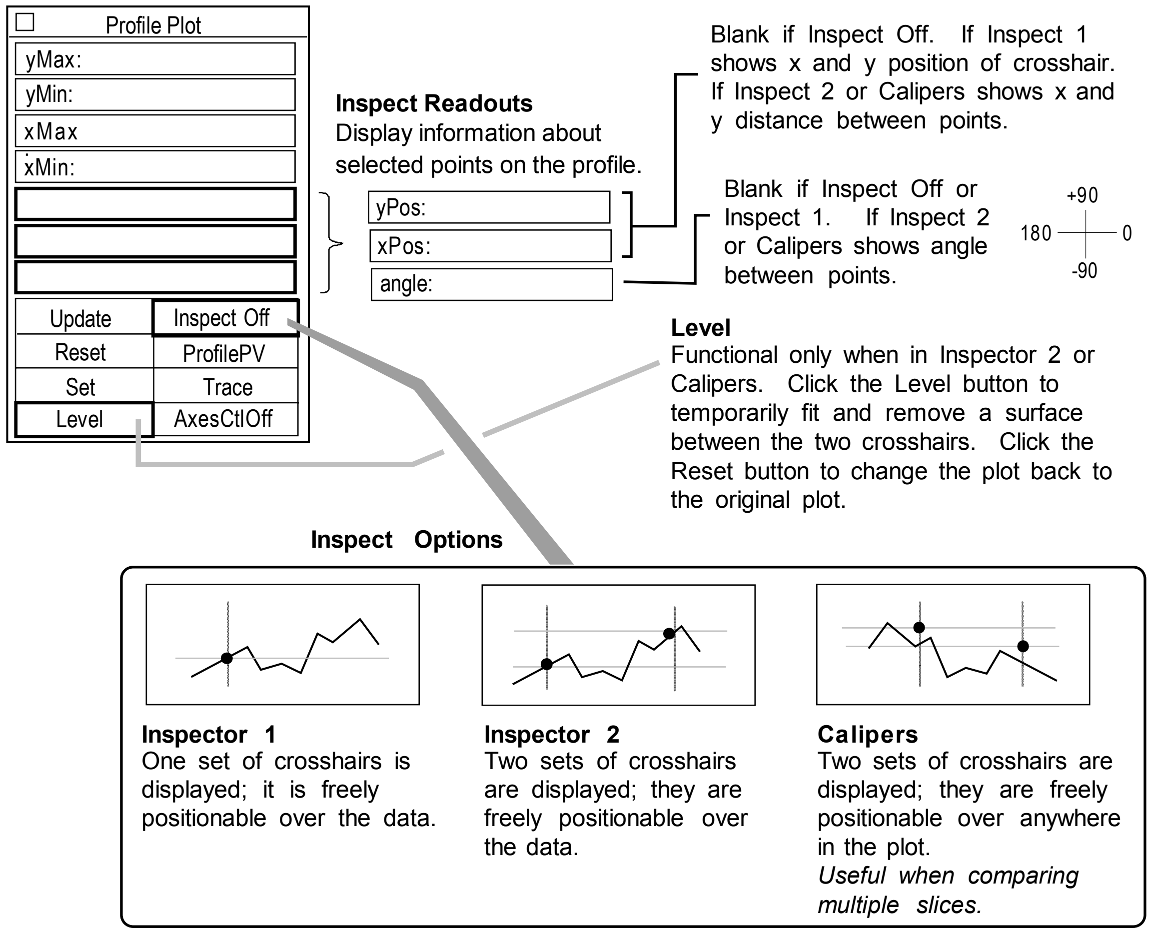
Resizing the Plot

The plot can be resized to any proportions allowed by the data window it resides in. When you resize the plot, keep in mind that the aspect ratio of width to height can be distorted so much that the plot does not even resemble the test part.

1. Click the window Resize box or select the Plot menu's Resize command.
2. Press the left mouse button and drag the lower right corner bracket of the window outline until it is the desired size, and release the mouse button.

Inspecting the Profile Plot

The inspect feature is used to examine areas of interest in the plot. It incorporates three parts of the plot Controller, the Inspect button, the Inspect Readouts, and the Level button.



Note: Crosshairs are only displayed when the Controller is open and the Inspect button is on Inspector 1, Inspector 2, or Calipers.

Moving the Inspect Crosshairs

1. Click the left mouse button on a location on the plot; the nearest crosshairs will jump to the location.
2. Or press and hold the left mouse button on a location on the plot; the nearest crosshairs will jump to the location. Move the mouse to position the crosshairs, then release the mouse button to place the crosshairs.

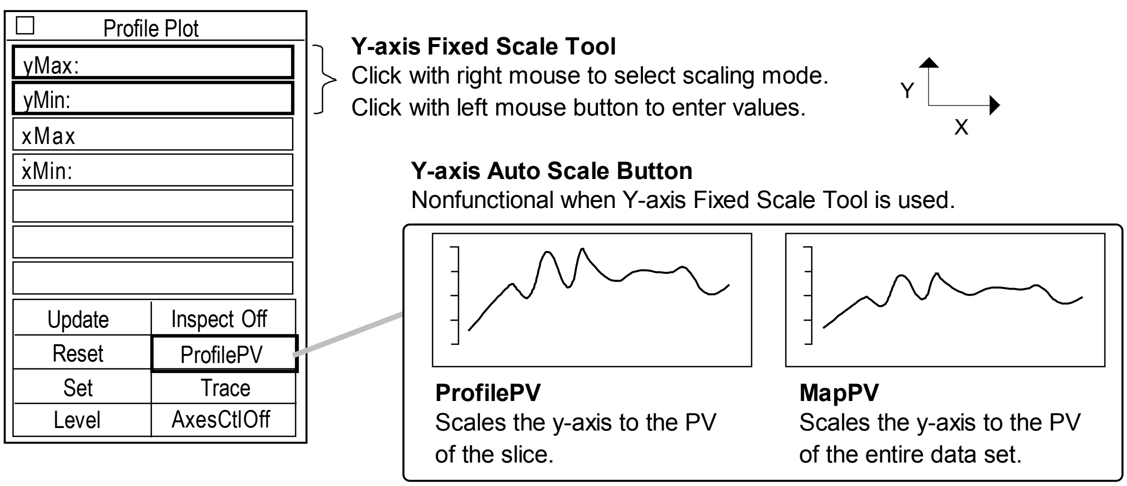
Note: If you are using multiple slices, Inspector 1 and Inspector 2 are linked to the last created or modified slice. This slice is the green line in the profile plot.

Sample Use of Inspect Feature for Two-dimensional Plots

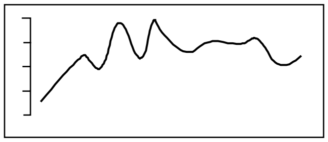
Plot	*Sample Use*
Profile	Inspector 1 - measure an individual peak or valley. Inspector 2 - measure distance between two points on profile.
Autocovariance	Inspector 1 - measure the correlation length.
Power Spectrum	Inspector 1 - show the power and spatial frequency at a given point.
Histogram	Inspector 1 - show the number of data points at a particular height.
Bearing Ratio	Inspector 1 - show the bearing ratio exposed at any depth. Inspector 2 - show the height between two bearing ratios.
Encircled Energy	Inspector 1 - show the spot radius at a specific percentage.
MTF Profile	Inspector 1 - show the modulation value at a specific spatial frequency.

Scaling the Profile Plot's Y-axis

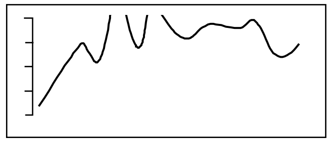
The y-axis or vertical axis of the plot has both auto scaling and user selectable fixed scaling. The auto scale mode is determined by the plot Controller's PV button. The plot Controller Y-axis Fixed Scale Tool is used for configuring the fixed scale options. If the Fixed Scale Tool is used, auto scaling is disabled.



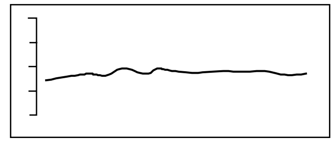
The Y-axis Fixed Scale Tool is useful when comparing the results of many similar parts; the y-axis scale does not change every time a measurement is made. Fixed scaling should be used with caution, data may be obscured if you input inappropriate values. Data can be clipped by making the y-axis too small; data can be compressed by making the y-axis too big; and the plot may be blank because the data does not fall within the range of the y-axis.



Data within the y-axis



Clipped data



Compressed data

Changing the Y-axis Fixed Scale Mode

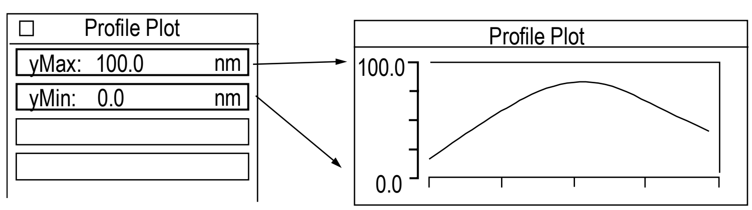
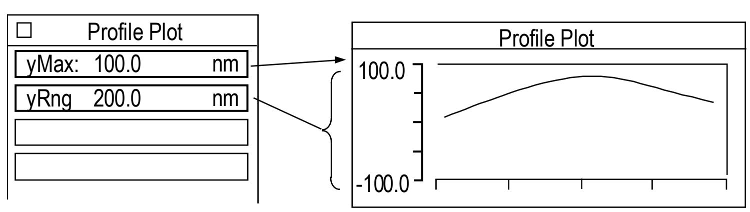
1. Position the pointer over the Y-axis Fixed Scale Tool. Click the right mouse button to change modes.

   Note: There must be values entered in the fixed scale tool for it to function. Note that 0 (zero) is an entry.

Entering Values in the Y-axis Fixed Scale Tool

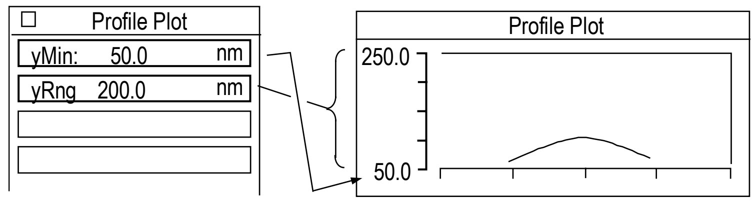
1. Position the pointer over one of the two boxes in the Y-axis Fixed Scale Tool.
2. Click the left mouse button, enter a numeric value and press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

Example Use of the Y-axis Fixed Scale Tool

Fixed Scale Modes	*Example*
yMax specifies the upper value. If left blank, yMax defaults to the peak of the data. **yMin** specifies the lower value. If left blank, yMin defaults to the valley of the data.	
yMax specifies the upper value. If left blank, yMax defaults to the peak of the data. **yRng** specifies the range of the scale. If left blank, the scale expands downward to show the data.	

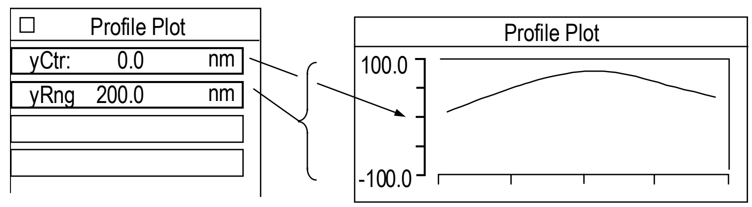
yMin specifies the lower value. If left blank, yMin defaults to the valley of the data.

yRng specifies the range of the scale. If left blank, the scale expands upward to show the data.



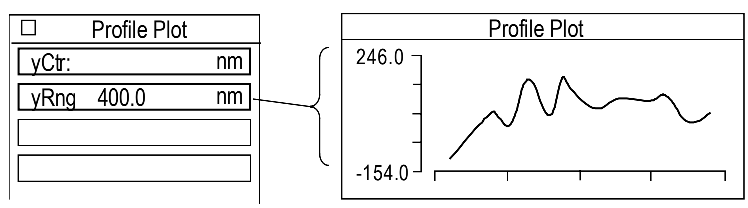
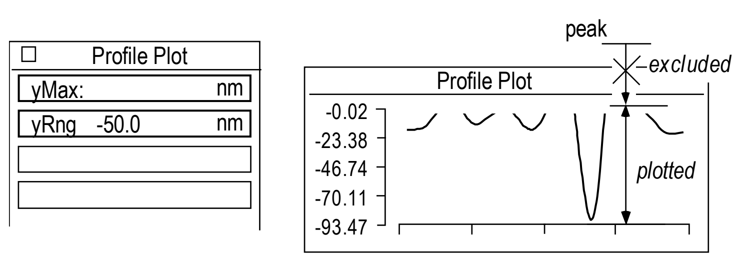
yCtr specifies the center of the scale. If left blank, yCtr defaults to the mean of the data.

yRng specifies the range of the scale. If left blank, the scale expands to show the data.



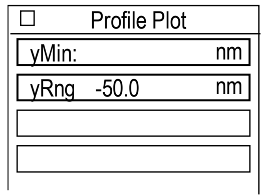
The Y-axis Fixed Scale Tool's yRng Function

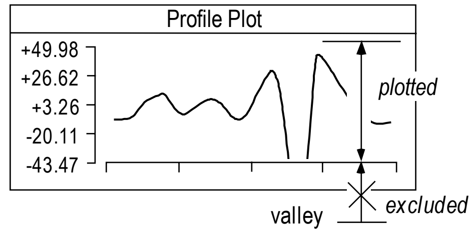
The Y-axis Fixed Scale Tool yRng setting has dual functions. When a positive number is entered it specifies the overall size of the axis. When a negative number is entered, it invokes an exclude option; which works only with the yMax and yMin settings.

YRng Function	*Example*
yRng (positive) Specifies the overall size of y-axis.	
yMax specifies the upper value. yMax (blank) defaults to the peak. **yRng** (negative) specifies the upper data range to exclude from the plot. (When used with yMax.)	

yMin specifies the lower value. yMin (blank) defaults to the valley.

yRng (negative) specifies the lower data range to exclude from the plot. (When used with yMin.)

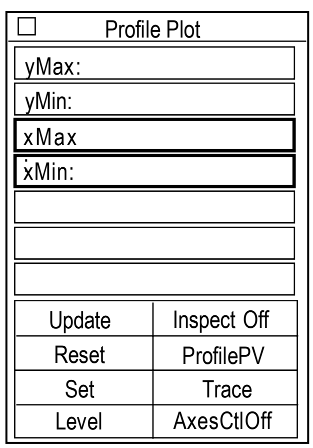


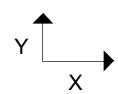


Scaling the Profile Plot's X-axis

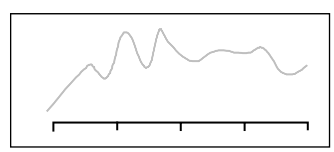
The x-axis or horizontal axis of the plot is dependent upon the size of the slice drawn in the corresponding map data window Filled plot. All slices start at position zero on the x-axis. Multiple linear slices all start at zero no matter their location. Single circular slices display in units, multiple circular slices are normalized to 360 degrees.

Normally, the plot automatically defaults to the length of the slice. The X-axis Fixed Scale Tool can be used override the default x-axis. If The X-axis Fixed Scale Tool is used, the x-axis will always be the same no matter what changes are made to the slices. The same cautions mentioned under y-axis fixed scaling apply to x-axis fixed scaling.





X-axis Fixed Scale Tool
Click with right mouse to select scaling mode.
Click with left mouse button to enter values.
If no values are entered, the x-axis matches the length of the slice.



X-axis

Changing the X-axis Fixed Scale Mode

1. Position the pointer over the X-axis Fixed Scale Tool. Click the right mouse button to change modes.

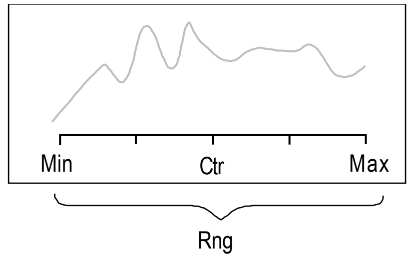
   Note: There must be values entered in the fixed scale tool for it to function. Note that 0 (zero) is an entry.

xMax specifies the upper value. If left blank, xMax defaults to the length of the longest slice.

xMin specifies the lower value. If left blank, xMin defaults to zero.

xCtr specifies the center of the scale. If left blank, xCtr defaults to the mean of the data.

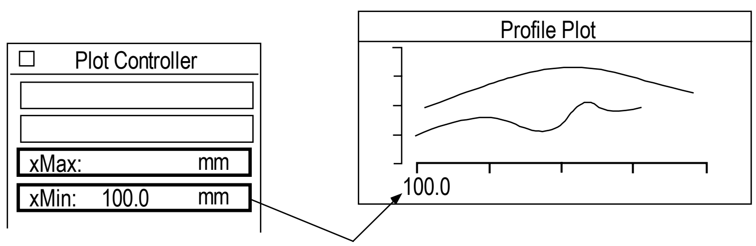
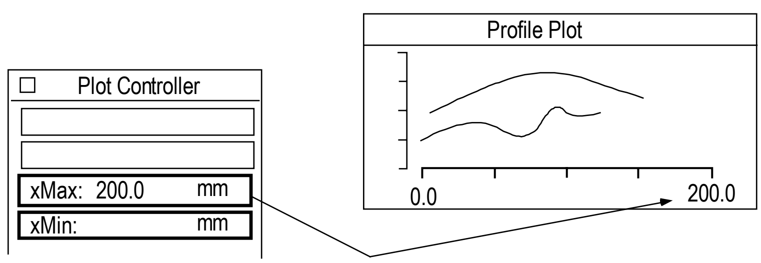
xRng specifies the range of the scale. If left blank, the scale expands to show the data.



Entering Values in the X-axis Fixed Scale Tool

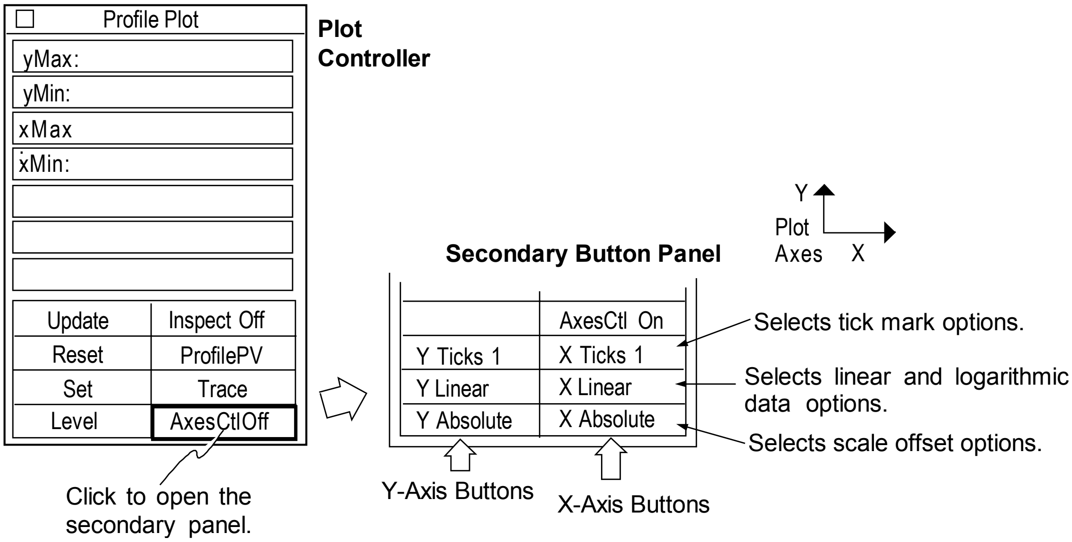
1. Position the pointer over one of the two boxes in the X-axis Fixed Scale Tool.
2. Click the left mouse button, enter a numeric value and press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

Example Use of the X-axis Fixed Scale Tool

Fixed Scale Modes	*Example*
xMax specifies the upper value. If left blank, xMax defaults to the length of the longest slice. **xMin** specifies the lower value. If left blank, xMin defaults to zero.	 By specifying xMin you zoom in on the upper section of the plot. xMax defaults to the longest slice.
The other modes work similar to those shown for the Y-axis Fixed Scale Tool.	 By specifying xMax you can compare multiple data files with the same x-axis. xMin defaults to 0. The beginning of all profile plots is always 0.

Additional Profile Plot Axes Control

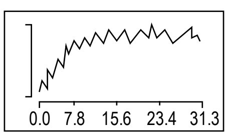
Additional control over the plot display is available through the plot Controller by clicking on the Axes Ctl button with the left mouse button. This opens a secondary button panel.



Secondary Button Panel Selections

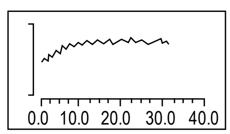
Ticks 1

The difference between data extremes is divided into four equal parts; numbers are not rounded.



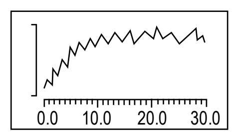
Ticks 2

Expands plotting area, divides it into four parts with "nice" numbers; tick marks are added.



Ticks 3

Plots only data area, divides the axes to display "nice" numbers, more tick marks are added.

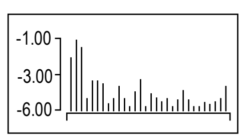


Linear

Plot data linearly.

Log 10, Log e, Log 2

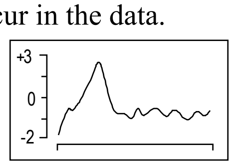
Plots logarithm of the data; it expands small values hidden in a linear scale.



Log scales are generally used with the Power Spectrum Plot.

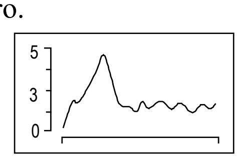
Absolute

Plots the values as they occur in the data.



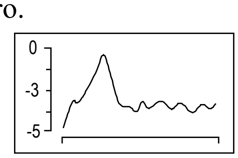
Min Rel

Plots the values starting at zero.



Max Rel

Plots the values ending at zero.



Selecting a Axes Control Option

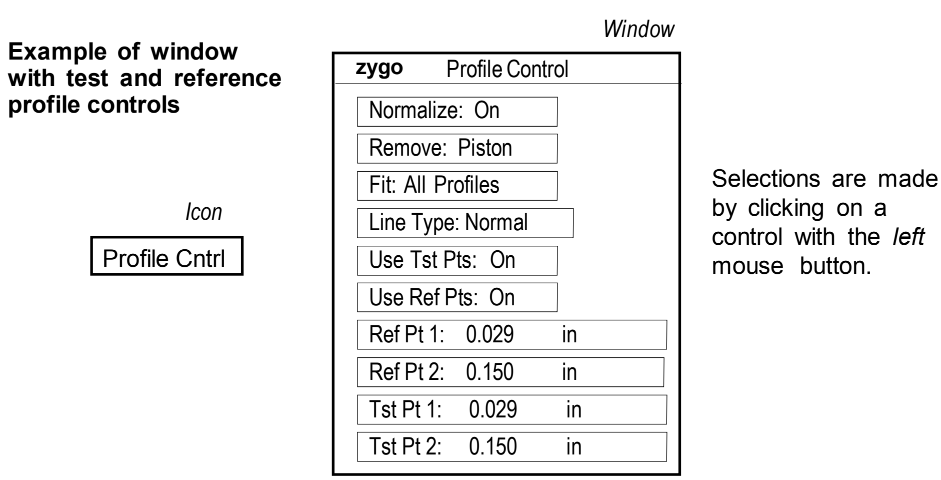
1. Click the Axes CtlOff button to open the secondary button panel.
2. Click the Tick, Linear, or Absolute button with the left mouse button to cycle through the choices for the applicable axis.
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

Using Test and Reference Areas in Profile Plots

A number of controls used together provide the ability to define test and reference segments on profile data. The test segment, defined by the Tst Pt controls, is compared to the reference segment, defined by the Ref Pt controls. Profile plots and results are based on the test segment. Test and reference profile controls are used in the Disk Dub-off application.

Other controls available in the same menu provide the ability to fit and remove shapes from the reference segment. These controls are created using the profile data window menu's New Control → command.

An example of a window configured with the profile controls is shown below. The controls are explained in the following table.



Test and Reference Profile Controls

Controls	*Description*
Normalize	When On, all slices are adjusted to relate to one another. Linear slices shift so the first valid data point is at zero on the x-axis. Circular slices are made the same length with x-axis in degrees.
Remove	Subtracts the selected shape from all slices; choices are Piston, Line, Circle, and None. Piston compensates for offset in the z-axis. Line compensates for residual tilt. Circle removes a best fit circle from the data. None turns off remove.
Fit	Determines how shapes are fit; choices are First Profile and All Profiles. First Profile fits the shape in the Remove control to the first slice only; it is removed from all. All Profiles fits the shape in the Remove control to all slices; it is removed from all.
Line Type	Specifies how fit is performed when the Remove control is set to Line; choices are 2 Point and Normal. Normal allows the software to find the points to fit a line. 2 Point uses Ref Pt 1 and Ref Pt 2 to define the line to fit; 2 Point requires valid data at each point.
Use Ref Pts	When On, the Ref Pt 1 and Ref Pt 2 controls are active; they specify where the fit is done.
Ref Pt 1	Specifies the starting point of the reference segment along the x-axis.
Ref Pt 2	Specifies the ending point of the reference segment along the x-axis.
Use Tst Pts	When On, the Tst Pt 1 and Tst Pt 2 controls are active; they specify over what area the profile results are calculated.
Tst Pt 1	Specifies the starting point of the test segment along the x-axis.
Tst Pt 2	Specifies the ending point of the test segment along the x-axis.

Other Plots

Section

5

MetroPro provides numerous ways to display data. Some plots are three dimensional views of data, while others provide special analysis functions.

A plot is a graphic representation of measurement data. This section provides details on plots other than the Filled Plot and Profile Plot. Plots reside in data windows and are created by selecting the New Plot command from the data window's menu. Each plot display is controlled with a plot Controller, which is accessed by clicking the plot with the middle mouse button. The availability of each plot varies depending on the application.

What Plots are Described in this Section?

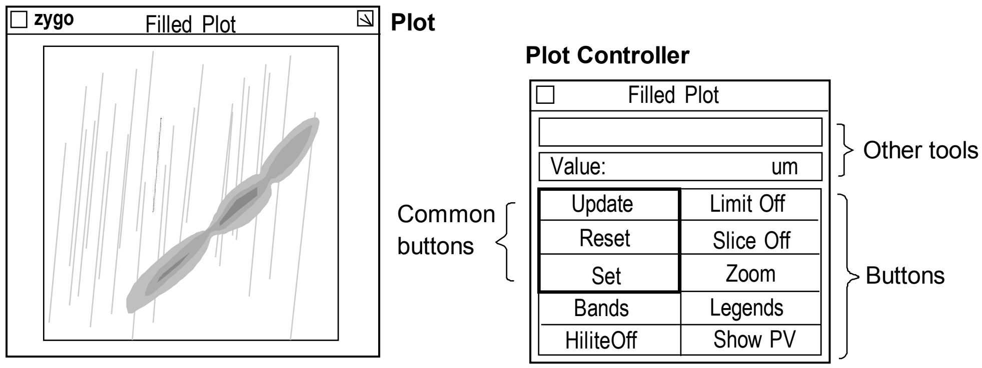
Plot	***Description***
3D	Displays data (surface) in a three dimensional wire frame or solid representation that can be rotated in any orientation. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The plot is resizable.
Autocovariance	Used to determine the periodicity of a surface; it shows the dominant spatial frequencies along a cross section or slice of the test surface. The x-axis is the length along the slice and the y-axis is normalized height values. The plot is resizable. Requires a defined slice in a corresponding Filled plot.
Bearing Ratio	Displays the bearing ratio at a range of depths for the *entire* data matrix. It simulates the effect of wear on a bearing surface. The x-axis is the bearing ratio and the y-axis is the depth from the highest peak. The plot is resizable.
Encircled Energy	Displays the distribution of energy within a PSF; it is representative of the *entire* data matrix. The x-axis is the radius of a circle and the y-axis is the percent of total energy contained within that circle. It illustrates the quality of the optic. The plot is resizable.

Plots in this Section (continued)

Plot	Description
Oblique	Displays data in three dimensions with the x-axis horizontal, the y-axis inclined from horizontal, and the z-axis vertical. All three axes of the plot normally include labeled scales. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The plot is resizable.
Profile Spectrum Plots	Includes: Amplitude Spectrum, Peak Amplitude Spectrum, Power Spectral Density, and Power Spectrum. Plots the spatial frequency component of the data versus the frequency. The plot is resizable. Requires a defined slice in a corresponding Filled plot.
Solid	Displays surface data as a function of slope as viewed along the instrument's z-axis. Areas with different slopes are represented by different shades. The Solid plot displays high frequency irregularities better than the Filled plot. The Solid plot size is fixed, even though the Plot window size is not fixed. If the Solid plot does not display, your data is too large to fit in the window; simply make the plot window larger.

General Procedures for all Plots

The display within the plot window is modified by a plot Controller. Each plot has its own controller.



Opening the Plot Controller

1. Position the pointer on the plot window and press the middle mouse button.
2. If this is the first time the controller opened, an outline of the Controller appears. Drag the mouse to position the Controller and release the mouse button. The Controller appears when you let go of the mouse.

Using the Plot Controller

All plot Controller buttons are activated by positioning the pointer over the button and clicking the left mouse button. If there are several choices to a button, repeat click the mouse to cycle through the selections. Click the right mouse button to cycle through choices in the opposite direction. The general procedure is:

1. Click the plot Controller button(s). Some actions occur immediately.
2. If necessary, update the plot by clicking the Update button.
3. Store new plot Controller settings by clicking the Set button.

   Note: When a measurement is taken or data is loaded, the plot Controller settings revert or reset to the stored settings.

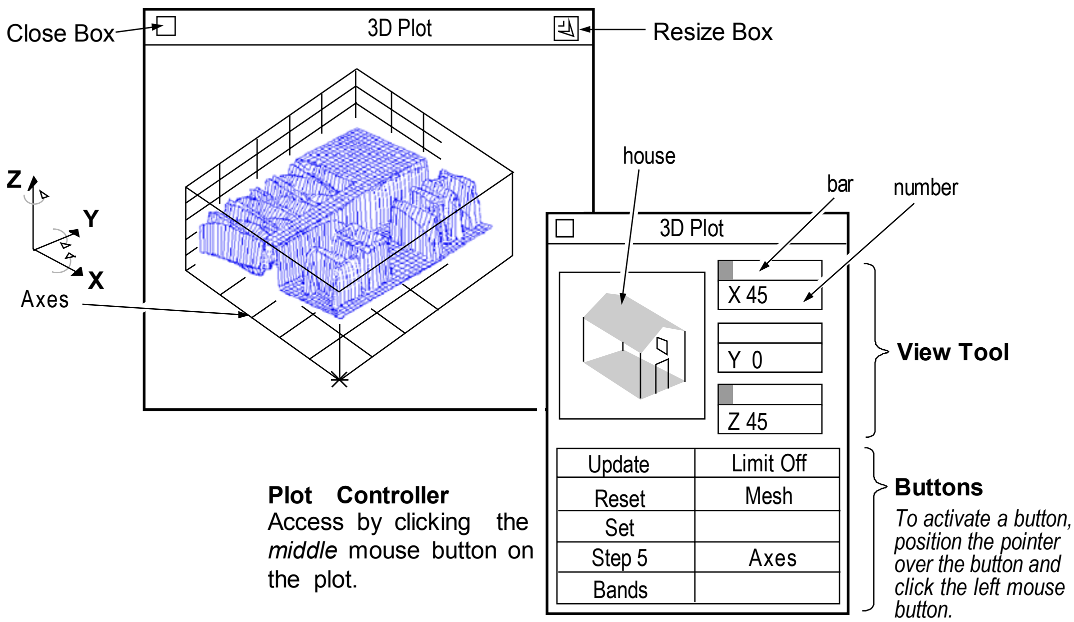
4. Make other temporary modifications to the plot using the Controller. Revert the Controller settings back to the stored settings by clicking the Reset button.

Permanently Saving Plot Settings

1. After you have changed the plot display with the Controller, you can save these settings by clicking the Set button with the left mouse button. This temporarily preserves changes made with the Controller.
2. To permanently preserve changes made to the plot with the Controller, Plot menu, or Resize box, the application must be saved. To save the application, access the Application Window menu and select the Re-save Application command.

3D Plot

A 3D plot displays surface data as viewed in a three dimensional wire frame or solid model that can be rotated. The 3D plot can be viewed in any orientation. Areas with different magnitudes or height are represented by different colors, or in a one color plot as different shades. A 3D plot is available in a map data window and is created using the New Plot command. To open the Controller, click the plot with the middle mouse button.



Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the “set” Controller settings.

Set - Makes the current Controller settings the master or “set” display.

Step - Selects how much of the data is plotted. 1 = all data, 2 = every 2nd data point, etc... up to 12. Auto Step - automatically selects the step size for optimum display of the plot.

Color - Selects the color of the plot. Choices: Bands (15 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum (48 colors), and Neon (a variation of Spectrum).

Limit - Determines if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off limits are not displayed in the plot. *Note:* To display limits in the plot, high limits must be set in a PV Result box in the same data window.

For more information, see “Displaying Limits in the 3D Plot”.

Mesh - Selects how the plot is displayed. Mesh displays data as wire frame. Fill displays data as a solid model. MeshFill displays data as a filled wire frame. Mono displays data as a monochrome, or one color mesh.

Axes - When on, the plot display includes an outline of a three dimensional box with reference lines.

Using the 3D Plot's View Tool

1. Click the middle mouse button on the plot to open its Controller.
2. *House* Position the pointer on the house, press the left mouse button, move the mouse to reposition the house, and then release the mouse button.
3. *Bar* Position the pointer on the bar for one axis, press and hold the left mouse button, move the mouse to resize the bar, then release the mouse button.
4. *Number* Position the pointer on the number for one axis, click the left mouse button, enter a numeric value from the keyboard, then press [Return].
5. To activate your changes, click the plot Controller's Update button.

Selecting 3D Plot Resolution

1. Click the left mouse button on the plot Controller's Step button until the desired step is displayed. When set to Auto Step, the number of data points used in the plot is automatically selected so the plot displays with optimum detail and speed.
2. To activate your changes, click the plot Controller's Update button.

Using Colors in the 3D Plot

Click the plot Controller's Color button to change the color of the plot.

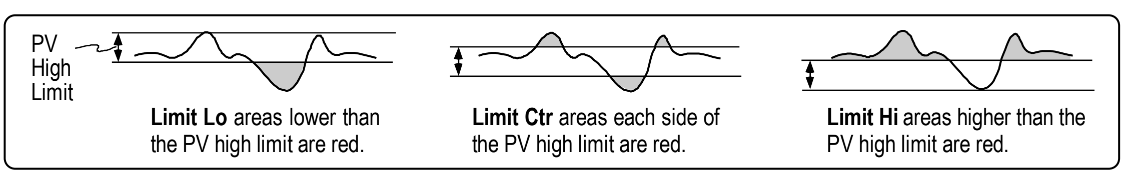
- Spectrum shows the greatest detail in the center of plotted height values.
- Neon shows the greatest detail near the top and bottom of plotted height values.
- Greys to display limits.

Resizing the 3D Plot

The plot can be resized to any proportions allowed to by the data window it resides in. The 3D plot is designed with square proportions. The plot can be resized so the width to height aspect ratio is distorted so much that the plot does not even resemble the test part.

1. Click the plot window Resize box or select the Plot menu's Resize command.
2. Press and hold the left mouse button, drag the lower right corner bracket of the window outline until it is the desired size, then release the mouse button.

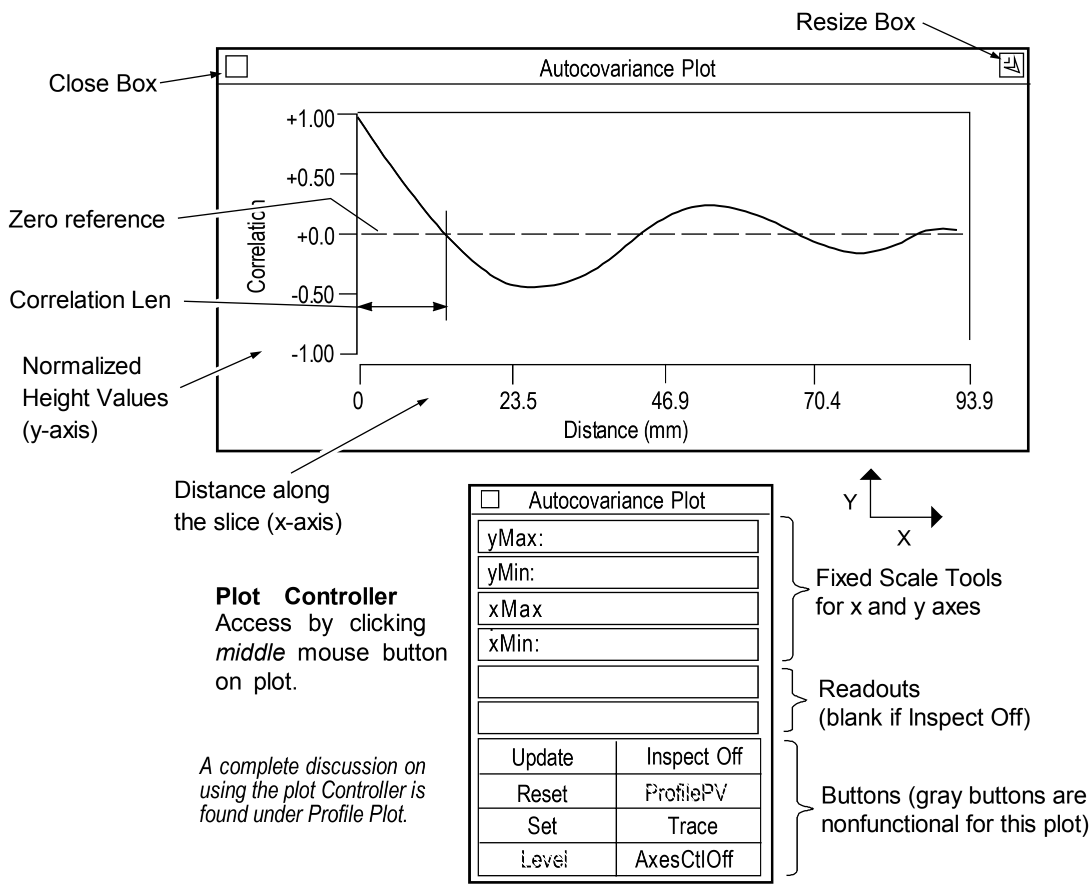
Displaying Limits in the 3D Plot



1. Click the plot color to Greys. Click the Limits button to select the limit mode. Then click the Controller's Update button.
2. In the PV result in the same data window, select the Limits → High command from the result's menu. Enter a high limit for the PV result and press [Return].

Autocovariance Plot

The Autocovariance plot is an indicator of the randomness of a profile of the test surface. Autocovariance is used to determine the periodicity of a surface. The Autocovariance plot is available in phase profile data windows and is created using the New Plot command. To open the plot Controller, click on the plot with the middle mouse button.



For periodic surfaces, the plot has a characteristic sinusoidal shape that is related to the period of the dominant spatial frequencies of the surface. For random surfaces the first zero crossing point indicates the distance along the surface at which the surface becomes uncorrelated. Autocovariance is also known as Autocorrelation Function or ACF.

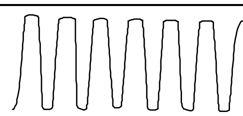
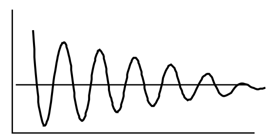
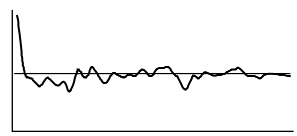
$$\text{Autocovariance} = \sum_{i=1}^{N-m} \cdot Y_i \, Y_{i+m}$$

Where: m is the shift position, an integer that ranges from zero to some fraction of N, and N is the number of discrete elements Yi in the profile.

Autocovariance is a measure of similarity between two identical but laterally shifted profiles. Autocovariance is useful to distinguish the repetitive irregularities from random irregularities. Repetitive features may indicate tool wear or machine deficiencies. When examining the Autocovariance plot, look at the general shape, when the plot first crosses zero, and the distance to the first peak.

If the surface is random, having no repetitive waveforms, the Autocovariance plot rapidly drops to zero and then stays near zero. If the plot oscillates around zero in a periodic manner, then the surface has a dominant spatial frequency; by measuring the distance to the first peak (second maximum) its period is determined. If there are smaller ripples on the overall Autocovariance plot, then the surface has some periodic features.

The Correlation Len result shows the length along the x-axis where the autocovariance function first crosses zero. It can be thought of as the minimum distance along the profile where one point has no relation to the next. In a perfectly random surface, the correlation length is zero because no points have any relationship to other points. In a part with a non-random surface, correlation length is one quarter of the period of the dominant pattern.

Description	***Profile***	***Autocovariance Plot***
Surface with dominant waveform.		
Surface with random waveform.		

Note: The Autocovariance is calculated for *profiles*; thus, the results are indicative of the slice location and may not accurately reflect the entire part. For this reason the slice should be as long as possible; the longer the slice length, the greater the accuracy.

Displaying the Autocovariance plot

1. In a corresponding phase map data window, define a linear slice through the data within the Filled plot.
2. If the Autocovariance plot is blank make sure that you are using a linear slice and not a circular slice; that you are using corresponding data; and that the slice is drawn over an image area in the Filled plot.

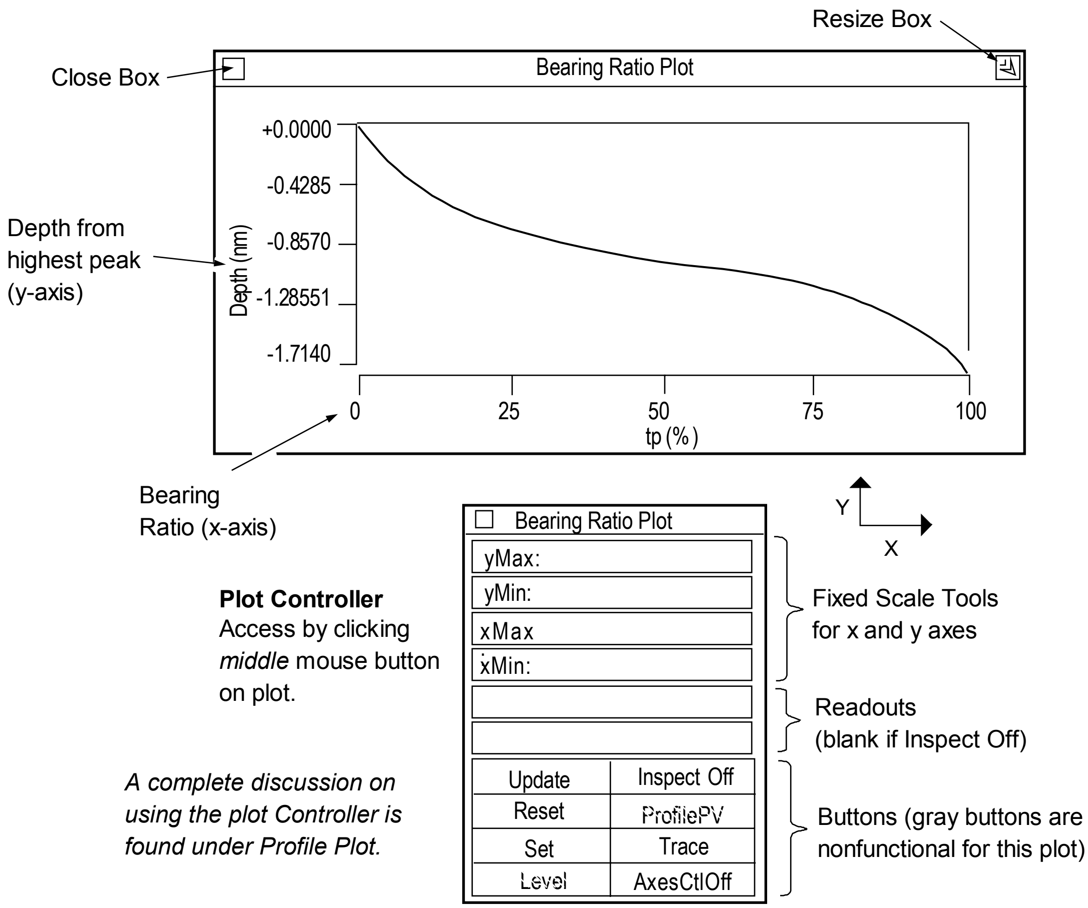
   Note: No profile data is calculated or displayed until a linear slice is defined by the user within a Filled plot made in a corresponding phase map Data window. Slicing is covered in Section 4.

Changing the Autocovariance Plot

The plot display is adjusted and modified with the plot Controller. The Autocovariance plot Controller works the same way as standard profile plot Controller.

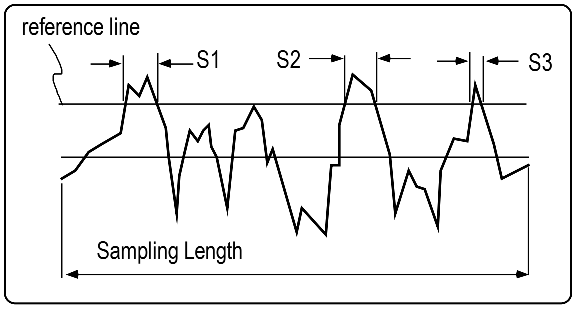
Bearing Ratio Plot

The Bearing Ratio plot displays the bearing ratio at a range of depths for the entire data matrix. The Bearing Ratio plot is available in a Phase map Test/Default Data window and is created using the New Plot command. To open the plot Controller click on the plot with the middle mouse button.



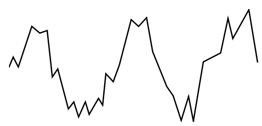
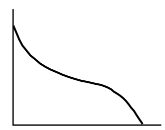
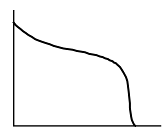
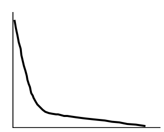
To state it differently, the Bearing Ratio plot is a set of bearing ratio values on the horizontal axis plotted against depths on the vertical axis. The Bearing Ratio plot simulates the effect of wear on a bearing surface. The Bearing Ratio plot is also known as the Abbott and Firestone curve (AFC), or the material ratio curve.

Bearing ratio, or tp, is the ratio (expressed as a percentage) of the length of the bearing surface at a specified depth below the highest peak. To simplify this discussion, bearing ratio is described here in relation to a slice of data, even though the Bearing Ratio plot represents the entire surface. A reference line is drawn parallel to the center to intersect the data; the bearing ratio is the ratio of the sum of these subtended lengths to the sampling length.



$$\text{Bearing Ratio} = \frac{S1 + S2 + S3}{L} \times 100\%$$

Where L is the sampling length and Sx is the subtended length.

Description	***Profile***	***Bearing Ratio Plot***
Ground surface with random heights		
Honed surface with peaks removed		
Turned surface with dominating peaks		

The Bearing Ratio plot, although simulating the effect of wear, can never take the place of actual tests, as there are known limitations:

- It tends to ignore the geometric form and waviness of the test surface, which may have much more to do with the bearing contact of two surfaces than does a roughness profile.
- In practice two contacting surfaces are involved and the surface features of each contribute towards wear.

Changing the Bearing Ratio Plot

The plot display is adjusted and modified with the plot Controller. The Bearing Ratio plot Controller works similar to the profile plot Controller.

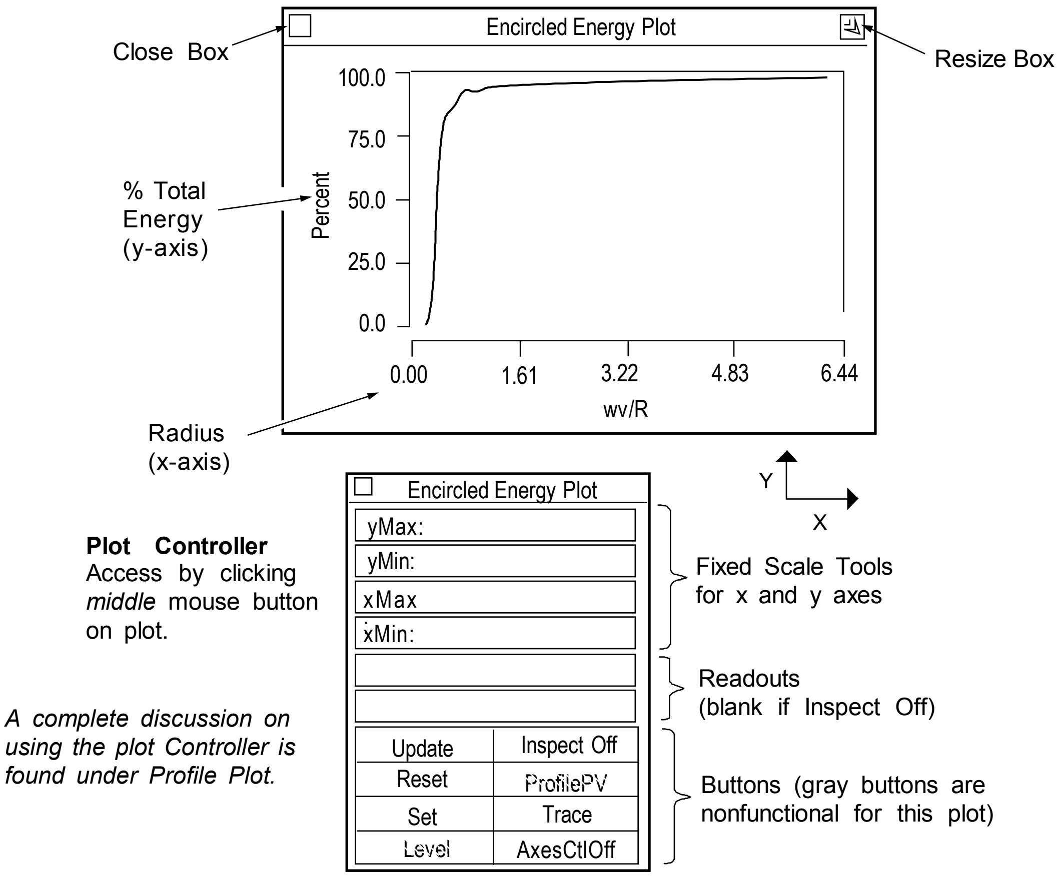
Bearing Ratio Reference Material

William Drews and Werner Weniger, "Rediscovering the Abbott-Firestone Curve", *Quality*, September 1989, pp. 50-53.

E.J. Abbott and F.A. Firestone, "Specifying Surface Quality", *Journal of Mechanical Engineering*, 55 1933: 569.

Encircled Energy Plot

The Encircled Energy plot shows the distribution of energy within the PSF plot; it is obtained from the PSF. The Encircled Energy plot is available in the PSF Data window and is created using the New Plot command. To open the plot Controller click on the plot with the middle mouse button.



Think of the Encircled Energy plot as a drawing of circles with increasing radii centered at the center of the PSF spot. For each circle, the amount of energy it encloses is measured. This value is normalized by the total energy in the spot and plotted on the y-axis as a percentage. The plot illustrates how focused the energy is. A well corrected lens system will have a plot similar to the one shown above. Poorer quality lenses will not rise as quickly.

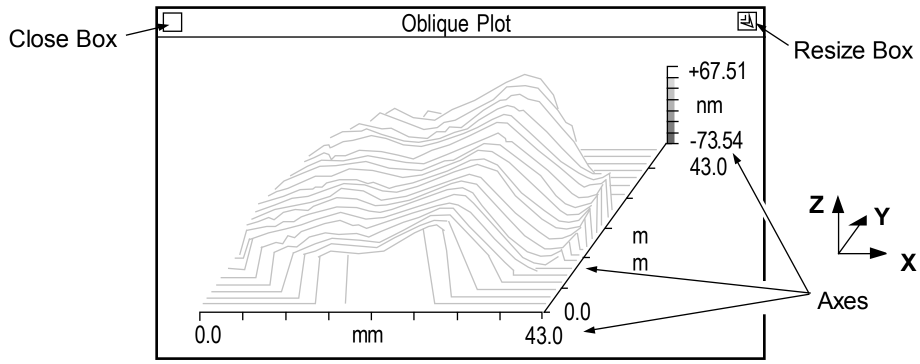
> **Note:** The Encircled Energy Plot requires an entry in the f-number control.

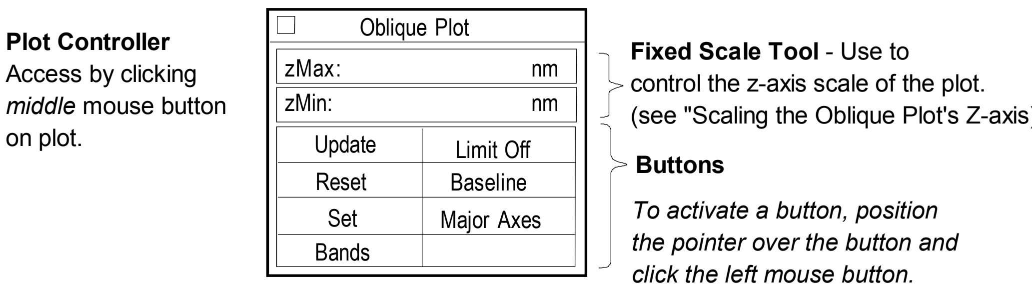
Changing the Encircled Energy Plot

The plot display is adjusted and modified with the plot Controller. The Encircled Energy plot Controller works similar to the profile plot Controller.

Oblique Plot

An Oblique plot is a three dimensional display of the data with the x-axis horizontal, the y-axis inclined from horizontal, and the z-axis vertical. All three axes of the plot typically include labeled scales. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The Oblique plot is available in map data windows and is created using the New Plot command. To open the Controller, click on the plot with the middle mouse button.





Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the "set" Controller settings.

Set - Makes the current Controller settings the master or "set" display.

Color - Selects the color of the plot. Choices: Bands (15 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum (48 colors), and Neon (a variation of Spectrum).

Limit - Determines if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off displays no limits in the plot. *Note:* To display limits in the plot, high limits must be set in a PV Result box in the same data window.

For more information, see "Displaying Limits in the Oblique Plot".

Display - Selects how the plot is displayed. Baseline displays data with droplines and baselines. Stack F displays data as a floating oblique with a filled contour plot. Stack B displays data as a baseline oblique with a filled contour plot. Floating displays data without droplines or baselines.

Axes - Selects how the axes are displayed. Major Axes shows x, y, and z axes. Box 1 shows x, y, and z axes surrounding the data. Box 2 is a variation of Box 1. No Axes displays the data with no axes.

Resizing the Oblique Plot

The plot can be resized to any proportions allowed by the data window in which it resides. The Oblique plot is designed to be displayed in a 2:1 rectangular format. If you resize the plot the width and height aspect ration can be distorted so much that the plot does not even resemble the test part.

1. Click the window Resize box or select the Plot menu's Resize command.
2. Press the left mouse button and drag the lower right corner bracket of the window outline until it is the desired size; then release the mouse button.

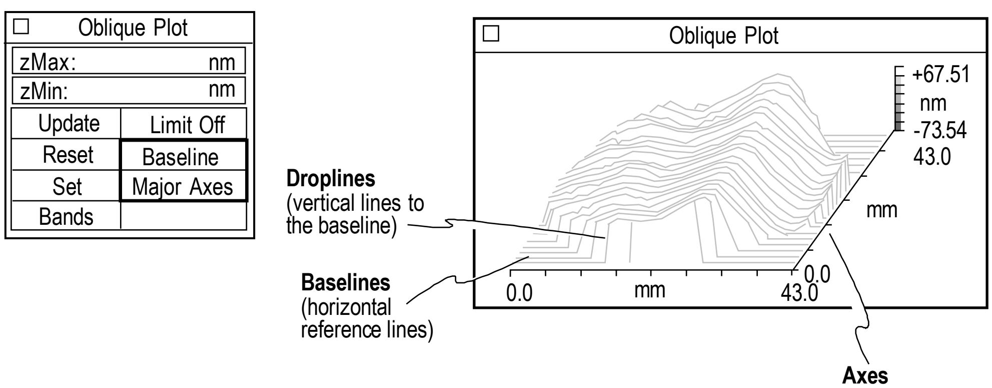
Using Colors in the Oblique Plot

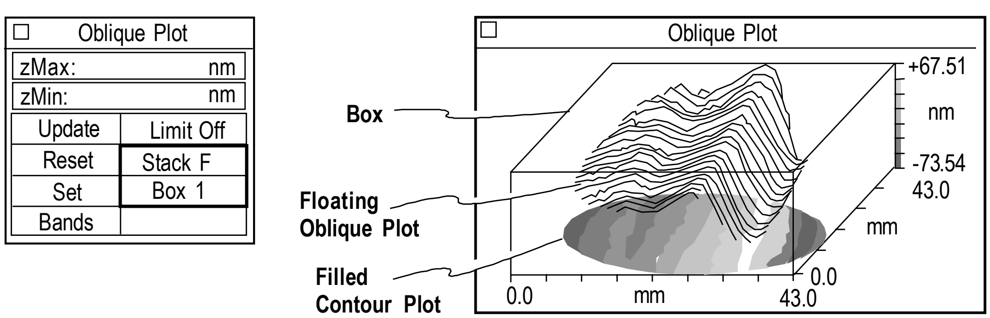
Click the plot Controller's Color button to change the color of the plot.

- Spectrum shows the greatest detail in the center of plotted height values.
- Neon shows the greatest detail near the top and bottom of plotted height values.
- Greys to display limits.

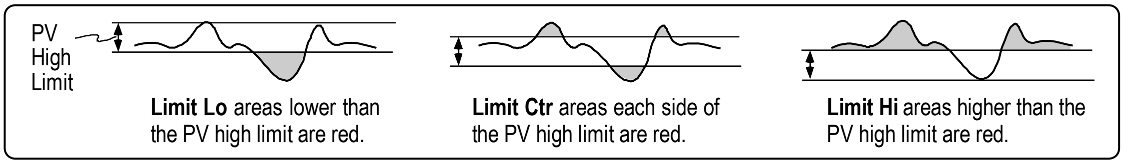
Changing The Oblique Plot's Display Options

1. Click the Display button to select the way data is displayed.
2. Click the Axes button to select how the plot axes are displayed.
3. Click the plot Controller's Update button.



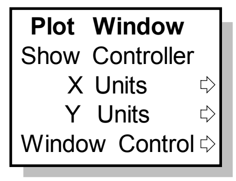


Displaying Limits in the Oblique Plot



1. Click the plot color to Greys. Click the Limits button to select the limit mode. Then click the Controller's Update button.
2. In the PV result in the same data window, select the Limits → High command from the result's menu. Enter a high limit for the PV result and press [Return].

The Oblique Plot's Menu



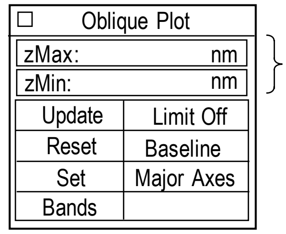
Show Controller open the plot controller.

X-Y Units select measurement units for the horizontal or x-axis and the inclined or y-axis. The x and y axes scales are dependent on the field of view of the instrument. If x and y axes are pixels, instrument calibration is required.

Z Units select measurement units for the vertical or z-axis. The z-axis scale is determined automatically by the data or the Z-axis Fixed Scale Tool if it is used.

Window Control use to move, resize and delete the window, and to rename or hide the window's title bar.

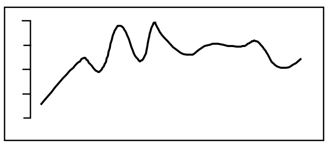
Scaling the Oblique Plot's Z-axis



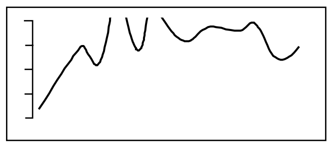
Z-Axis Fixed Scale Tool

The Z-axis Fixed Scale Tool is useful when comparing the results of many similar parts; the z-axis scale does not change every time a measurement is made.

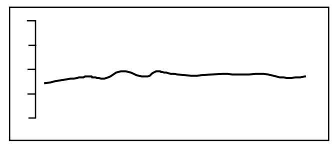
Fixed scaling should be used with caution; data can be obscured if you input inappropriate values. Data is clipped when the z-axis is too small; data is compressed by making the z-axis too big; and the plot may be blank because the data does not fall within the range of the z-axis.



Data within the y-axis



Clipped data



Compressed data

Changing the Z-axis Fixed Scale Mode

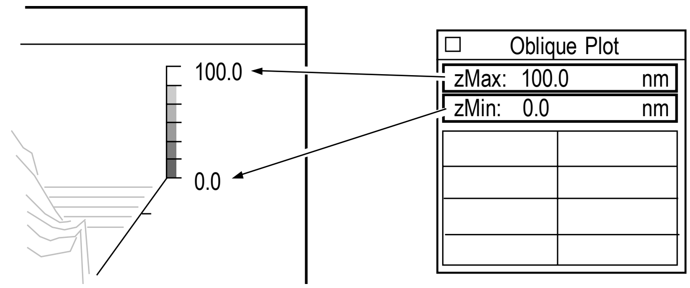
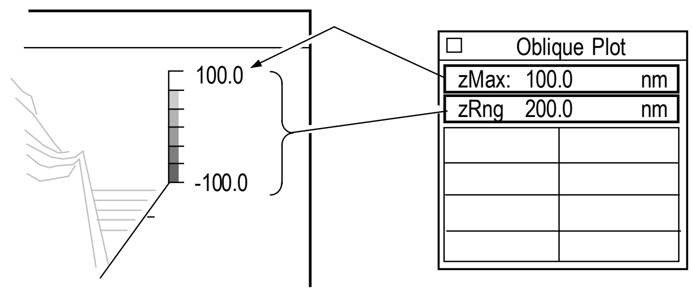
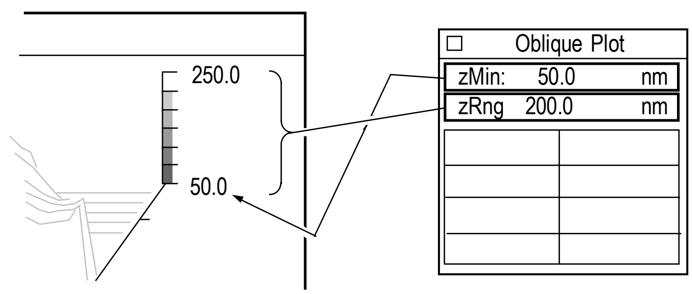
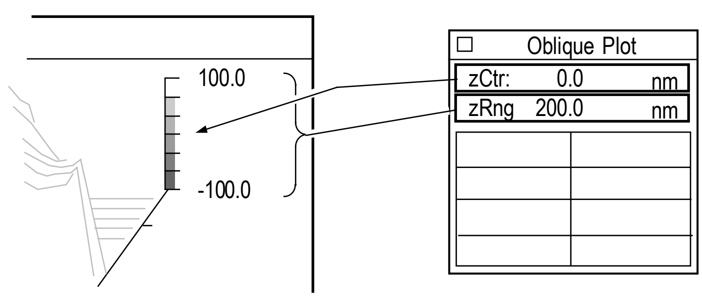
1. Position the pointer over the Z-axis Fixed Scale Tool. Click the right mouse button to change modes.

   Note: There must be values entered in the fixed scale tool for it to function. Note that 0 (zero) is an entry.

Entering Values in the Z-axis Fixed Scale Tool

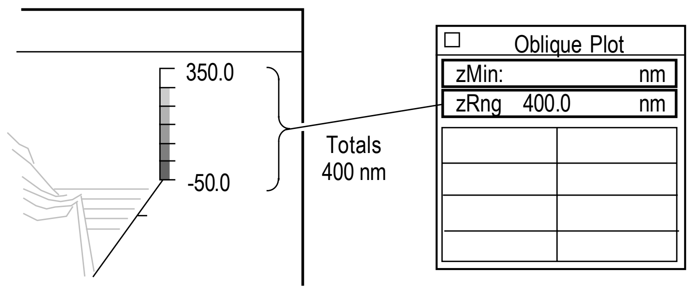
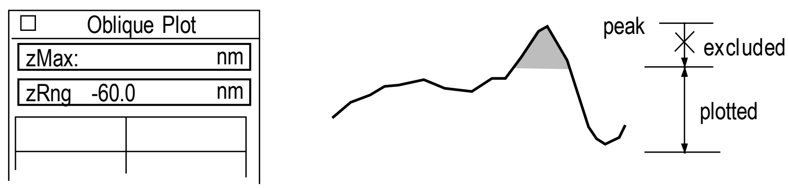
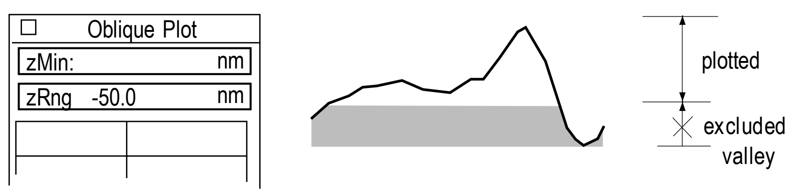
1. Position the pointer over one of the two boxes in the Z-axis Fixed Scale Tool.
2. Click the left mouse button, enter a numeric value, then press [Return]. To erase values, click the left mouse button, delete all characters, then press [Return].
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

Example Use of the Z-axis Fixed Scale Tool

Fixed Scale Modes	***Example***
zMax specifies the upper value. If left blank, zMax defaults to the peak of the data. **zMin** specifies the lower value. If left blank, zMin defaults to the valley of the data.	
zMax specifies the upper value. If left blank, zMax defaults to the peak of the data. **zRng** specifies the range of the scale. If left blank, the scale expands downward to show the data.	
zMin specifies the lower value. If left blank, zMin defaults to the valley of the data. **zRng** specifies the range of the scale. If left blank, the scale expands upward to show the data.	
zCtr specifies the center of the scale. If left blank, zCtr defaults to the mean of the data. **zRng** specifies the range of the scale. If left blank, the scale expands to show the data.	

The Z-axis Fixed Scale Tool's zRng Function

The Z-axis Fixed Scale Tool zRng setting has dual functions. When a positive number is entered it specifies the overall size of the axis. When a negative number is entered, it invokes an exclude option; which works only with the zMax and zMin settings.

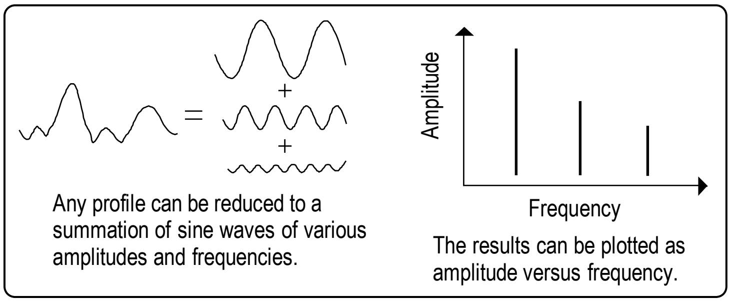
zRng Function	*Example*
zRng (positive) Specifies the overall size of z-axis.	
zMax specifies the upper value. zMax (blank) defaults to the peak. **zRng** (negative) specifies the upper data range to exclude from the plot. (When used with zMax.)	
zMin specifies the lower value. zMin (blank) defaults to the valley. **zRng** (negative) specifies the lower data range to exclude from the plot. (When used with zMin.)	

Profile Spectrum Plots

This discussion covers four plots, all based on profile data. These plots are available in phase profile data windows and are created with the New Plot command.

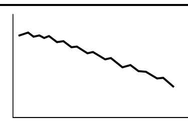
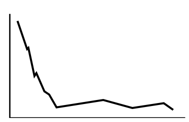
- Amplitude Spectrum Plot
- Peak Amplitude Spectrum Plot
- Power Spectral Density Plot
- Power Spectrum Plot

Any profile can be reduced to a summation of sine waves of various amplitudes and frequencies. This spatial frequency data is obtained from a Fourier analysis of the profile. The profile spectrum plots are used to display the spatial frequency data.



Picture any given test surface as being made up of a combination of sine waves. When displayed as bars, every sine wave component of the test surface appears as a vertical line. Picture any given test surface as being made up of a combination of sine waves. When displayed as bars, every sine wave component of the test surface appears as a vertical line. Its height represents the amplitude or power and its position represents its frequency. For all three plots, logarithmic scaling is often used for the y-axis to compress large amplitudes and expand small ones.

The profile spectrum plots help to characterize the surface features in terms other than roughness. Examine the general shape of the plot. Look at the slope of the plot and the height. Many surfaces tend to have spectrum plots that fall off quickly at the low frequencies and then level out; if this is the case, the surface is dominated by lower spatial frequencies (waviness). When the spectrum plot falls off more evenly over the horizontal axis the surface is dominated by high spatial frequencies (roughness). Spikes usually appear when the surface has distinct spatial frequencies due to a machining process. The spike occurs at the spatial frequency associated with the machining method.

Description	***Power Spectrum Plot***
Surface with little waviness and very high spatial frequencies (microroughness).	
Surface with low spatial frequencies dominant (waviness).	

Note that most surfaces tend to look smoother when examined over increasingly smaller regions, such as when using higher power microscope objectives. The lower power objectives tend to show much more waviness than high power objectives (10X and up). Changing objectives filters the spatial frequencies due to the different magnifications.

Also, note that the use of the filtering controls can drastically affect the spectrum plots, as filtering changes the relative frequency content of the data.

The Amplitude Spectrum Plot

Displays spatial frequency data as amplitude versus frequency. The height of a bar (y-axis) indicates the amplitude of a component sine wave. The position of the bar (x-axis) indicates the frequency. Y-axis units are selectable and are linked to the Height Units control. X-axis units are selectable in cycles per lateral unit and are linked to the Lateral Units control. This plot is also called the Peak Amplitude Spectrum Plot.

The Power Spectral Density Plot

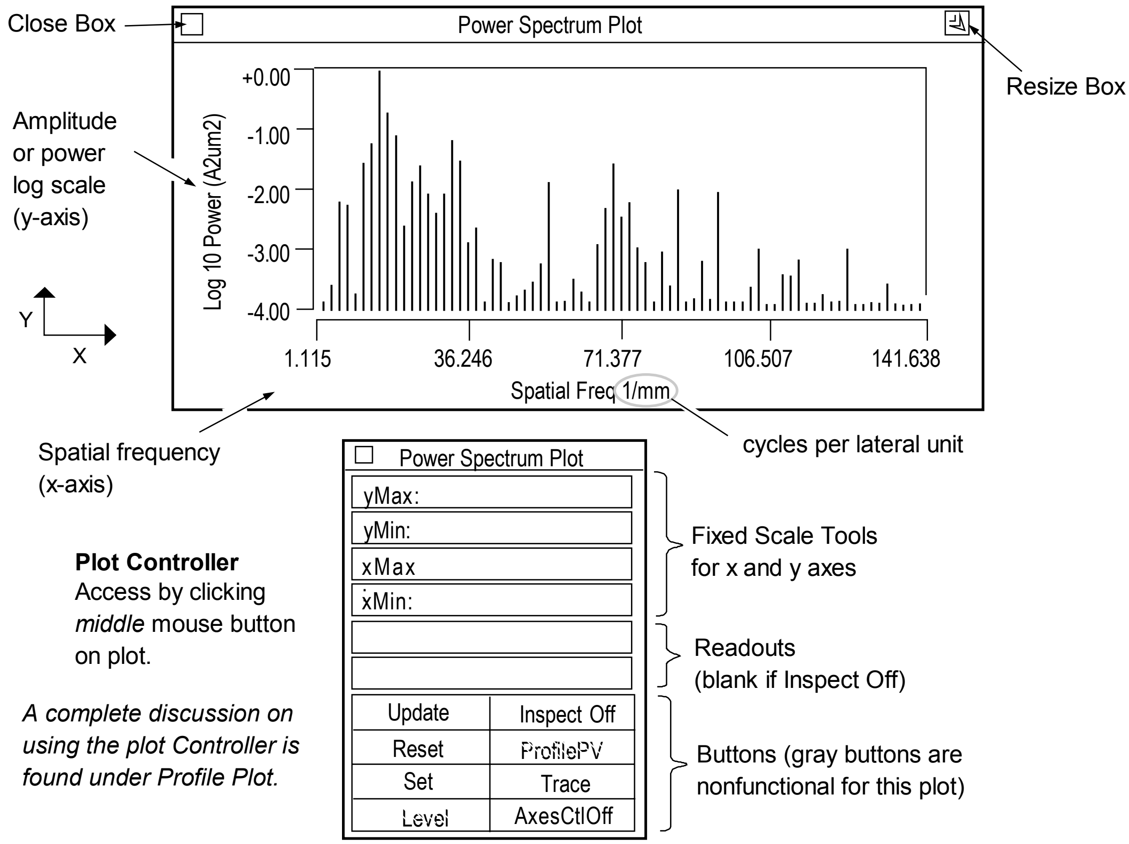
Displays spatial frequency data as power density versus frequency. Power density is calculated as the square of the amplitude of a sine wave multiplied by the length of the profile. The height of a bar (y-axis) indicates the power density of a component sine wave. The position of the bar (x-axis) indicates the frequency. Y-axis units are always angstroms squared microns (A^2um). X-axis units are selectable, in cycles per lateral unit and are linked to the Lateral Units control.

The Power Spectrum Plot

Displays spatial frequency data as power versus frequency. Power is calculated as the square of the amplitude of a sine wave multiplied by the square of the length of the profile. The height of a bar (y-axis) indicates the power of a component sine wave. The position of the bar (x-axis) indicates the frequency. Y-axis units are always angstroms squared microns squared (A^2um^2). X-axis units are selectable in cycles per lateral unit and are linked to the Lateral Units control.

Changing the Profile Spectrum Plots

The plot display is adjusted and modified with the plot Controller. To open the plot Controller, click on the plot with the middle mouse button. The profile spectrum plot Controllers work similar to the profile plot Controller. A secondary button panel for control over the axes is accessed by clicking on the AxesCtl button.



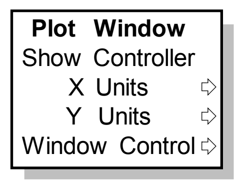
Note: The spectrum plots are calculated for *profiles*; thus, results are indicative of the slice location and orientation and may not accurately reflect the entire part. The longer the profile length, the greater the accuracy.

Displaying the Profile Spectrum Plots

1. In a corresponding map phase data window, define a linear slice through the data within the Filled plot. Slicing is described in Section 4.
2. If the profile spectrum plot is blank make sure that you are using a linear slice and not a circular slice; that you are using corresponding data windows; and that the slice is drawn over an image area in the Filled plot.

   Note: No profile data is calculated or displayed until a linear slice is defined by the user within a Filled plot made in a corresponding phase map data window.

The Profile Spectrum Plot's Menu



Show Controller open the plot controller.

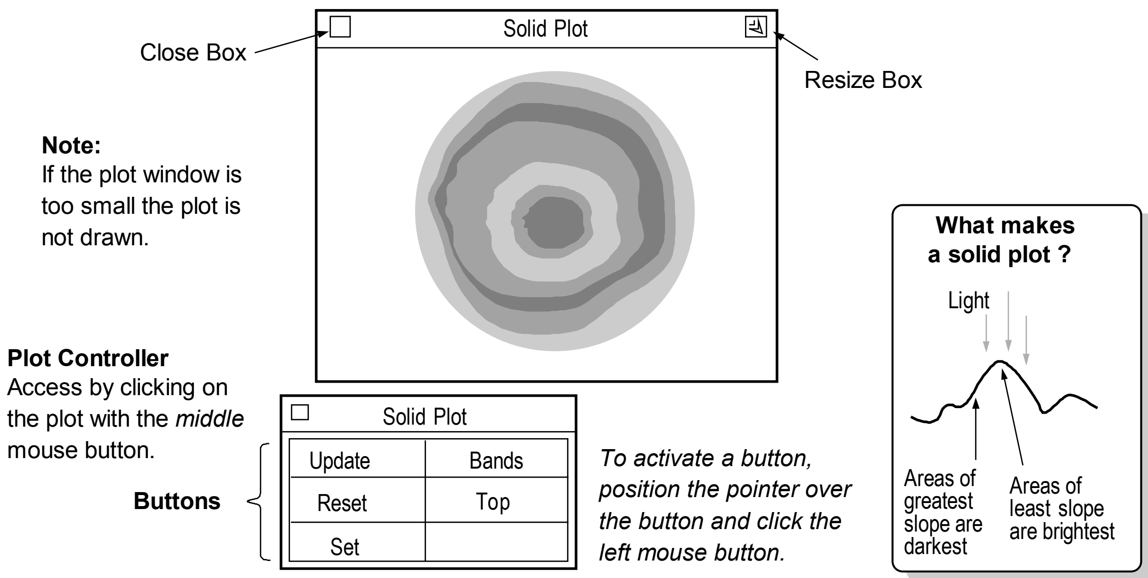
X Units select measurement units for the horizontal or x-axis. If x-axis units are pixels, instrument calibration is required.

Y Units select measurement units for the vertical or y-axis.

Window Control use to move, resize and delete the window, and to rename or hide the window's title bar.

Solid Plot

A Solid plot displays surface data as a function of slope as viewed along the instrument z-axis. Areas with different slopes are represented by different shades. The Solid plot displays high frequency irregularities better than the Filled plot. A Solid plot is available in map data windows and is created using the New Plot command. To open the plot Controller, click on the plot with the middle mouse button.



Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the "set" Controller settings.

Set - Makes the current Controller settings the master or "set" display.

Color - Selects the color of the plot. Choices: Bands (15 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum (48 colors), and Neon (a variation of Spectrum).

View - Selects the view of the data. Top displays a view from above. Oblique displays an inclined view.

Resizing the Solid plot

The plot window is resizable, but the Solid plot size is fixed. Hence, the plot window may be enlarged or reduced, but the size of the plot will not change.

1. Click the window Resize box or select the Plot menu's Resize command.
2. Press and hold the left mouse button, drag the lower right corner bracket of the window outline until it is the desired size, then release the mouse button.

Note: If the window is too small the plot is not drawn.

Special Results

Section 6

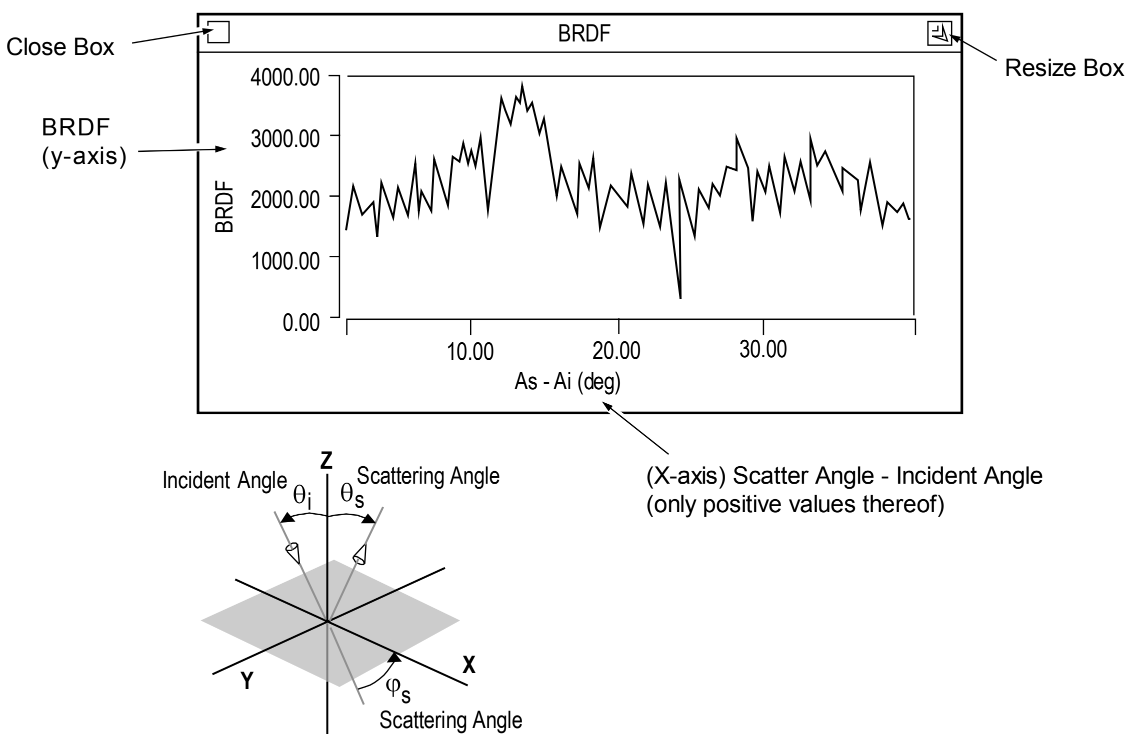
MetroPro provides countless results. Specialized result plots, tables, and windows are covered in this section.

This section describes various specialized results, they are listed in alphabetical order. These results reside in data windows and are created by selecting the New Result (or New Plot) command from the data window's or the Result box's menu. The availability of these results varies depending on the application and data window.

BRDF

BRDF or Bidirectional Reflective Scatter Distribution Function is used to describe scattered light patterns. It is obtained by applying a two-dimensional FFT transform to the input data. The BRDF calculation is only valid for s-polarized in and s-polarized out. It is used to detect component defects and to analyze polished surfaces.

Note: The numerical FFT on the data is a model of the theoretical BRDF analysis and limits the output to the angle entered in the Scattering Angle control.



The BRDF plot displays the BRDF of a surface on the y-axis and the scattering angle minus the incident angle on the x-axis, and only positive values thereof. BRDF analysis requires entries in the Wavelength, Refractive Index, Incident Angle, and Scattering Angle controls. These controls are created with the data window menu's New Control command.

Control	***Function***
Wavelength	Specifies the wavelength of the output data. It is used to display results as if the measurement was performed at a wavelength other than the instrument's wavelength.
Refractive Index	Specifies the refractive index of the part being measured.
Incident Angle	Specifies the angle of the incoming light from the z-axis. It is the polar angle of s-polarized in.
Scattering Angle	Specifies the angle (φ_s) of the outgoing light relative to the plane of incidence; results are calculated based on this angle. It is the polar angle of s-polarized out.

BRDF Reference Material

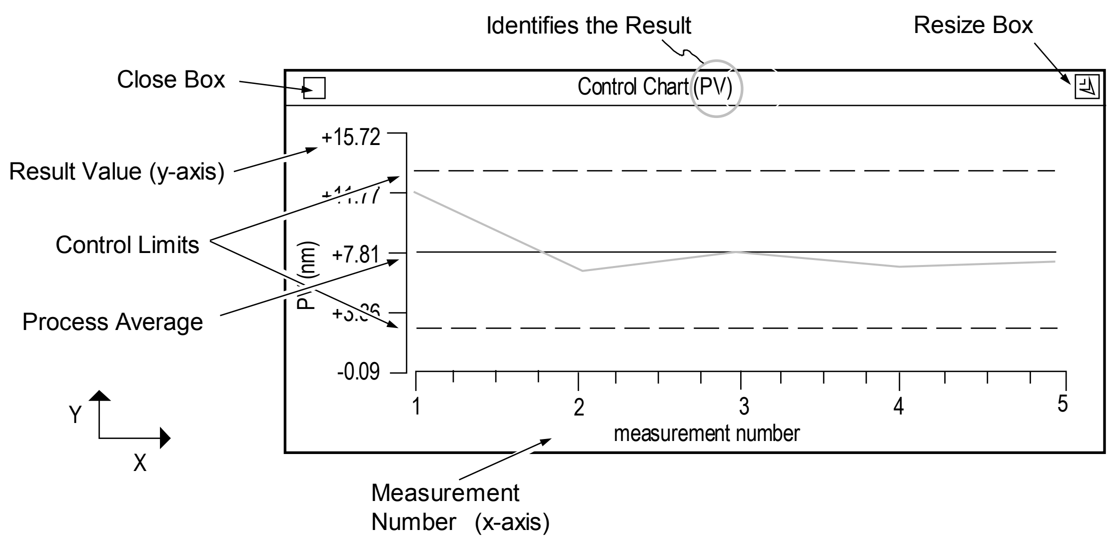
E. L. Church, P. Z. Takacs, and T. A. Leonard, *The Prediction of BRDFs from Surface Profile Measurements* (SPIE Vol. 1165 Scatter from Optical Components, 1989)

Control Chart

A Control Chart is a two dimensional display showing the historical record of one result over multiple measurements. The horizontal or x-axis represents the number of measurements, while the vertical or y-axis represents the absolute result value. Control Charts are available for all results.

The Control Chart is used to shows the variation of one result over a series of measurements. It can be used to compare one result over multiple measurements on similar parts. The Control Chart is for “display” purposes, its contents cannot be saved. To save or output the results of numerous measurements use the Report window.

Control Charts are available in all data windows where there are results; they are also available in the Process window. It is created using the Result menu’s Plots command.



Creating a Control Chart

A Control Chart can be made for any displayed result. However, it must reside within the same Data window as the result.

1. Determine which result(s) you want to track. If the result does not exist within the data window use the New Result command to create it.
2. Position the pointer over the result and select the Plots → Control Chart command. An outline of the chart appears.
3. Move the mouse to position the window. Click the left mouse for the Control Chart to appear.

   Note: When first created the chart is blank. It is updated as measurements are made or as existing data is loaded.

Using the Control Chart

The Control Chart is blank until measurements are made. As measurements are completed the chart is automatically updated with measurement data, control limits, and the mean average line. The settings of the controls in the Process window affect the use of the Control Chart.

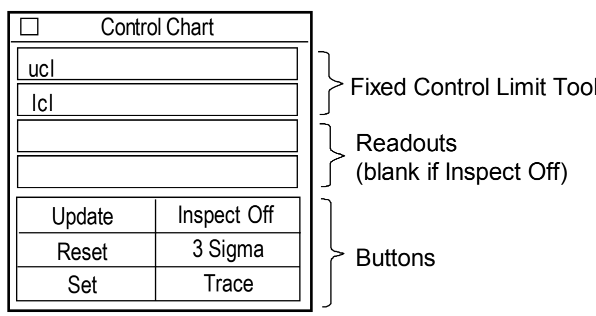
Process Window Control	***Function in Control Chart***
Window Size	Determines the number of measurements displayed on the chart.
Auto Store	If On, the chart is updated as measurements are made.
Store button	When clicked the existing data is entered into the chart.
Clear button	Erases all data from the chart.
Undo button	Removes the last data entered into the chart.

Changing the Control Chart

Most changes for the Control Chart are made with the plot Controller. The Control Chart plot Controller generally works similar to the profile plot Controller. To open the plot Controller for the Control Chart, click on the chart with the middle mouse button.

Plot Controller
Access by clicking on the plot with the *middle* mouse button

A complete discussion on using the plot Controller is found under Profile Plot.



Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the "set" Controller settings.

Set - Makes the current Controller settings the master or "set" display.

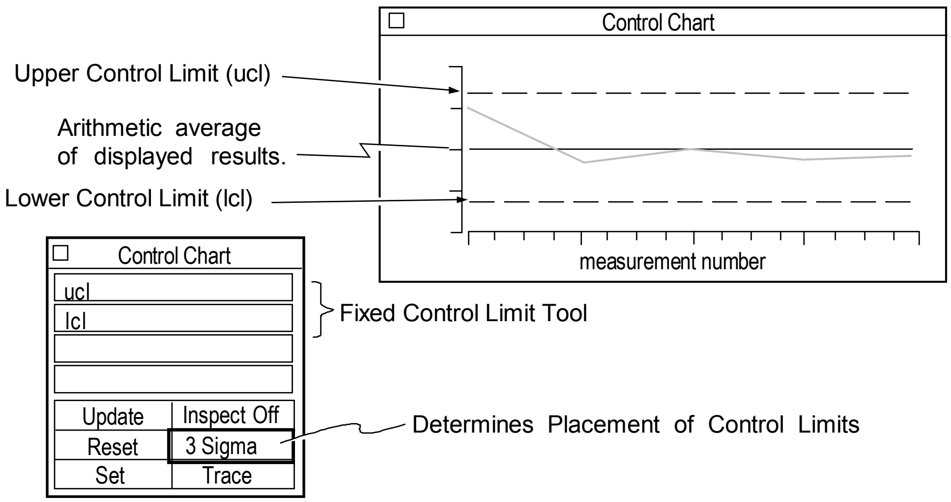
Inspect - Turns inspect features on and off. When Inspect Off the readouts and the plot crosshairs are non-functional. For other selections see Section 4.

Sigma - Selects the position of control limits. 3 Sigma places the limits at three times the standard deviation. 2 Sigma places the limits at two times the standard deviation. 1 Sigma places control limits at the standard deviation. No CLs removes the limits from the chart.

Display - Selects how data is displayed. Trace displays data as a line graph. Bar displays data as a series of vertical bars. Scatter displays data as points.

Working With Automatic Control Limits

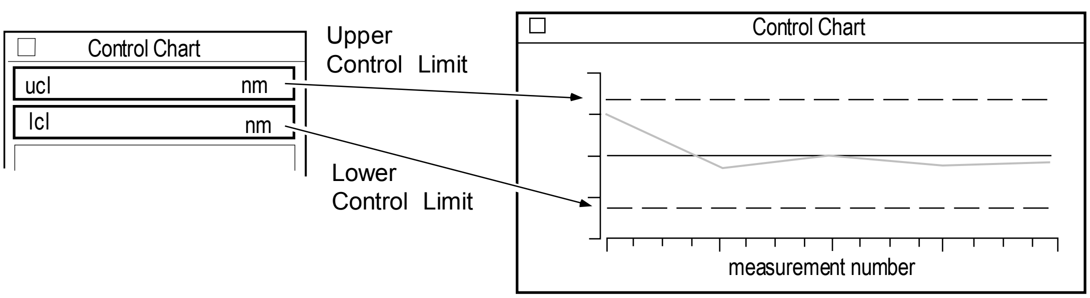
In the default mode, the control limits are automatically calculated based on the displayed results and the setting of the Sigma button. Control limits provide a guide to analysis. They are not specification limits, but are reflections of the natural variability.



1. Click the Sigma button with the left mouse button to select the placement of the limits.
2. Click the plot Controller's Update button to redraw the chart.

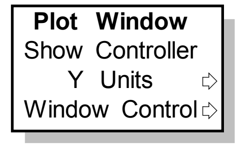
Working With Fixed Control Limits

Control limits may also be turned into specification limits if the Fixed Control Limit Tool is used. If the Fixed Control Limit Tool is used, limits do not change every time a measurement is made and the setting of the Sigma button is ignored.



1. Position the pointer over one of the two boxes in the Fixed Control Limit Tool.
2. Click the left mouse button, enter a numeric value and press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the chart.
4. To preserve your changes, click the plot Controller's Set button.

The Control Chart Menu



Show Controller open the plot controller.

Y Units select measurement units for the vertical or y-axis. If y-axis units are pixels, instrument calibration is required.

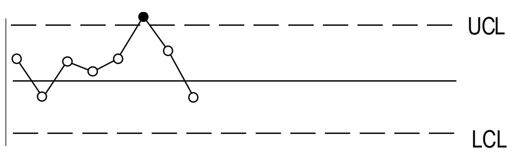
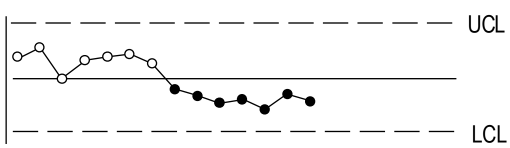
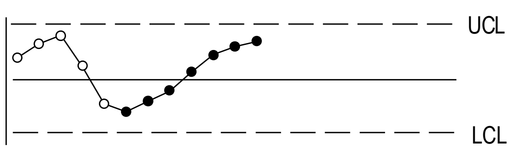
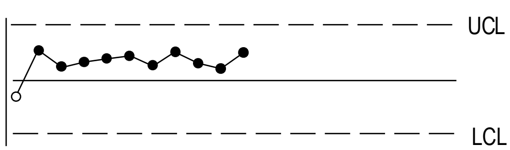
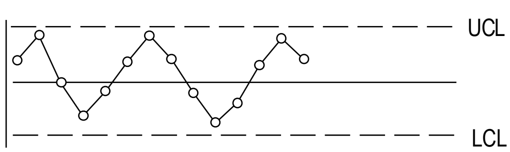
Window Control use to move, resize and delete the window, and to rename or hide the window's title bar.

Bringing Existing Data into the Control Chart

In its default setting, the Chart shows data as measurements are made, but it can also graph existing data.

1. Load an existing data set into MetroPro using the Load Data button.
2. Click the Store button in the Process window.
3. Repeat the above steps for additional data sets.

Reading Control Charts

Control Chart	*Feature of Data*
	**Point Outside of Limit** Control limits are calculated to measure the natural variability of a process. Any point outside the limit is considered abnormal and requires investigation.
	**Run** A series of seven points on one side of the center line is considered abnormal.
	**Trending** Seven points in a continuous upward or downward direction.
	**Grouping** A majority of points on one side of the center line is considered abnormal. A majority is defined as: 10 out of 11, 12 of 14, or 16 of 20.
	**Cycling** Any repetitive up and down trend is abnormal and requires investigation.

DMI Test

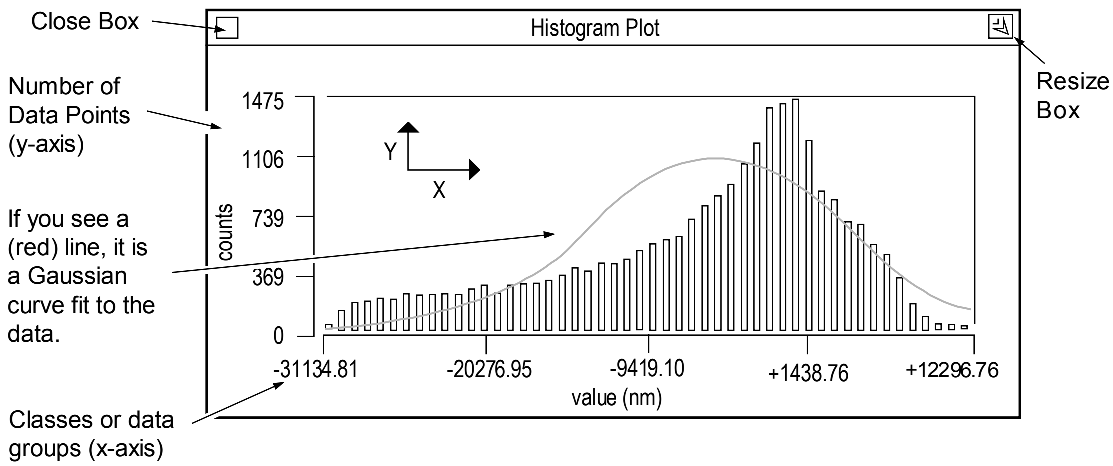
The DMI Test is a Data window available in the GPI application for testing the operation of a Zygo ZMI system or Distance Measuring Interferometer. This feature is used with the GPI radius scale option. The purpose of these results is to track the output of the distance measuring interferometer for a length of time. The values in the result boxes are updated continuously; and by analyzing the various readings, you can determine the stability of the ZMI in your measurement environment. The amount of allowable variation in the readings is dependent on the degree of accuracy you need for your measurement application.

Controls and Buttons	***Description***
Test Drift button	Click to initiate a drift test. This helps to determine the performance of the ZMI system in its present operating environment.
Read button	Click to obtain measurement data from the ZMI system on screen. Click the mouse button (anywhere) to cancel the distance display.
DMI Mode	Selects the frequency of the measurement beam. Choices are Freq 1 or Freq 2.
Test Time (min)	Specifies the time in minutes for the DMI test. Enter a value from 1 to 60. (0.1 minute = 6 seconds) Enter a value that approximates the amount of time it takes to make a measurement.

Results	***Description***
Last Reading	The last value obtained.
Max Reading	The maximum value obtained during the sample.
Min Reading	The minimum value obtained during the sample.
Drift Range	The maximum reading minus the minimum reading.
Drift Mean	The arithmetical average of all readings.
Drift Std Dev	The standard deviation or variation of the readings.
Num Readings	The number of readings from the DMI.
Test Time (min)	Indicates the elapsed time of the test.

Histogram Plot

A Histogram plot is a two dimensional display representing the spread or distribution of data. The horizontal, or x-axis, represents values, while the vertical, or y-axis, represents the occurrences or frequency of the values. A map Histogram plot is based on the all acquired data, where the profile Histogram is based on along a cross section or slice of the test surface. The profile Histogram requires a defined slice in a corresponding Filled plot. The Histogram plot is created using the New Plot command.



The Histogram plot shows the dispersion or spread of the entire data set, if it is used in a map Data window; or the distribution of the data defined by the slice(s), if it is used in a profile Data window. There are a discreet number of data groups used for the x-axis of the Histogram plot . Each data point is categorized to the nearest group, then the frequency of these groups at each interval is plotted. Some Histograms will show a Gaussian curve fit to the data, it is displayed in red. The peak of the Gaussian curve is the average of all classes; it is the sum of all the measured data divided by the total number of data points.

The distributions in the Histogram plot show a pattern of variation of the test surface. A surface with random features has a height distribution that fits the Gaussian curve. A surface with a dominant shape has a non-Gaussian height distribution.

The formula for the Gaussian curve is: $ae^{\frac{-t^2}{2}}$

Where a is a normalization factor, e is equal to 2.71828, and t is equal to $\frac{x - \bar{x}}{sd}$; and where x is each value on x-axis of histogram, $\bar{x}$ is the mean of the data, and sd is the standard deviation of the data.

Displaying the Histogram Plot

If the Histogram plot is used in a map data window, it displays data soon after the measurement.

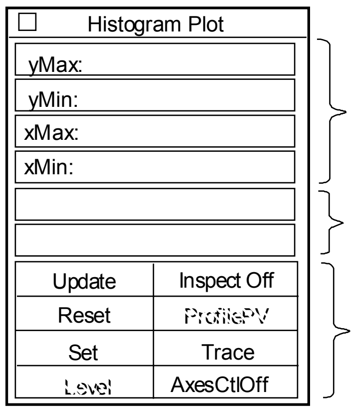
If the Histogram plot is used in a profile data window, a slice must be defined in a corresponding map data window Filled plot before any data is displayed.

Changing the Histogram Plot

The plot display is adjusted and modified with the plot Controller. The Histogram plot Controller works similar to the profile plot Controller. To open the Histogram plot Controller click on the plot with the middle mouse button.

Plot Controller
Access by clicking
middle mouse button
on plot.

A complete discussion on using the plot Controller is found under Profile Plot.



Fixed Scale Tools for x and y axes

Readouts (blank if Inspect Off)

Buttons (gray buttons are nonfunctional for this plot)

Update - Redraws the plot to match the current Controller settings.

Reset - Restores button settings to match the "set" Controller settings.

Set - Makes the current Controller settings the master or "set" display.

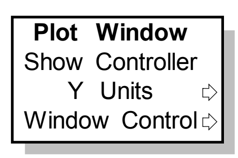
Inspect - Turns inspect features on and off. When Inspect Off the readouts and the plot crosshairs are non-functional. For other selections see Section 4.

Display - Selects how data is displayed. Trace displays data as a line graph. Bar displays data as a series of vertical bars. Scatter displays data as points.

Axes CtlOff - Selects options for the axes scales; opens a secondary button panel.

See "Controlling the Profile Plot's Axes".

The Histogram Plot's Menu



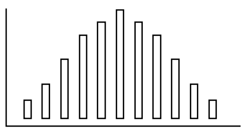
Show Controller open the plot controller.

Y Units select measurement units for the vertical or y-axis. If y-axis units are pixels, instrument calibration is required.

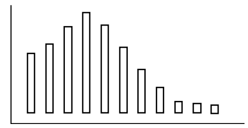
Window Control use to move, resize and delete the window, and to rename or hide the window's title bar.

Understanding Histograms

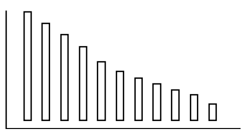
A histogram is a tool to recognize patterns; they provide information on the degree of variation of the data as well as indicate a distribution pattern. Dispersion of the data can produce a wide variety of shapes depending upon the data we are viewing.



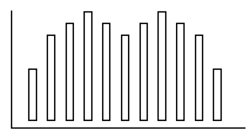
Normal
Most values fall toward the center of the distribution and the variation on both sides of the center is balanced.



Skewed
A skewed histogram has a long tail on one side. This can indicate a shift of some variable.



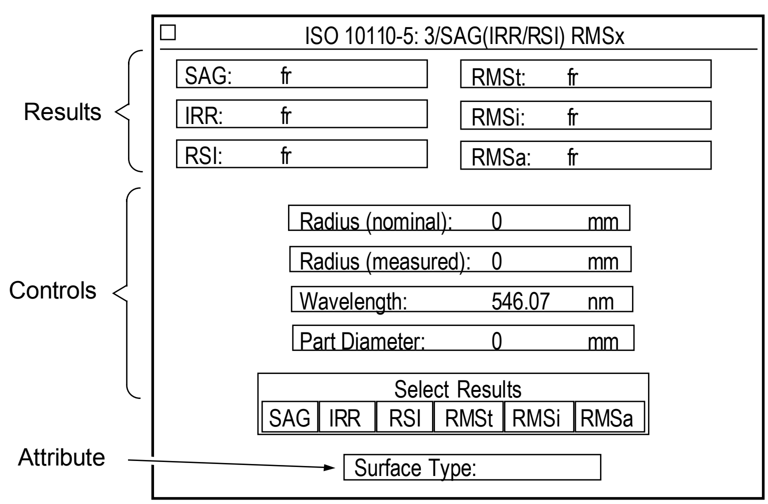
Precipiced
Most values appear shifted to one of the sides. This could occur when the data has been sorted or when there is some natural barrier.



Bi-Modal
There appear to be two peaks. This usually occurs when two different data groups are mixed.

ISO 10110-5 Window

The ISO 10110-5 Window is specialized window that provides results specified by the ISO figure specification (ISO 10110-5). The window is preconfigured with results and controls when created. It typically is used with a GPI XP or Mark IV*xp* interferometer system. Additional information is available in the SPIE (Society of Photo-Optical Instrumentation Engineers) Proceeding Reprint Volume 1776, Interferometry: Surface Characterization and Testing (1992).



Example of ISO 10110-5 Window

ISO Controls and Results

Controls	*Description*
Select Results	Selects which ISO results are calculated. They can be selected in any combination. Choices are SAG, IRR, RSI, RMSt, RMSi, and RMSa.
Wavelength	Selects the wavelength of the output results. This defaults to 546.07 nm by ISO 10110-5 and corresponds to the green emission line of mercury.
Radius (measured)	Specifies the actual measured radius of curvature of the part being measured. This radius is supplied from some other means, such as the Radius Scale Application.
Radius (nominal)	Specifies the nominal radius of curvature of the part being measured. Either Radius entry is required, but not both.
Part Diameter	Specifies the nominal part diameter of the part being measured. Required entry.

Results	*Description*
3/A(B/C)	SAG, IRR, and RSI in ISO form.
IRR	Irregularity (IRR) is the tolerance of the surface form error which remains after the sagitta error is removed. It is the PV with respect to the best fit reference sphere.
RMSa	Residual RMS from the best fit AAS (Approximating Aspheric Surface) after best fit plane and sphere are subtracted. A version of RMS error.
RMSi	Residual RMS from the best fit sphere after best fit plane is subtracted. A version of RMS error.
RMSt	Residual RMS from the best fit plane. A version of RMS error.
RSI	Rotationally Symmetric Irregularity (RSI) is the tolerance on the rotationally symmetric component of the surface form error after the best fit sphere is subtracted. It is the PV of the Approximating Aspheric Surface (AAS).
SAG	Sagitta error (SAG) is the tolerance on the power or focus of the surface with respect to a reference sphere with the nominal radius of curvature.
Surface Type	Displays the type of surface the ISO results are based on. This is an Attribute only.

MTF

The MTF (Modulation Transfer Function) of an optical system indicates the ability of the system to resolve detail as a function of the spatial frequencies present in the object. Perfect resolution is indicated by an MTF value of 1; at the cutoff frequency of the lens the value of the MTF decreases to 0.

In MetroPro, MTF is available as a map and a profile data window; these data windows are created with the New Data Window → Phase Test/ Default → MTF command. Plots and results inside of these windows represent the ability of a lens or optical system to resolve object detail.

The Filled plot and 3D plot available inside the MTF map data window provide a qualitative indication of the performance of the lens system. A symmetric cone shape 3D plot indicates a well assembled, centered lens system performing near the diffraction limit. An asymmetric shape indicates a lens system where the rotational symmetry has been affected either inadvertently through improper fabrication or deliberately as a result of the design.

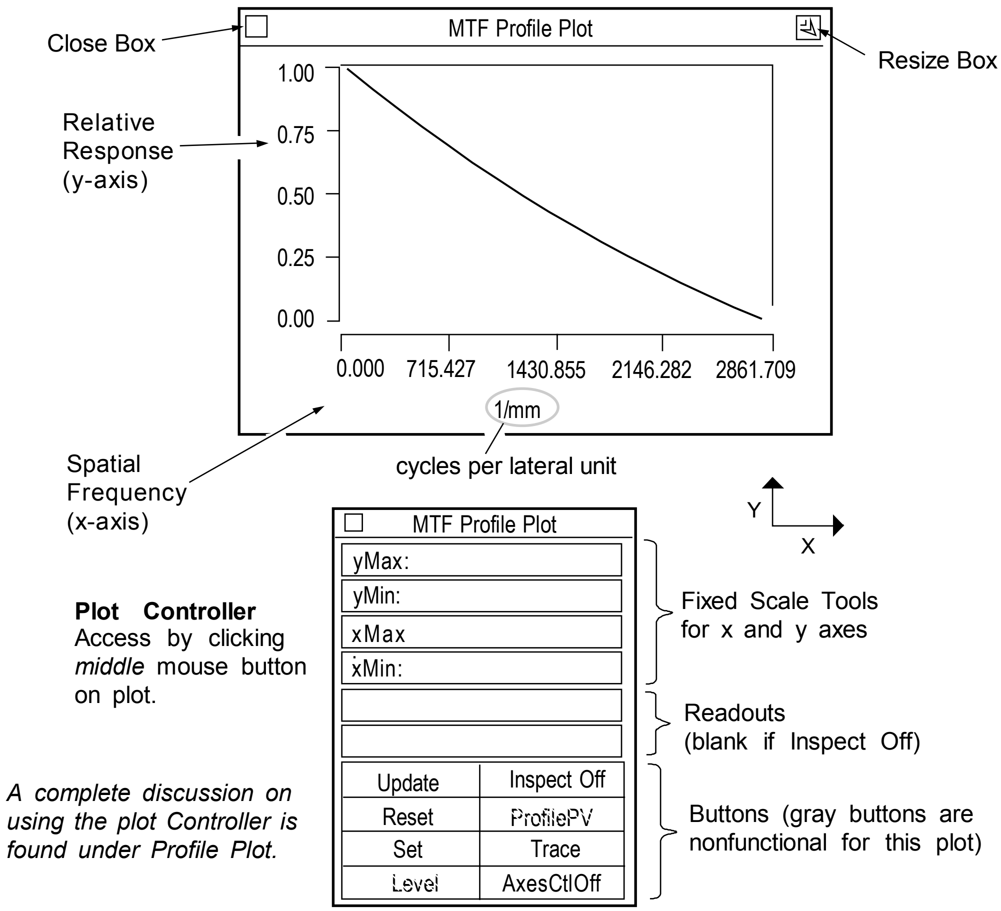
If quantitative information concerning the MTF data is desired, you have two options: the MTF Profile plot and the MTF table. The MTF Profile plot allows you to view a profile of the MTF data in any angular orientation. This makes it possible to quantitatively observe the variation in a lens response with object orientation. Where the MTF Profile plot reaches zero is the maximum spatial frequency that can be resolved by the lens; this frequency is called the cutoff frequency. The cutoff frequency is displayed in a Cutoff Freq result. The number entered in the f-number control is used for the calculation of the Cutoff Freq result.

The MTF Profile plot makes it possible to quantitatively observe the variation in a lens response at any object orientation. The functional form of the MTF curve is dependent on the wavefront quality, the wavelength of the light, and the size and shape of the aperture. If precise MTF versus spatial frequency data is required, the inspectors can be used to obtain the x and y values for any location on the MTF curve. The cutoff frequency is the maximum spatial frequency that can be resolved by the lens; it is where the MTF curve goes to zero.

The MTF table provides tabulated values of the MTF in four orientations: 90°, 45°, 0°, and -45°. This is equivalent to creating profiles in four directions from the center of the MTF Filled plot to the edge and listing the modulation values for various spatial frequencies.

MTF Profile Plot

The MTF Profile plot allows the user to view a profile of the MTF data in any angular orientation. The MTF Profile plot is available in a MTF profile Data window and is created using the New Plot command. To open the plot Controller click on the plot with the middle mouse button.



Displaying the MTF Profile Plot

1. In a corresponding map MTF Data window, define a Radial Ctr slice through the data within the Filled plot. Slicing is described in Section 4.
2. If the plot is blank make sure that you are using corresponding MTF data windows; and that the slice is drawn over an image area in the Filled plot.

Note: No profile data is calculated or displayed until a Radial Ctr slice is defined by the user within a Filled plot made in a corresponding map MTF Data window.

MTF Profile Plot X-axis Units

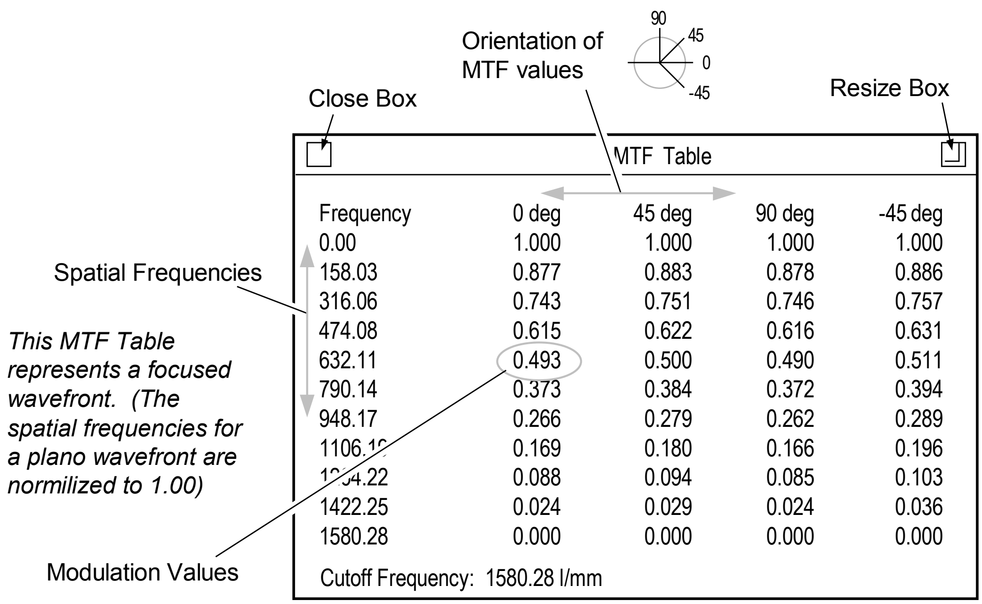
The x-axis units on the MTF Profile plot vary depending upon the wavefront of the optic being tested. With an optic that has a focused wavefront, or an f-number greater than zero, the x-axis is shown in cycles per millimeter (l/mm). With an optic that has a plano or afocal wavefront, or an f-number equal to zero, the x-axis units are normalized to one.

Changing the MTF Profile Plot

The plot display is adjusted and modified with the plot Controller. The MTF plot Controller works similar to the profile plot Controller.

MTF Table

The MTF table is a specialized window that lists the MTF results in numerical form. It is available in the MTF map data window; and it is created with the New Result command. To print a copy of the MTF table, selected the Window Control → Print command.



Frequency	0 deg	45 deg	90 deg	-45 deg
0.00	1.000	1.000	1.000	1.000
158.03	0.877	0.883	0.878	0.886
316.06	0.743	0.751	0.746	0.757
474.08	0.615	0.622	0.616	0.631
632.11	0.493	0.500	0.490	0.511
790.14	0.373	0.384	0.372	0.394
948.17	0.266	0.279	0.262	0.289
1106.19	0.169	0.180	0.166	0.196
1264.22	0.088	0.094	0.085	0.103
1422.25	0.024	0.029	0.024	0.036
1580.28	0.000	0.000	0.000	0.000

MTF Reference Material

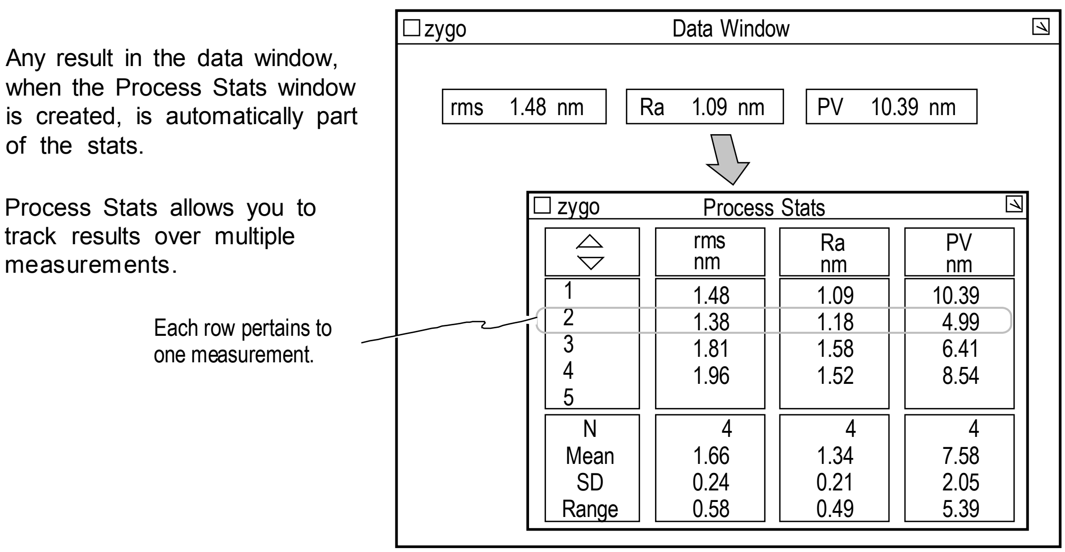
Joseph W. Goodman, *Introduction to Fourier Optics* (New York: McGraw Hill, 1968).

Process Stats

Process Stats (Statistics) is a specialized result window which displays statistics about results for multiple measurements. It is useful when comparing the results of multiple measurements on similar parts. It serves as a statistical process tool. It is created using the New Result → Process Stats command.

The information displayed inside the Process Stats window is determined by the results within the same data window when the Stats result is created. Only results are displayed in the Stats window, Annotations and Attribute boxes are not.

The Process Stats result window is available in all data windows that have results, including both profile and map data. Process Stats are also available in the Process window. The Process Stats result window is similar to Profile Stats window, except the Process Stats is for multiple measurements, where Profile Stats is for multiple profiles on a single measurement.



Creating the Process Stats Window

1. Ensure that the results you want to appear in the Stats window are displayed in the same data window. Otherwise, create the desired Result boxes.

2. Use the New Result → Process Stats command to create the Process Stats window. When the window outline appears, press and hold a mouse button, move the mouse to relocate the window, then release the button.

   Note: When first created the Stats window is blank. The Stats window is updated as measurements are made or as existing data is loaded. The column order is determined by the creation order of the results. The total number of measurements displayed is determined by the Window Size control in the Process window.

Using Process Stats

Process Stats are blank until measurements are made. As measurements are completed the chart is automatically updated with measurement data and statistics. The settings of the controls in the Process window affect the use of the Process Stats.

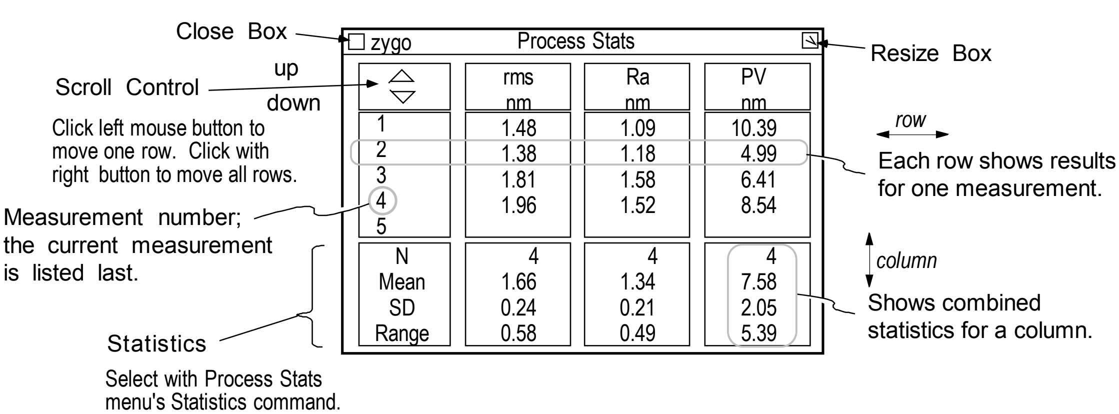
Process Window Control	*Function in Process Stats*
Window Size	Determines the number of measurements displayed in the stats.
Auto Store	If On, the chart is updated as measurements are made.
Store button	When clicked the existing data is entered into the Process Stats.
Clear button	Erases all data.
Undo button	Removes the last data entered into the stats.

The Process Stats Window

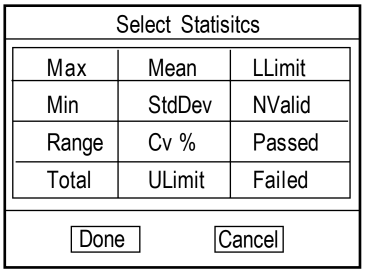
The Process Stats window lists the results for multiple measurements and provides combined statistical information on each result. Depending upon the state of the controls in the Process window, results can be dynamically updated as measurements are made, or existing data sets can be opened and added.

Each row of results in the Process Stats window corresponds to one measurement. The measurements are listed in reverse order, with the current measurement is listed last. Results in the window are listed in order of creation.

The Process Stats window is a "display" window, its contents cannot be saved. To save or output the results of numerous measurements use the Report window.



Displaying the Statistics in the Process Stats



Max The maximum value of all results in the column.

Min The minimum value of all results in the column.

Range The maximum result value minus the minimum value.

Total The sum of the values in the column.

Mean The arithmetical average of the values in the column.

StdDev The standard deviation of all values in the column.

Cv % Coefficient of variation times 100. CV is equal to StdDev divided by Mean.

ULimit Shows the setting of the high limit in the result.

LLimit Shows the setting of the low limit in the result.

NValid The number of valid measurements.

Passed The number of measurements within set limits for the result.

Failed The number of measurements outside set limits for the result.

1. Position the pointer over the window and press the right mouse button.
2. Select the Statistics command. A Select Statistics dialog opens.
3. Click the buttons in the dialog box to select the statistics to display, then click the Done button.

Changing the Height of the Process Stats

The height or y-direction can be resized with the Resize box or the Resize command. The center portion of the Process Stats window is the only resizable section, the top and bottom sections are fixed. Any number of rows may be displayed, even more or less rows of data than exist. Blank rows indicate no data. Click the left or right mouse button on the Scroll control to move rows up or down.

1. Press and hold the left mouse button on the Resize box, a central resize outline appears.
2. Move the mouse to change the height of the window and then release the mouse button.

Changing the Width of the Process Stats

The width or x-direction is determined by the number of results displayed and their individual specified widths. To change the width of one column:

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Value Format → Width command. Input a new width value with the keyboard and press [Enter].
3. Repeat these steps for other results.

Bringing Existing Data into the Process Stats

In its default setting, the Process Stats window shows data as measurements are made, but it can also display statistics on existing data.

1. Load an existing data set into MetroPro using the Load Data button.
2. Click the Store button in the Process window.
3. Repeat the above steps for additional data sets.

Adding or Removing the Results Displayed in the Process Stats

1. Delete the current Stats window with the Window Control → Delete command. Confirm your action by clicking the Yes button in the Dialog box.
2. Add or delete Result boxes in the same data window.
3. Select the New Result → Process Stats command. When the window outline appears, press and hold a mouse button, move the mouse to relocate the window, then release the mouse button. A new Process Stats window appears.

Changing Result Units in the Process Stats

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Units command and choose a measurement unit.

Displaying Limits in the Process Stats

Limits can be set for each result column so that individual results in the column are displayed in red or green depending on the numeric result.

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Limits command, enter a value with the keyboard, then press [Enter]. Limits → High specifies the high limit; any result in the result column above this value turns red. Limits → Low specifies the low limit; any result in the result column under this value turns red.

Process Stats (Limits)

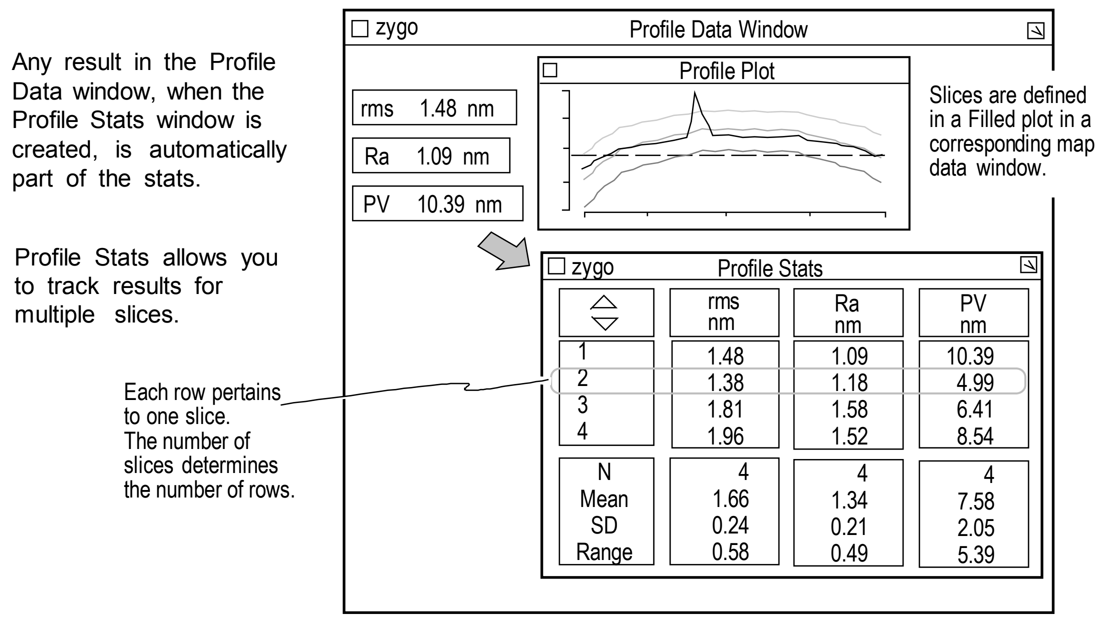
The Process Stats (Limits) window is a variation of the Process Stats window. They both display statistics about results, tracking them over multiple measurements. With standard Process Stats all measurements are displayed. In the case of Process Stats (Limits) only those measurements that pass all user set limits on results are displayed.

If user set limits for even one result in the window are exceeded, the measurement is not displayed in the statistics. If there are no limits set for results with the result menu's Limits command, then the Process Stats (Limits) window will have the same function as the standard Process Stats window.

Profile Stats

Profile Stats is a specialized result window which displays various statistics about profile data. The information displayed inside the Profile Stats window is determined by the slice(s) in a corresponding Filled plot. The results that show up in the Profile Stats result are copies of those found in the same data window when the Stats result is created. Only results are displayed in the Stats window, Annotations and Attribute boxes are not.

Profile Stats relate to profile data; it is different from Process Stats, which can relate to any results. The Profile Stats window is created using the New Result → Profile Stats command.



Creating the Profile Stats Window

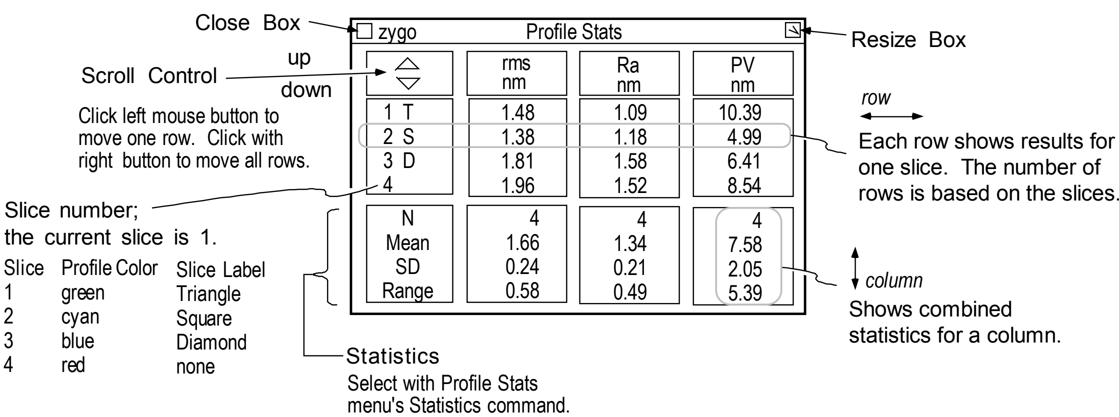
1. Ensure that the slices you want to appear in the Stats windows are created in the Filled plot of the corresponding map data window. Otherwise, create the desired slices.
2. Ensure that the results you want to appear in the Stats window are displayed in the profile data window. Otherwise, create the desired Result boxes.
3. In the profile data window, select the New Result → Profile Stats command to create the Profile Stats window. When the window outline appears, press and hold a mouse button, move the mouse to relocate the window, then release the button.

   Note: If there are no valid slices the Stats window is blank. The Stats window is updated as measurements are made or as the slices are modified or moved through the existing data. The row order is determined by the creation order of the slices. The column order is determined by the creation order of the results.

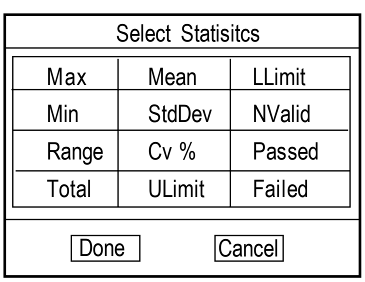
The Profile Stats Window

The Profile Stats window lists the results for one or more slices and provides combined statistical information on each result. When the slices in the corresponding Filled plot are modified, the Stats results are automatically updated. Each row of results in the Stats window corresponds to one slice. The top row lists the results on the “current” slice, which is the last created or modified slice. The underlying rows list the results in consecutive order.

The order that the results appear in the Stats window is determined by the row order of the slices in the profile data window at the time the Stats result is created. To change the order, you must delete the Stats window, change the order of the slices in the data window, and recreate the Stats result. Stats cannot be part of a Report window.



Displaying the Statistics in the Profile Stats



Max The maximum value of all results in the column.

Min The minimum value of all results in the column.

Range The maximum result value minus the minimum value.

Total The sum of the values in the column.

Mean The arithmetical average of the values in the column.

StdDev The standard deviation of all values in the column.

Cv % Coefficient of variation times 100. CV is equal to StdDev divided by Mean.

ULimit Shows the setting of the high limit in the result.

LLimit Shows the setting of the low limit in the result.

NValid The number of valid measurements.

Passed The number of measurements within set limits for the result.

Failed The number of measurements outside set limits for the result.

1. Position the pointer over the window and press the right mouse button.
2. Select the Statistics command. A Select Statistics dialog opens.
3. Click the buttons in the dialog box to select the statistics to display, then click the Done button.

Changing the Height of the Profile Stats

The height or y-direction can be resized with the Resize box or the Resize command. The center portion of the Profile Stats window is the only resizable section, the top and bottom sections are fixed. Any number of rows may be displayed, even more or less rows of data than exist. Blank rows indicate no data. Click the left or right mouse button on the Scroll control to move rows up or down.

1. Press and hold the left mouse button on the Resize box, a central resize outline appears.
2. Move the mouse to change the height of the window and then release the mouse button.

Changing the Width of the Profile Stats

The width or x-direction is determined by the number of results displayed and their individual specified widths. To change the width of one column:

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Value Format → Width command. Input a new width value with the keyboard and press [Enter].
3. Repeat these steps for other results.

Bringing Existing Data into the Profile Stats

In its default setting, the Process Stats window shows data as measurements are made, but it can also display statistics on existing data.

1. Load an existing data set into MetroPro using the Load Data button.
2. Click the Store button in the Process window.
3. Repeat the above steps for additional data sets.

Adding or Removing the Results Displayed in the Profile Stats

1. Delete the current Stats window with the Window Control → Delete command. Confirm your action by clicking the Yes button in the Dialog box.
2. Add or delete Result boxes in the same profile data window until the results you want are displayed.
3. Use the New Result → Profile Stats command to create a new Profile Stats window. When the window outline appears, press any mouse button, move the mouse to relocate the window, and release the button.

Changing Result Units in the Profile Stats

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Units command and choose a measurement unit.

Displaying Limits in the Profile Stats

Limits can be set for each result column so that the slice results within the set limits display green and those out of specification display red.

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Limits command, enter a value with the keyboard and press [Enter]. Limits → High specifies the high limit; any result in the result column above this value turns red. Limits → Low specifies the low limit; any result in the result column under this value turns red.

PSF

The PSF (Point Spread Function) is a mathematical representation of the energy distribution in the output of a lens or optical system. The PSF plots display the absolute value of the light amplitude at the focus of the wavefront. The form of the PSF function is dependent on the wavefront quality, the wavelength of the light, and the size and shape of the aperture.

Plots and results inside of the PSF data window represent the energy intensity distribution around the image of a point source. The Filled plot and 3D plot available inside the PSF Data window provide a qualitative indication of the performance of the lens system. The Filled plot display for a perfect lens system would be represented by a bright central spot surrounded by rings of decreasing brightness. This pattern is commonly referred to as an Airy disk. The Encircled Energy Plot displays quantitative information of the distribution of energy within the PSF plot.

> **Note:** If the PSF data does not fall to zero at the edge of the Filled or 3D plot due to a large amount of aberration, the data displayed in the plot is incorrect due to aliasing. In other words, the data that falls off one edge is added to the data on the opposite edge.

You may control the resolution of the array used in the computation of PSF analysis with the PSF Size control. A Strehl result displays the ratio of the peak intensity of light in an aberrated point image to that of unaberrated point image. The number entered in the f-number control is used for the calculation of PSF.

PSF Reference Material

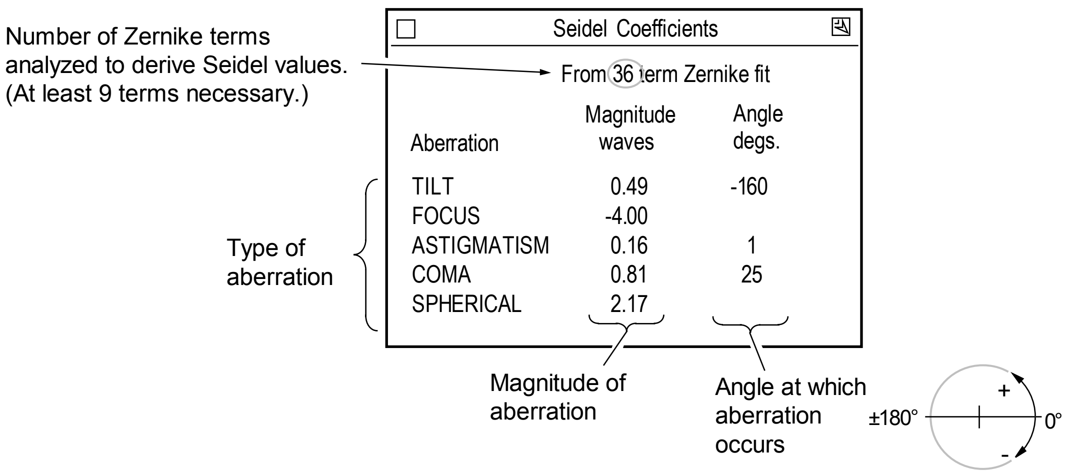
Joseph W. Goodman, *Introduction to Fourier Optics* (New York: McGraw Hill, 1968).

Seidel Coefficients

Seidel aberrations are the first and third order wavefront aberrations of an optical system. They are also known as primary, or third-order aberrations. There are nine Seidel results: All (described below), TltMag, TltAng, FocMag, AstMag, AstAng, ComMag, ComAng, and SA.

> **Note:** Seidels are designed for circular data sets. Seidels of noncircular data sets may be erroneous.

Seidel "All" results are listed in a specialized window which may be created in a phase data window using the New Result → Seidels → All command. Each aberration listed in this window may be displayed as individual Result boxes.



The wavefront aberration coefficients for the first order include tilt and focus. The wavefront aberration coefficients for the third order include astigmatism, coma, and spherical aberration. In the result window, the magnitude of each aberration is shown in waves. For tilt, astigmatism, and coma, the angle of the aberration is shown in degrees. Values for both tilt and coma vary ±180°, while the values for astigmatism vary ±90°.

Zernike polynomials are used to calculate Seidel results, and at least 9 Zernike terms must be analyzed for Seidel results to be displayed.

Seidel Formulas

Where z(number) represent Zernike terms, z4 is the 4th term, z5 is the 5th term, etc…

Result	*Formula*
AstAng (Z)	$0.5 \arctan\left(\frac{z5}{z4}\right)$
AstMag (Z)	$2\sqrt{z4^2 + z5^2}$
ComAng (Z)	$\arctan\left(\frac{z7}{z6}\right)$
ComMag (Z)	$3\sqrt{z6^2 + z7^2}$
FocMag (Z)	$2\,(z3) - 6\,(z8)$
SA (Z)	$6.0\,(z8)$
TltAng (Z)	$\arctan\left(\frac{y\ tilt}{x\ tilt}\right)$
TltMag (Z)	$\sqrt{x\ tilt^2 + y\ tilt^2}$

Slope Data

Slope data windows present data about the slope of the wavefront. Plots created in the Slope X window shows slope information occurring the x-axis, the Slope Y window shows the y-axis.

Slope data displayed as a Filled plot provides a good visual representation of the relative slopes present in the surface, or the transmitted wavefront, of the item being tested. The plots are useful for spotting small defects that may be hidden by overall surface, or transmitted wavefront, errors in other types of plots. The Slope X Filled plot appears as a solid surface with x-axis slopes highlighted by what appears to be a light source to the left of the plot. The Slope Y Filled plot is similar, except that only slopes occurring in the y-axis are shown, and the apparent light source is below the plot.

X and Y slopes of each data point are determined by comparing the values of the data points surrounding it.

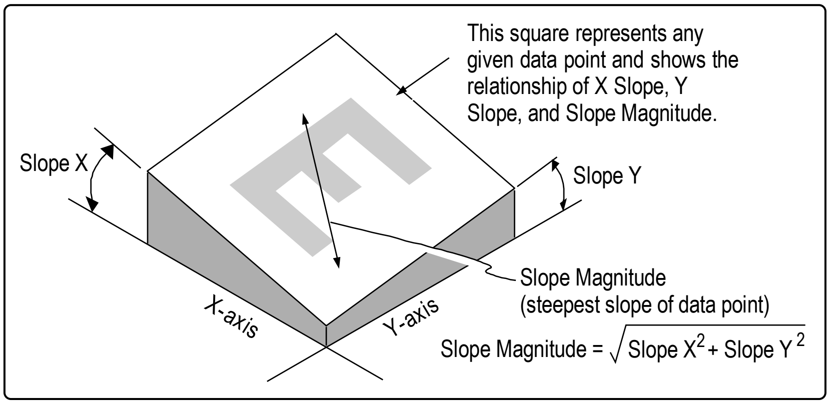
For Data Point E:

$$\text{Slope X} = \frac{F - D}{2}$$

$$\text{Slope Y} = \frac{B - H}{2}$$

A	B	C
D	**E**	F
G	H	I

This block represents any given group of nine adjacent data points.



Plots created in a Slope Mag Data window shows information about slopes occurring in between the X and Y axes. In a Slope Mag Filled plot, areas of steepest slope appear brightest (regardless of whether the slope is positive or negative), while areas of least slope appear darkest (the inverse of the way a standard Solid plot is displayed). Therefore, only the rising and falling edges (areas of steepest slope) of wavefront features are clearly shown in the Slope Mag Data window.

If testing a part with a slope specification, create a Peak Result box in the Slope Mag Data window. Change the measurement units for the Peak result with the PV menu's Units command.

Spectrum Data

The Spectrum Data window shows spatial frequency spectrum data obtained by applying a two-dimensional FFT transform to test/default data. The use of the Spectrum Data window increases the time required for analysis.

The Spectrum Data window breaks data into frequency components. The plots can be used to determine if a surface is anisotropic and for viewing surface characteristics, such as machining marks and other repetitive structures. Z-axis scaling for plots is the log of the magnitude of the 2D FFT.

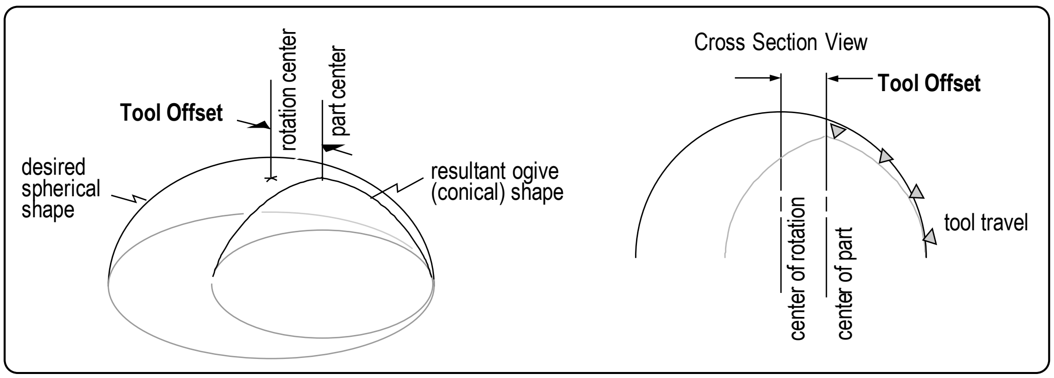
The data displayed in the Spectrum Data window is controlled by the Remove, Shape, and Window controls. These controls are created with the data window menu's New Control command.

Tool Offset

MetroPro can be configured to calculate the tool decentration or offset of turned spherical parts. Calculation of tool offset is usually done so the cutting tool can be reset closer to the axis of rotation. Measuring the tool offset of spherical parts is best performed using a GPI XP interferometer. This entry describes measuring tool offset, and covers the Nominal RadCrv and Tool Offset Sign controls, and the Tool Offset result.

In the case of a diamond-turned optical component, the optical figure is generated as the tool is moved over the surface to create a circular arc. The Tool Offset result establishes to what extent the center of this circular tool arc lies on the spindle axis or axis of rotation. If the tool's center is misaligned with respect to the spindle axis, an aberration known as ogive error is generated. The term "ogive" is so named because of its resemblance to a pointed gothic archway.

Tool Offset is the horizontal decentration, which will actually alter the overall figure of the part. When there is vertical decentration, the tool is denied access to the central region of the spherical part; it does not affect the surface figure significantly. Tool Offset is concerned only with horizontal decentration.



Item	*Description*
Nominal RadCrv control	Specifies the nominal or planned radius of curvature of the spherical part. This value must be entered before making a measurement. Use a negative sign for concave surfaces, convex surfaces are positive.
Tool Offset Sign control	Changes the sign of the Tool Offset result to accommodate different test setups or lathe polarity. Settings are Unchanged or Changed.
Tool Offset result	The lateral distance from the physical center of the part to the center of the curve of the arc of the cutting tool, along the horizontal axis of the part.

Measuring Tool Offset

1. Open the standard GPI application.
2. In the phase map data window, create Nominal RadCrv and Tool Offset Sign controls with the New Control command. Then use the New Result command to create the Tool Offset result.
3. Click on the Nominal RadCrv control and enter the nominal or planned radius of curvature of the test part.
4. Set up the interferometer as instructed in the operator's manual for measuring a spherical part.
5. Before making a measurement, you must perform lateral calibration. An overview of lateral calibration is: Click the Calibrate button. Press and hold the left mouse button, move the mouse to draw a line across the image area, then release the mouse button. The line should match up to some portion of the image for which you know the dimension. Enter the dimension of the line in millimeters and press [Enter]. Close the Calibrator window.
6. Press F1 or click the MEASURE button. When the analysis is complete, the Tool Offset result is displayed. A sample ogive wavefront is shown.
7. To preserve changes made to the application, access the Application Window menu and select the Save Application command. In the File Handler, click the Current Selection box, enter a name for the file, ending with ".app", then press [Enter]. Click the Done button to close the File Handler.

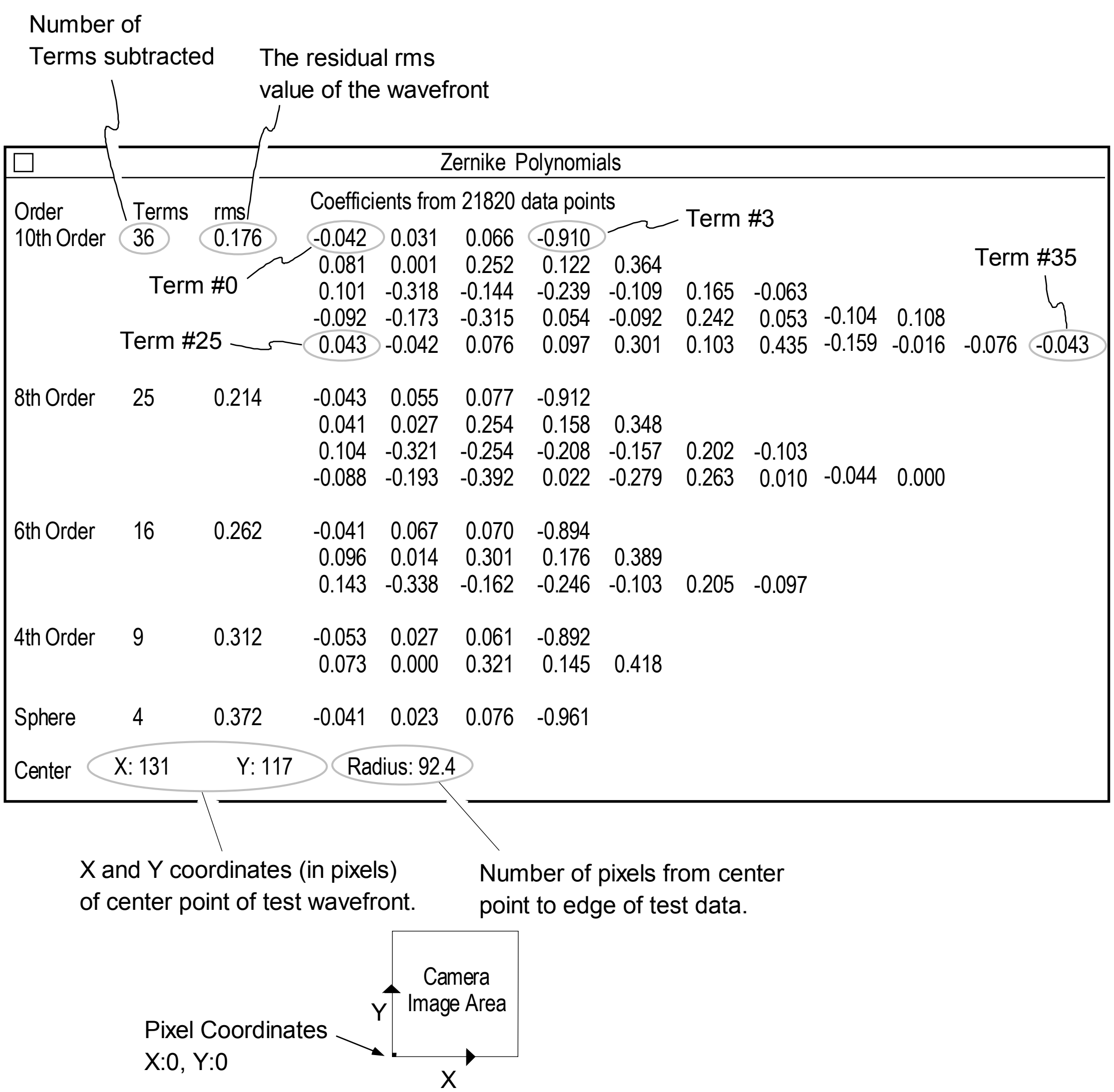
Sample of
Ogive Wavefront

Zernike Polynomials

To aid in the interpretation of optical test results, it is often convenient to express wavefront data in polynomial form. Zernike polynomials are frequently used for this purpose since they are made up of terms that are of the same form as the types of aberrations often observed in optical tests.

> **Note:** Zernikes are designed for circular data sets. Zernikes of noncircular data sets may be erroneous.

Zernike polynomial terms are listed in a specialized window which may be created in a Phase Data window using the New Result → Zernikes command. The number of terms analyzed and then displayed in the Zernike result window are controlled with the Zernike Terms control. The number of data points used in the Zernike result are selected with a Zernike Sample control.



Zernike Polynomials Table

In this table, ϕ = polar coordinate angle, and ρ = radius (normalized to 1 at the edge of the aperture). The numbers in columns m and n are the indices for Zernike polynomials.

n	*m*	*Term #*	*Polynomial*	*Meaning*
0	0	0	1	Piston
1	+1	1	$\rho \cos \phi$	X Tilt
	-1	2	$\rho \sin \phi$	Y Tilt
	0	3	$2\rho^2-1$	Focus
2	+2	4	$\rho^2 \cos 2\phi$	Astigmatism 0° or 90°
	-2	5	$\rho^2 \sin 2\phi$	Astigmatism ±45°
	+1	6	$(3\rho^2-2)\rho \cos \phi$	X Coma and Tilt
	-1	7	$(3\rho^2-2)\rho \sin \phi$	Y Coma and Tilt
	0	8	$6\rho^4-6\rho^2+1$	Spherical and Focus
3	+3	9	$\rho^3 \cos 3\phi$	
	-3	10	$\rho^3 \sin 3\phi$	
	+2	11	$(4\rho^2-3)\rho^2 \cos 2\phi$	
	-2	12	$(4\rho^2-3)\rho^2 \sin 2\phi$	
	+1	13	$(10\rho^4-12\rho^2+3)\rho \cos \phi$	
	-1	14	$(10\rho^4-12\rho^2+3)\rho \sin \phi$	
	0	15	$20\rho^6-30\rho^4+12\rho^2-1$	
4	+4	16	$\rho^4 \cos 4\phi$	
	-4	17	$\rho^4 \sin 4\phi$	
	+3	18	$(5\rho^2-4)\rho^3 \cos 3\phi$	
	-3	19	$(5\rho^2-4)\rho^3 \sin 3\phi$	
	+2	20	$(15\rho^4-20\rho^2+6)\rho^2 \cos 2\phi$	
	-2	21	$(15\rho^4-20\rho^2+6)\rho^2 \sin 2\phi$	
	+1	22	$(35\rho^6-60\rho^4+30\rho^2-4)\rho \cos \phi$	
	-1	23	$(35\rho^6-60\rho^4+30\rho^2-4)\rho \sin \phi$	
	0	24	$70\rho^8-140\rho^6+90\rho^4-20\rho^2+1$	
5	+5	25	$\rho^5 \cos 5\phi$	
	-5	26	$\rho^5 \sin 5\phi$	
	+4	27	$(6\rho^2-5)\rho^4 \cos 4\phi$	
	-4	28	$(6\rho^2-5)\rho^4 \sin 4\phi$	
	+3	29	$(21\rho^4-30\rho^2+10)\rho^3 \cos 3\phi$	
	-3	30	$(21\rho^4-30\rho^2+10)\rho^3 \sin 3\phi$	
	+2	31	$(56\rho^6-105\rho^4+60\rho^2-10)\rho^2 \cos 2\phi$	
	-2	32	$(56\rho^6-105\rho^4+60\rho^2-10)\rho^2 \sin 2\phi$	
	+1	33	$(126\rho^8-280\rho^6+210\rho^4-60\rho^2+5)\rho \cos \phi$	
	-1	34	$(126\rho^8-280\rho^6+210\rho^4-60\rho^2+5)\rho \sin \phi$	
	0	35	$252\rho^{10}-630\rho^8+560\rho^6-210\rho^4+30\rho^2-1$	

The more terms specified for analysis, the longer the analysis will take. Also, when a given number of terms are specified for analysis, all lower-order terms (except for 3-term) are analyzed and displayed as well. For example, if you specify an analysis of 16 terms, analyses for 9 terms and 4 terms are performed at the same time. You must select a Zernike fit of at least 9 terms if you want to display Seidel coefficient results.

Zernikes Files

Zernike results may be saved as compatible CODE V Zernike data files. Select the type of CODE V file with the Code V Type control. To save a Zernike file click the Save Zernike button. In the File Handler, click the Current Selection box, enter a name for the file, ending with ".zfr", and press [Enter]. Then click the File Handler's Done button.

Zernike Reference Material

Max Born and Emil Wolf, *Principles of Optics* (New York: Pergamon Press, 1980).

Daniel Malacara, *Optical Shop Testing* (New York: John Wiley and Sons, 1978) Appendix 2.

Lateral Calibrator and Mask Editor

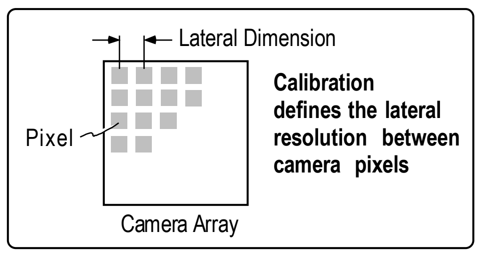
Section

7

Two of the most common tools used within MetroPro are the Calibrator and Mask Editor. The Calibrator establishes lateral resolution. The Mask Editor defines areas of interest in the part.

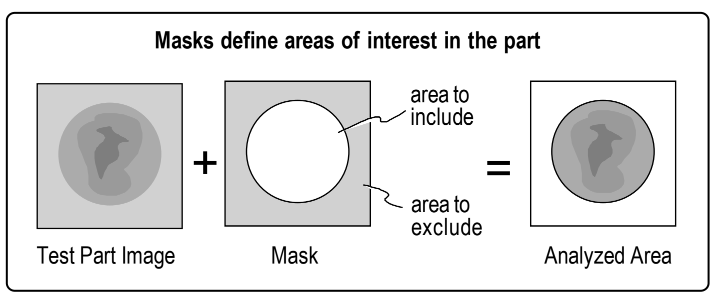
Calibration establishes the lateral measurement resolution of each camera pixel. Calibration is performed with the Lateral Calibrator window; this window is opened by clicking on the Calibrate button. The Lateral Calibrator window allows you to provide MetroPro with a reference dimension with which it can compute the lateral dimension "seen" by each pixel of the instrument's camera. The Lateral Calibrator window varies depending on the instrument.

Calibration is necessary for MetroPro to calculate some results and to provide absolute units of measure, such as millimeters or microinches. Without calibration, MetroPro uses camera pixels, which are relative units of measure.



The Mask Editor is a specialized window used to create and modify masks. Masks identify subsets of the full camera image to include and/or exclude in a measurement or analysis. The Mask Editor is opened by clicking on the Mask Data button.

Masks can be used to speed the measurement cycle, to compare one area of a part to another area on the same part, or to isolate various test areas on the part.



Lateral Calibrator – GPI, MicroLUPI, MESA, DVD-400

Calibration establishes the lateral resolution of each camera pixel. Calibration is required to use lateral dimensions other than pixels, and whenever the GPI's zoom setting is changed. The Lateral Calibrator window serves these basic functions:

- Establish "real" measurement units for the lateral dimensions of plano or flat parts.
- Correct for spherical distortion within the instrument when measuring spherical parts. This applies only to the GPI or the MicroLUPI, and requires a Zygo Lateral Calibration Artifact matched to the Transmission Sphere or objective in use.

To open the interferometer Lateral Calibrator window, click the Calibrate button.

Lateral Calibrator Window for the GPI, MicroLUPI, MESA, and DVD-400

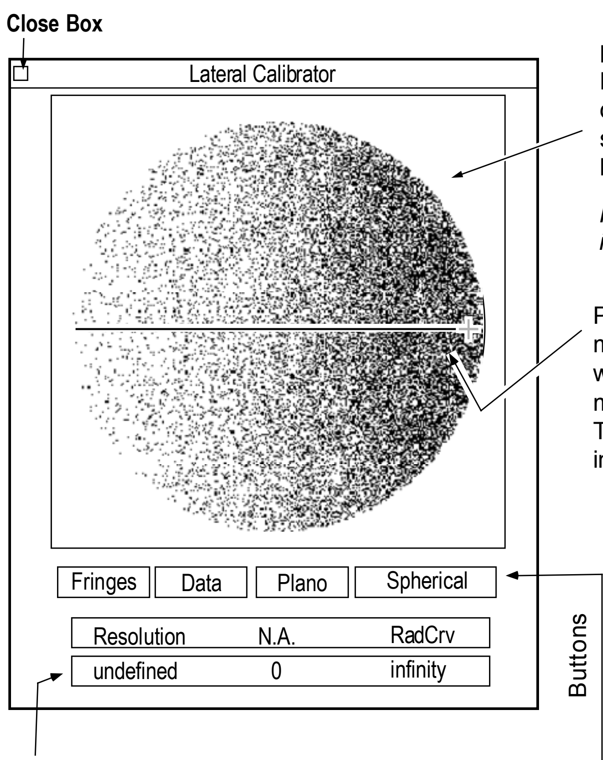


Image Area
Displays image of intensity data. The data source is selected with Fringes or Data buttons.

Note that an image appears only if the instrument is working.

Press and hold the left mouse button, move the mouse to draw a line for which you will specify length in millimeters.
The line shown is drawn across the instrument aperture.

Fringes/Data Select the source of the image area. Fringes display the current fringe pattern; Data displays data from the current measurement. Only one of these two buttons can be selected at a time.
Plano/Spherical Specify the wavefront of the interferometer. Plano refers to a flat wavefront; Spherical refers to a spherical wavefront. Only one of these two buttons can be selected at a time.

Resolution shows the lateral dimension for each camera pixel. "Undefined" means that the instrument is not calibrated.
N.A. shows the the numerical aperture of the Calibration Artifact. Refers to spherical calibration only.
RadCrv shows radius of curvature of the Calibration Artifact. Refers to spherical calibration only.

The menu for the Lateral Calibrator is accessed by pressing the right mouse button. The menu provides you with basic window commands. The window can be moved with the menu command or by pressing the middle mouse button on the window title bar. The window can be closed with the menu command or by clicking in the window close box with the left mouse button. The Enter Cal command is for use with microscope objectives.

Lateral Calibrator
Enter Cal.
Move
Close
To Front
To Back

Plano Calibration Procedure

The Lateral Calibrator window opens with “Plano” selected; this setting is used for calibrating the instrument for flat or plano parts.

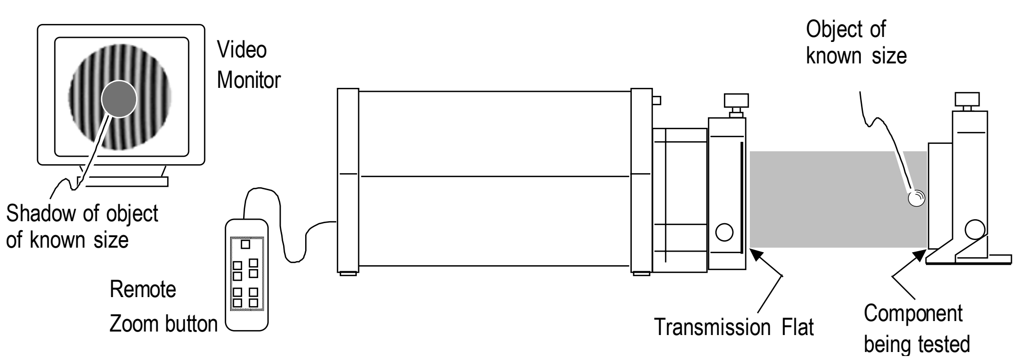
Calibration can only be performed if an instrument is connected and working. Calibration must be made before making measurements. You cannot recalibrate existing data that is loaded into the application. Although the Lateral Calibrator window uses metric units, actual measurement results are displayed in whatever units of measure you choose for the results or plots.

1. Set up the interferometer and test part as instructed in the operation manual. Align the test part. Set the GPI’s zoom setting as desired.
2. Click the MetroPro Calibrate button to open the Lateral Calibrator window. Click either the Fringes button or Data button to specify the source of the fringe pattern.
3. Position the crosshairs over the part image and press the left mouse button, move the mouse to draw a line across some portion of the image, and release the mouse button.

   Note: The longer the line is drawn the greater the accuracy.
4. In the entry box, type the dimension in millimeters for the line just drawn and press Enter.

Plano Calibration Hints

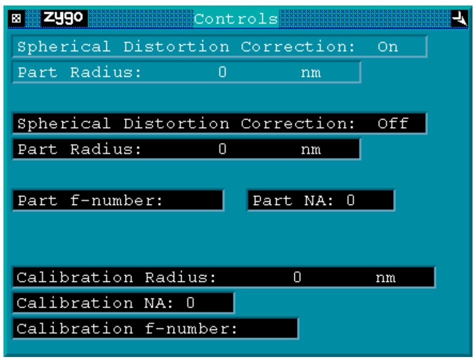
When using a transmission flat, a simple way to calibrate is to place an object of known size in the field of view. In the Lateral Calibrator window, draw the definition line across the shadow of the object and enter its dimension in the entry box. This method works at any zoom setting, as long as the edges of the reference object are visible in the image area of the Lateral Calibrator window.



Spherical Distortion Correction

The Lateral Calibrator, along with a couple of MetroPro controls, can be used to correct for spherical distortion within the instrument when measuring spherical parts. This applies only to the GPI or the MicroLUPI, and requires a Zygo Lateral Calibration Artifact. The Artifact used for spherical calibration must be matched to the objective or Transmission Sphere you are using.

Spherical Distortion Controls and Attributes



When correcting for spherical distortion, you must enter the nominal part radius in the Part Radius control, and make sure the Spherical Distortion Correction control is On. These controls are available within a Control window with the New Control → Distortion Correction command. There are also a number of attributes for this feature. The attributes are available within a Control window with the New Attribute → Distortion Correction command. The Control window shown here was created using these commands.

Control or Attribute	***Description***
Spherical Distortion Correction	When On, spherical measurements use the spherical calibration data to correct for distortion. The corresponding Attribute shows the state of this control for the current measurement. A value is also required in the Part Radius control.
Part Radius	Specifies the nominal radius of the part under test. The units can be changed with the Unit command from the Control Box's menu. The Spherical Distortion Correction control must be On.
Part f-number	Attribute that displays the f-number of the test part.
Part NA	Attribute that displays the numerical aperture of the test part.
Calibration Radius	Attribute that displays the radius of the Calibration Artifact as entered during the spherical calibration procedure.
Calibration NA	Attribute that displays the numerical aperture of the Calibration Artifact as entered during the spherical calibration procedure.
Calibration f-number	Attribute that displays the f-number of the Calibration Artifact as entered during the spherical calibration procedure.

Spherical Calibration Procedure

Calibration can only be performed if an instrument is connected and working. Calibration must be made before making measurements. You cannot recalibrate existing data that is loaded into the application. Although the Lateral Calibrator window uses metric units, actual measurement results are displayed in whatever units of measure you choose for the results or plots.

1. Place the Calibration Artifact, that is matched to the Transmission Sphere or objective in use, in the output beam of the interferometer. Adjust the interferometer to center the Calibration Artifact into a bulls-eye fringe pattern. Set the GPI's zoom setting as desired. Make sure the adjuster ring of the MicroLUPI's objective is aligned to the radius of the Calibration Artifact.
2. Click the Measure button to make a measurement of the Artifact.
3. Click the MetroPro Calibrate button to open the Lateral Calibrator window. Make sure the Spherical and Data buttons are selected.
4. Position the crosshairs over the part image and press the left mouse button, move the mouse to draw a line between the inside edges of the second concentric ring. Then release the mouse button
5. In the first entry box, enter the actual diameter of the ring the line was drawn across. (Provided with each artifact.)
6. In the second entry box, type in the radius of curvature of the Calibration Artifact.

The Lateral Calibrator - Used to Correct for Spherical Distortion

Note that the line drawn over the artifact data is from the inside edges of the second concentric ring.

7. To activate spherical correction for subsequent measurements, set the Spherical Distortion Correction control to On and enter the nominal radius of the test part in the Part Radius control. These controls are available within a Control window with the New Control → Distortion Correction command.

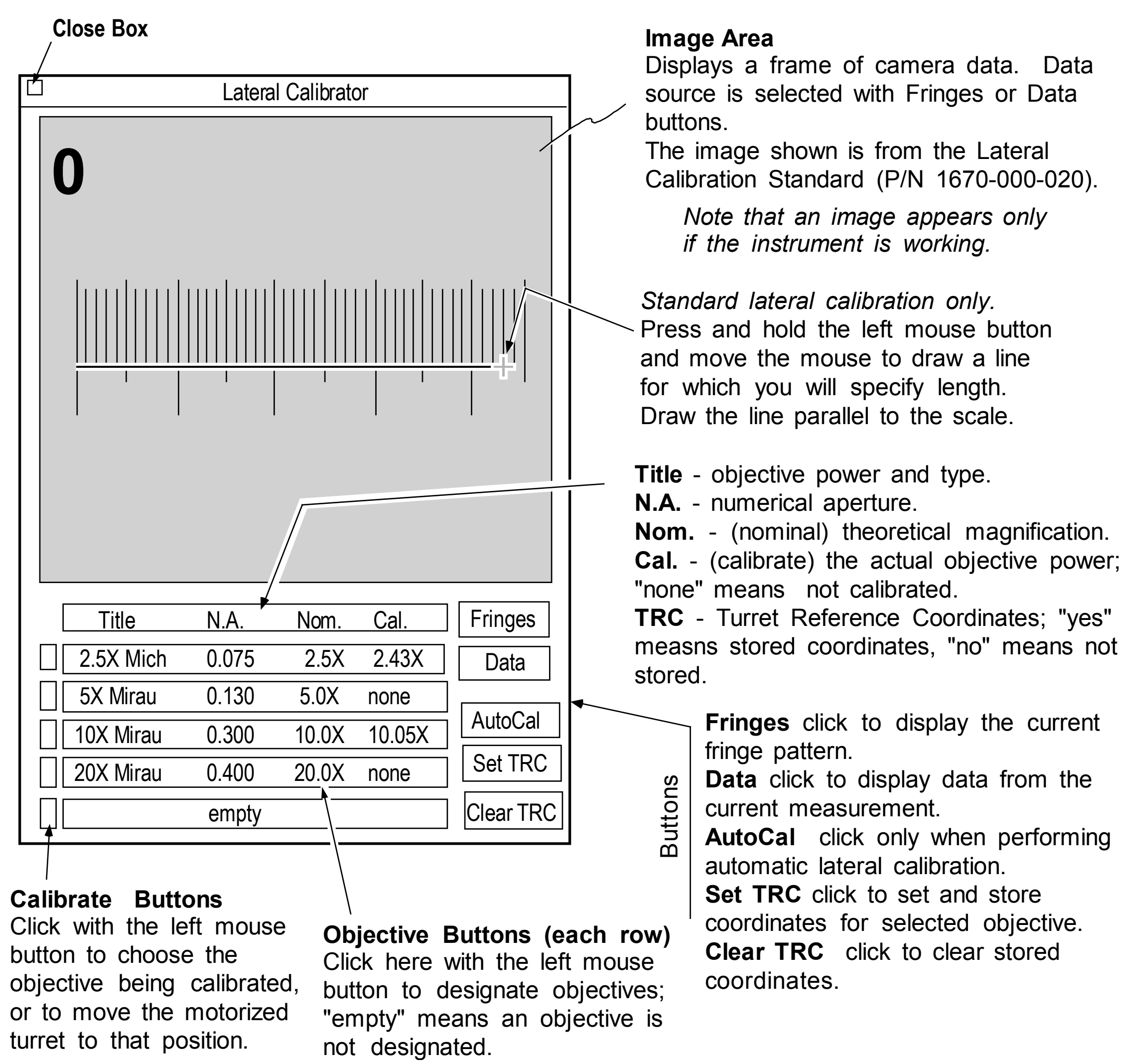
Lateral Calibrator - Microscopes

Calibration specifies the actual magnification for each objective and establishes the accuracy of the lateral measurements for each microscope objective. A Lateral Calibration Standard is required to perform calibration. The Lateral Calibrator window for microscopes serves these functions:

- Establish “real” measurement units for the lateral based results, such as the units in the Oblique plot and the Profile plot, and the Length and RadCrv results.
- Designate what objectives are installed. This determines what choices show up in the MetroPro Objective button when it is clicked.
- Create turret reference coordinates (TRC) so test parts stay aligned and in focus when objectives are switched. Motorized turret required.
- Provide for improved calibration with the automatic lateral calibration feature.
- Remastering objectives to a “golden” part standard with the Enter Cal command.

To open the microscope Lateral Calibrator window, click the Calibrate button.

Lateral Calibrator Window for Microscopes



Designating Objectives

This determines the objective choices in the MetroPro Objective button and associates a particular objective with a turret position.

1. Click on each row in the objective display with the left mouse button until the objective title appearing in the display matches the objective.

   Note: Make sure the numbered position (1-5) matches the position of the objective in the turret.

2. Select “empty” when there are no objectives to designate.

Creating TRC (Turret Reference Coordinates)

Using this function in MetroPro keeps the image of the sample part centered and in focus as objectives are switched. The TRC function automatically remembers each objective’s coordinates and adjusts positioning in 5 axes (X, Y, Z, and tip and tilt) when objectives are switched with the Objective button. A motorized turret is required.

Note: New TRC values must be established for all objectives installed in the motorized turret under the following conditions: an objective is removed, remounted, replaced, and/or the turret itself is removed and replaced.

1. Mount all objectives into the motorized turret.
2. Click the MetroPro Calibrate button to open the Lateral Calibrator. Use the Calibrator to assign the objectives in the turret to match the objectives specified in the Calibrator window.
3. Select an objective in the Calibrator, and click the Set TRC button.
4. Focus and null the microscope on a feature on a sample part. Move the stage to locate the feature under the on-screen crosshair.
5. After the objective is properly focused and nulled, click Yes.

   Note: To remove stored coordinates for an objective, select the objective in the Lateral Calibrator and then click Clear TRC.

6. Repeat steps 3 through 5 for other installed objectives.

   Note: MetroPro expects only small movements of the stage between objectives. The error message: “A turret reference coordinate is out of range. No stage axis was moved.” indicates that an objective’s TRC’s were not properly set up, or an objective was switched or replaced.

Standard Microscope Calibration Procedure

Warning!
Do not experiment with the Calibrator window. Clicking on an objective display which has been calibrated (denoted by a number under the "Cal." column) deletes that objective's calibration data.

Calibration can only be performed if an instrument is connected and working. Calibration must be made before making measurements. You cannot recalibrate existing data that is loaded into the application.

Objectives are calibrated at Zygo if they are purchased with the original system; recalibration is not required on these objectives. Perform the calibration procedure if you want to verify the calibration or add different objectives.

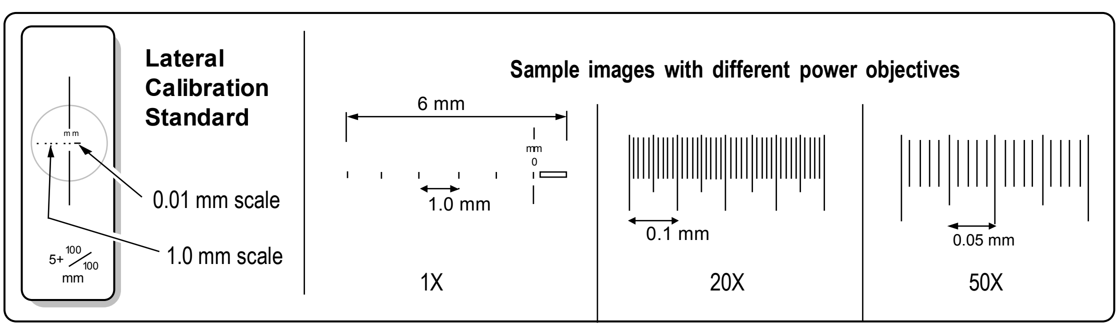
Note: A Zygo Lateral Calibration Standard, P/N 1670-000-020, is required to calibrate the objectives.
If calibration is not performed for an objective, MetroPro uses the nominal magnification.

1. Designate objectives as previously described.
2. Position the Lateral Calibration Standard under the objective. Focus the objective on the standard's lines and then null the fringe pattern. The lines in the Lateral Standard should be aligned parallel to the borders of the image window.

Note: Handle the Standard with care. The features are very fine and are easily damaged. Do not touch the measurement surface. To remove dust from the Standard, use a short burst of dry, filtered air. Store the Standard in its case when not in use.

3. Click the Calibrate button to open the Lateral Calibrator window. Then click the Fringes button. If you have problems seeing the lines on the standard, measure the Standard and then click the Data button in the Lateral Calibrator.

Sample Images of the Lateral Calibration Standard



continued next page

4. Select the objective to calibrate by clicking on the small box to the left of its title in the Lateral Calibrator window.
5. Draw a line across the image. Position the crosshairs over the image, press and hold the left mouse button; move the mouse to draw a line parallel to the Standard's scale; and release the mouse button for the end point. The longer the line drawn, the more accurate the calibration.
6. Using the keyboard, enter the length of the drawn line in millimeters, as determined by reading the Calibration Standard scale, then press Enter. Values obviously out of range for a given objective will not be accepted.
7. Repeat steps 2 through 6 for other objectives. Calibration data is automatically saved when the Lateral Calibration window is closed.

Calibration Procedure when Image Zoom is Free

This procedure applies only to microscopes with an image zoom option and when the Image Zoom control is set to Free. Note that calibration performed at a Free setting is temporary; settings are not saved.

1. Position the Lateral Calibration Standard under the objective. Focus the instrument on the standard's lines and null the fringe pattern.
2. Click the Calibrate button to open the Lateral Calibrator window. Select the objective to calibrate by clicking on the little box to the left of its name.
3. Draw a line over the image. Position the crosshairs over the image and click and hold the left mouse button; move the mouse to draw a line parallel to the Standard's scale; release the mouse button for the end point.
4. Enter the length of the drawn line in millimeters, as determined by reading the Lateral Calibration Standard scale. Press Enter when done.
5. Close the Lateral Calibrator window and make your measurement.

Automatic Microscope Lateral Calibration Procedure

Automatic Lateral Calibration is for the NewView microscope and requires a Precision Lateral Calibration Standard, Zygo P/N 6300-2198-01, and at least MetroPro software version 7.6.0. Zygo provides an Automatic Lateral Calibration application, AutoLatCal.app, to facilitate with the calibration procedure.

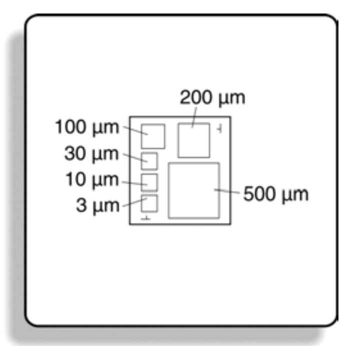
Automatic Lateral Calibration significantly improves the lateral measurement performance of the microscope. Automatic Lateral Calibration should be used, in place of the regular Lateral Calibration, when true three-dimensional measurements are required. A true three-dimensional measurement precisely maps height (z) data to the lateral (x-y) dimensions of the part. This higher level of calibration is recommended for spacing and angle results, such as S or Cone Angle. It is *not* required for roughness results or height-based results, such as Ra, PV, or rms.

1. Load and open the Automatic Lateral Calibration application (AutoLatCal.app).
2. Make sure the objectives are designated as previously described in this section.
3. Select the objective you want to calibrate with the MetroPro Objective button. If you have a motorized turret, the objective will move into position. Otherwise, move (manual turret) or mount (single objective mount), the applicable objective into position on the microscope.
5. Open the Measure Cntrl window and change the Image Zoom control to match the zoom setting on the microscope.
6. Position the Precision Lateral Calibration Standard under the objective.

   Note: Handle the Standard with care. The features are very fine and are easily damaged. Do not touch the measurement surface. To remove dust from the Standard, use a short burst of dry, filtered air. Store the Standard in its case when not in use.

7. Select the appropriate test area on the standard according to the Automatic Lateral Calibration Test Area Chart. Move the stage to place the selected test area within the field of view. If the objective and zoom setting are not listed in the chart, then move the stage to place 8-25 rows of dots within the field of view. For the 3-30 µm pitch clusters, select calibration areas away from the left edge of the standard.

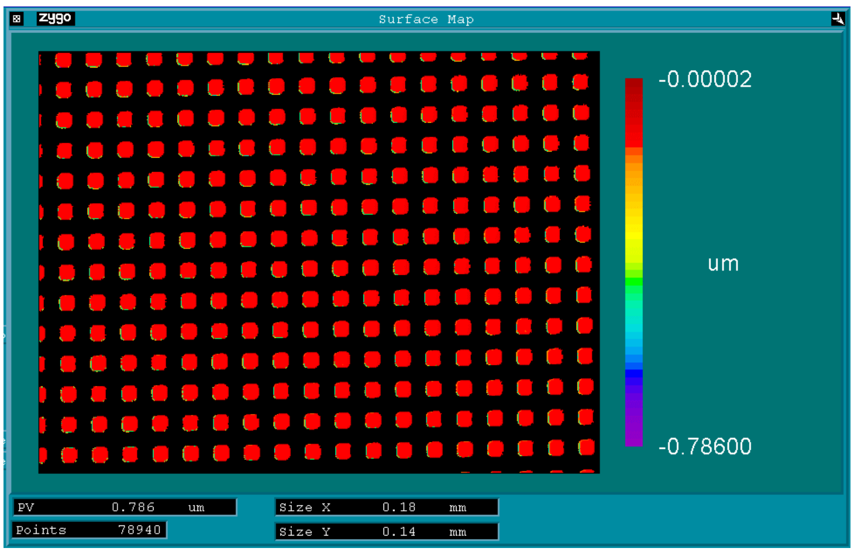
Precision Lateral Calibration Standard



8. Focus the objective on the standard until the dots are clearly visible on the video monitor. Adjust light level to make the dots visible if necessary.
9. Make sure that the dots either fill the view screen or are centered within the field of view. The dots should be aligned fairly parallel to the borders of the video monitor. Adjust the rotation of the standard if it is skewed more than the distance between two dots.

10. For a few of the lower magnification selections, the dots will not fill the entire view screen. To calibrate correctly, an acquisition mask is necessary. Create a square acquisition mask. Center the mask using the move control in the Mask Editor. The mask should be sized to contain all of the dots. There should be a small gap between the borders of the mask and the dots. Once the mask is created you must define the mask using the Define button in the Mask Editor.
11. Focus the objective and null the fringe pattern. There should be at most three fringes visible. Set light level to eliminate over-saturation and resultant data drop out.
12. Click the Measure button.
13. The measurement is valid if the dots are well defined with no data drop out and only dots are visible within the filled plot. There should only be dots visible; all other areas of the test mask should be black indicating no data is present.

Sample Measurement Showing Valid Data



14. If data is not valid, the Light Level is the most likely the cause. Readjust the Light Level and remeasure. If the data is still not valid, try another area on the test standard with the same grid spacing.
15. Click the Calibrate button to open the Lateral Calibrator window. Select the objective you are calibrating by clicking on the small box to the left of its title.
16. Click the Auto Cal button in the Lateral Calibration window. A prompt will appear for a length in microns. Enter the mean spacing for the measured area of the standard. The mean spacing value can be read from the certificate of calibration included with each standard.
17. Repeat steps 3 through 16 for other objectives or zoom settings. Calibration data is automatically saved when the Lateral Calibration window is closed.

Automatic Lateral Calibration Test Area Chart

Objective	Zoom Setting	Approximate Magnification	Proper Test Area (mean spacing um, mm)	Approximate Number of Rows, Columns
1x	0.4x	0.4x	500, 0.5	15, 15*
1x	0.5x	0.5x	500, 0.5	15, 15*
1x	0.8x	0.8x	500, 0.5	14, 15*
1x	1.0x	1.0x	500, 0.5	11, 14
1x	1.3x	1.3x	200, 0.2	21, 23*
1x	2.0x	2.0x	200, 0.2	13, 17
2x	0.4x	0.8x	500, 0.5	14, 15*
2x	0.5x	1.0x	500, 0.5	11, 14
2x	0.8x	1.6x	200, 0.2	17, 22
2x	1.0x	2.0x	200, 0.2	13, 17
2x	1.3x	2.6x	200, 0.2	10, 13
2x	2.0x	4.0x	100, 0.1	13, 17
2.5x	0.4x	1.0x	500, 0.5	11, 14
2.5x	0.5x	1.25x	200, 0.2	22, 29
2.5x	0.8x	2.0x	200, 0.2	13, 17
2.5x	1.0x	2.5x	200, 0.2	11, 14
2.5x	1.3x	3.25x	100, 0.1	16, 21
2.5x	2.0x	5.0x	100, 0.1	11, 14
5x	0.4x	2.0x	200, 0.2	13, 17
5x	0.5x	2.5x	200, 0.2	11, 14
5x	0.8x	4.0x	100, 0.1	13, 17
5x	1.0x	5.0x	100, 0.1	11, 14
5x	1.3x	6.5x	100, 0.1	8, 10
5x	2.0x	10.0x	30, 0.03	18, 24
10x	0.4x	4x	100, 0.1	13, 17
10x	0.5x	5x	100, 0.1	11, 14
10x	0.8x	8x	30, 0.01	22, 29
10x	1.0x	10x	30, 0.03	18, 24
10x	1.3x	13x	30, 0.03	14, 18
10x	2.0x	20x	30, 0.03	9, 12
20x	0.4x	8x	30, 0.03	22, 29
20x	0.5x	10x	30, 0.03	18, 24
20x	0.8x	16x	30, 0.03	14, 18
20x	1.0x	20x	30, 0.03	9, 12
20x	1.3x	26x	10, 0.01	22, 29
20x	2.0x	40x	10, 0.01	13, 17
50x	0.4x	20x	30, 0.03	9, 12
50x	0.5x	25x	10, 0.01	22, 29
50x	0.8x	40x	10, 0.01	13, 17
50x	1.0x	50x	10, 0.01	11, 14
50x	1.3x	65x	10, 0.01	8, 10
50x	2.0x	100x	3, 0.003	18, 24
100x	0.4x	40x	10, 0.01	13, 17
100x	0.5x	50x	10, 0.01	11, 14
100x	0.8x	80x	3, 0.003	22, 29
100x	1.0x	100x	3, 0.003	18, 24
100x	1.3x	130x	3, 0.003	14, 18
100x	2.0x	200x	3, 0.003	9, 12

* for proper calibration, a square Acquisition mask is required when using these objective and zoom settings.

This chart is used to: 1) determine which test area on the standard to use, as based on the objective and zoom settings, and 2) provide the millimeter (mm) mean spacing value to enter during the automatic lateral calibration procedure.

Troubleshooting Automatic Lateral Calibration

Problem	*Possible Solutions*
The data has holes or there is data in the background behind the dots.	Check the light level to ensure there in no saturation. The FDA Res control must be set to High. Check for dust on the Standard; remove with filtered air. Make sure the microscope's Measure filter is in place.
Error Message: "Standard too rotated"	The standard is not square to the measurement area. Realign the standard.
Error Message: "Did not find enough regions"	There is a problem in the measurement. Check the items mentioned in the first row.
Error Message: "Sorting failed"	There most likely is a missing dot or data showing up between dots. Check the items mentioned in the first row.
Error Message: "Magnification out of allowable range"	The objective and zoom selections don't match the expected results. Check the Image Zoom setting and designed objective. Also check that the proper grid spacing was entered when prompted.

Using the Enter Cal command

The Enter Cal command is used with microscope objectives for entering known calibrations without performing actual calibration. Known objective calibrations may be supplied by Zygo for each objective.

1. Install the objective in the instrument. Click the Calibrate button to open the Lateral Calibrator.
2. To designate the objective, click the objective display with the left mouse button until the objective title appearing in the display matches the objective that was installed.
3. Click on the small box to the left of the objective you want to calibrate.
4. Select the Enter Cal command from the Lateral Calibrator menu. Enter the known magnification and press [Enter].

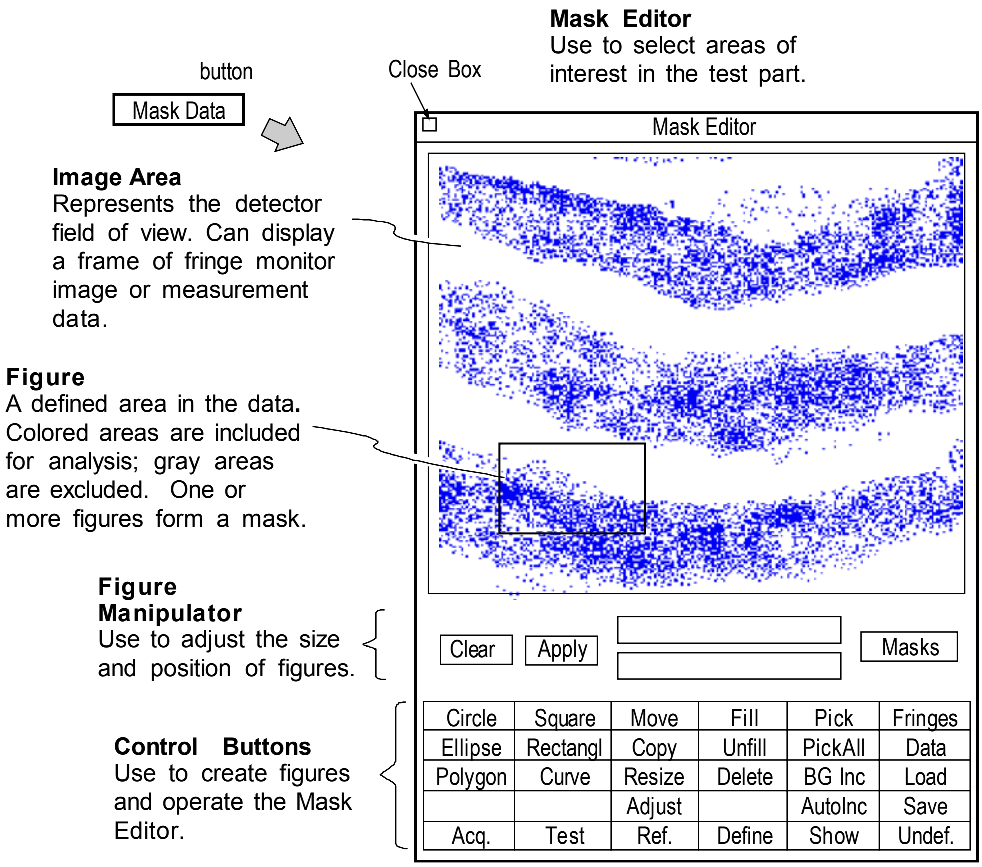
Remastering Objectives

The Enter Cal command may also be used for remastering. Remastering allows an objective to be calibrated to match a specific existing standard.

For example, you may have an extremely accurate standard ball bearing with a known radius of curvature. The RadCrv result in MetroPro may not precisely match this radius. With the Enter Cal command, you can change the magnification of a particular objective until the results match. Note that if your standard is not accurate, you will introduce a measurement error.

Mask Editor

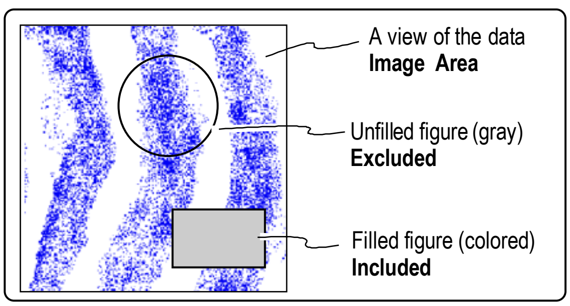
The Mask Editor is a specialized window used to create and modify masks. The Mask Editor allows you to select areas of interest, called masks, in a view of the test part called an "image area". Masks may be used to restrict the measurement to a particular area of interest or exclude a known bad area, such as a defect in a surface, from the measurement. Click the Mask Data button to open the Mask Editor.



What is a Mask?

Masks identify subsets of the full camera image to include and/or exclude in a measurement and/or analysis. If masks are not used, the entire camera image is acquired and analyzed.

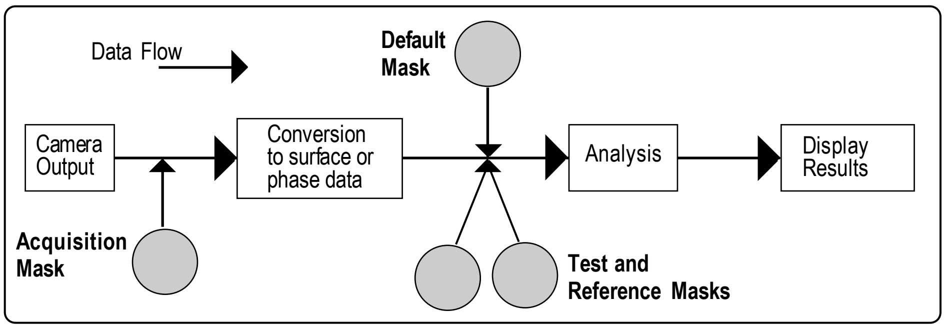
A mask is made up of one or more figures. A figure is a shape that defines an area in the data; these areas may be filled (colored) or unfilled (gray). If an area is colored, it is included; if an area is not colored, it is excluded.



The Four Masks of MetroPro

There are four types of masks: Default, Test, Reference, and Acquisition. All masks are created in a similar manner, but affect processing in different ways. Once a mask is created, it is applied automatically during any future analysis of all data.

The drawing below indicates the part of the process affected by the different types of masks. It also indicates how the masks can be used in combination. The Acquisition mask can be used with either the Default mask or the Test and Reference mask set, but not both. To prevent any conflicts, the software automatically disables the Default mask when a Test mask is defined. The following table describes the four masks.



Mask Type	Description
Default	Applied to the data during analysis. If masks are not defined with the Mask Editor, it is assumed you are using a Default mask. The Default mask is disabled when the Test mask is defined.
Acquisition	Applied to the data while it is being acquired, before the data is converted to surface or phase data, and before it is analyzed. An Acquisition mask is used to exclude areas that cause problems during the acquisition of data, such as excessive slopes from part edges (cause discontinuity errors), extremely differences in reflectivity (cause AGC errors), and excessive spurious data (cause connect errors). The Acquisition mask can also be used to speed up processing because it reduces the number of data points that are used in analysis.
Test	Defines an area of interest on the test part; this area is compared to a reference area on the same test part during the analysis process. The Test mask must be used in conjunction with the Reference mask. Used within Test+Reference data windows. If you use another data window and Test and Reference masks, you will see only data in the area defined by the Test mask.
Reference	Defines a reference area (or a standard for measuring against) on the test part against which the test area is compared during the analysis process. It must be used in conjunction with the Test mask.

The Mask Editor Buttons

Figure Buttons
Use to make and modify *figures*. Described below…

Activate any button by clicking the left mouse button.

Mask Editor

Clear | Apply | Masks

Circle	Square	Move	Fill	Pick	Fringes
Ellipse	Rectangl	Copy	Unfill	PickAll	Data
Polygon	Curve	Resize	Delete	BG Inc	Load
		Adjust		AutoInc	Save
Acq.	Test	Ref.	Define	Show	Undef.

Create Buttons
Use to create figures of different shapes.

Circle	Square
Ellipse	Rectangl
Polygon	Curve

Circle Square
Ellipse Rectangl
Polygon Curve

The last figure created is automatically picked.

Modify Buttons
Use to modify or change a selected or "picked" figure(s). Move, Copy, Resize, and Adjust require additional user input. Fill, Unfill, and Delete immediately work on "picked" figures.

Move	Fill
Copy	Unfill
Resize	Delete
Adjust	

Move - Use to move picked figure(s).

Copy - Use to copy picked figure(s).

Resize - Use to resize picked figure(s) proportionally.

Adjust - Use to change the height to width ratio of picked figure(s).

Fill - Use to fill picked figure(s); filled figures are in color.

Unfill - Use to unfill picked figure(s); unfilled figures show borders only.

Delete - Use to remove picked figure(s).

Move, Resize, or Adjust picked figures in small increments by pressing the arrow keys.

Shift Press shift at the same time to multiply the selected action.

Pick
PickAll
BG Inc
AutoInc

A light blue highlight indicates one or more figures are picked.

Pick - Use to select the figure(s) you wish to modify.

PickAll - Use to select all figures so they can be modified simultaneously.

BG (Background) - Use to include or exclude the background in the analysis. BG Inc includes the background; BG Exc excludes the background. Functions as a toggle switch.

Auto - Used to determine if figures are initially filled or unfilled when they are created. AutoInc automatically fills new figures; AutoExc automatically unfills new figures. Functions as a toggle switch. Does not affect previously defined figures.

Creating a Circle, Square, Ellipse, or Rectangle Figure

These figures can be created with the mouse or with the Figure Manipulator. The mouse method is described below; the Figure Manipulator is described later.

1. Click on the shape button with the left mouse button.
2. Position the pointer over the image area.
3. Press the left mouse button for the start point, drag the mouse, and then release the mouse button for the end point.

Creating a Polygon Figure

1. Click on the Polygon button with the left mouse button.
2. Position the pointer over the image area.
3. Click the left mouse button to begin the polygon and move the pointer to create a side of the polygon.
4. Click the left mouse button each time you wish to create a new corner point. Click the right mouse button for the last corner point. The polygon will automatically connect the last point to the first point.

Creating a Curve Figure

1. Click on the Curve button with the left mouse button.
2. Position the pointer over the image area.
3. Press and hold the left mouse button, move the mouse to draw the figure shape, then release the button to end. The curve will automatically close to the start point.

Picking or Selecting Figures

Figures must be selected or "picked" before they can be moved, copied, resized, adjusted, unfilled, filled, or deleted. *The most recently created figure is automatically picked.* Individual figures are picked with the Pick button, all figures are picked at once with the PickAll button. Any of the figure modify buttons can be used in sequence without repicking figures. When the Pick or PickAll buttons are highlighted in light blue it means a figure(s) is picked.

1. Click the Pick or PickAll button with the left mouse button. If the button is light blue, clicking it deactivates the currently picked selection.
2. Position the pointer on the border of a figure and click the left mouse button. The picked figure will flash momentarily.
3. You can continue to pick additional figures by clicking on their borders.

Moving Figures

Figures can be moved with the mouse or with the Figure Manipulator. The mouse method is described below; the Figure Manipulator is described later.

1. Pick the figure(s) (as explained previously) and then click on the Move button with the left mouse button.
2. Press and hold the left mouse button, drag the mouse to position the figure, and then release the mouse button. Or press the arrows keys for finer control.

Copying Figures

Figures can be copied with the mouse or with the Figure Manipulator. The mouse method is described in the following paragraph; the Figure Manipulator is described later.

1. Pick the figure(s) (as explained previously) and then click on the Copy button with the left mouse button. The copy appears directly over the top of the figure(s) being copied so you will not see it until you move the mouse.
2. Press and hold the left mouse button, drag the mouse to position the figure, and then release the mouse button.

Resizing or Adjusting Figures

Use the Resize button to change the size of a figure without affecting its proportions. Use the Adjust button to change the proportions of a figure. Figures can be resized or adjusted with the mouse or with the Figure Manipulator. The mouse method is described below.

1. Pick the figure(s) (as explained previously) and then click on the Resize or Adjust button with the left mouse button.
2. Press and hold the left mouse button, drag the mouse to modify the figure size, and then release the mouse button. Or press the arrow keys for finer control.

Filling and Unfilling Figures

Filled (colored) figures are included in the analysis and unfilled figures are excluded.

1. Pick the figure(s) (as explained previously) and then click on the Fill or Unfill button with the left mouse button.

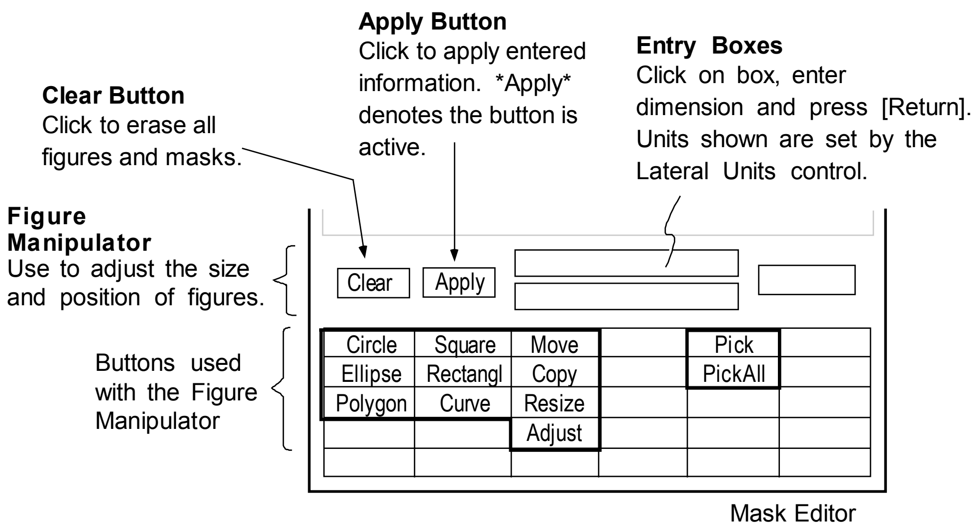
Deleting Figures

The Delete button erases all picked figures; it is permanent and cannot be undone. The Clear button removes all figures and defined masks.

1. Pick the figure(s) (as explained previously) and then click on the Delete button with the left mouse button.
2. Verify your action by clicking on the YES button in the Warning Message. Click NO to cancel the delete function.

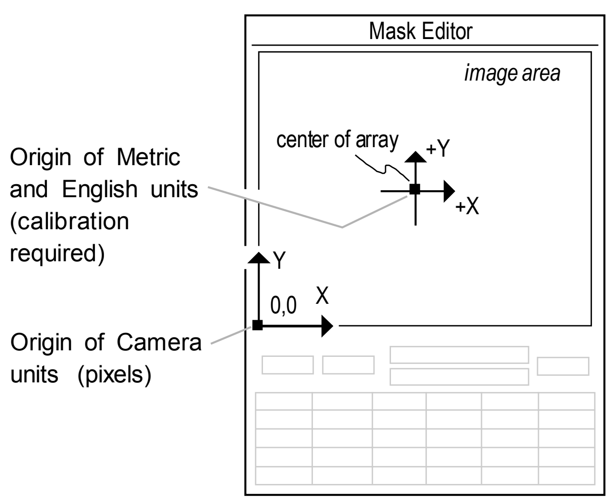
Using the Figure Manipulator

The Figure Manipulator is used during the creation of circle, square, ellipse, and rectangle figures to specify their size, or to specify the size of figures when using the Mask Editor Resize or Adjust buttons, or to specify the position of figures when using the Mask Editor Move or Copy buttons. The Figure Manipulator also functions as a readout device providing the size and location of figures.



To use the Figure Manipulator, you enter numbers into the entry boxes one at a time and then click the Mask Editor's Apply button with the left mouse button.

The lateral units displayed in the entry boxes depends upon the units selected with a Lateral Units control. Notice that any numbers shown in the entry boxes are referenced to coordinate systems of the image area as shown here.



Creating Circle or Square Figures with the Figure Manipulator

1. Click on the Circle or Square button.
2. Click on the "size" Entry box and type a dimension and press [Enter].
3. Click the Apply button. The figure will appear centered in the image area. If the dimension is too large the figure may fall outside the image area.

Creating Ellipse or Rectangl(e) Figures with the Figure Manipulator

1. Click on the Ellipse or Rectangl button.
2. Click on the "width" Entry box and type a dimension and press [Enter]. Then click the "height" Entry box and type the second dimension for the figure and press [Enter].
3. Click the Apply button. The figure will appear centered in the image area. If the dimensions are too large the figure may fall outside the image area.

Moving Figures with the Figure Manipulator

1. Pick the figure(s) (as explained previously) and then click on the Move button. This also can be used to find the location of an existing figure.
2. Click on an Entry box, type in a dimension and press [Enter].
3. Click the Apply button. The center of the picked figure(s) will move to the location indicated in the Entry boxes.

Copying Figures with the Figure Manipulator

1. Pick the figure(s) (as explained previously) and then click on the Copy button.
2. Click on an Entry box, type in a dimension and press [Enter].
3. Click the Apply button. The center of the new figure(s) is positioned over the location indicated in the Entry boxes.

Resizing Figures with the Figure Manipulator

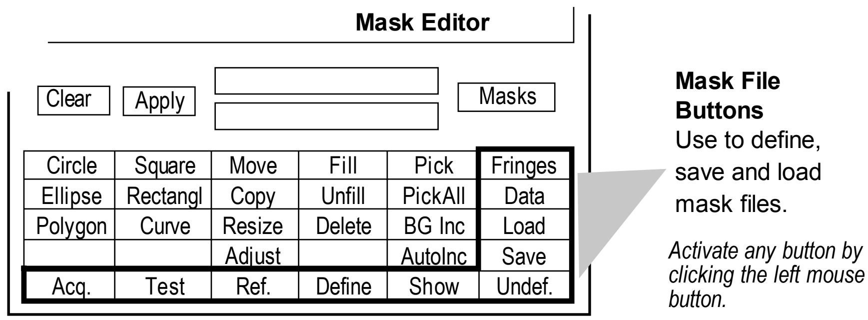
1. Pick the figure(s) (as explained previously) and then click on the Resize button.
2. Click on the "percent" Entry box, type in a percentage and press [Enter]. A number greater than 100 makes the figure larger; a number less than 100 makes the figure smaller.
3. Click the Apply button. The center of the new figure(s) is positioned over the location indicated in the Entry boxes.

Adjusting Figures with the Figure Manipulator

1. Pick the figure(s) (as explained previously) and then click on the Adjust button. This also can be used to find the size of an existing figure.
2. Click on an Entry box, type in a dimension and press [Enter].
3. Click the Apply button.

Working with Mask Files

There are four types of masks in MetroPro: Default, Acquisition (Acq.), Test, and Reference (Ref.) masks. Generally, the Default mask is all you need for most applications; it is any mask that is not defined as Acq., Test, or Ref. The buttons used for defining, saving, and loading mask files are shown below.



Mask Definition Buttons
Use to specify and display the type of *mask.*

Acq.	Test	Ref.	Define	Show	Undef.

The Acq., Test, and Ref. buttons function as a bank of toggle switches; only one button can be in the on position. When one of these masks is defined the button turns bright blue.

Acq. / Test / Ref. (Type) - Use to select a mask type other than the Default mask.
Acq. - Acquisition mask
Test - test mask
Ref. - reference mask
The pressed button is selected.

Define - Use to make the figure(s) in the image area the Test, Ref., or Acq. mask. When clicked, makes a mask for the mask type selected by the Type button; turns the selected mask button bright blue to indicate a mask is defined.

Show - Use to show or display a defined Test, Ref., or Acq. mask. When clicked, shows the mask for the mask type selected by the Type button.
Note: Only one mask is shown in the image window at one time.

Undef. - Use to delete the Test, Ref., or Acq. mask. When clicked, deletes the defined mask for the mask type selected by the Type button.

Note: When the Acq. Test, or Ref. buttons are not bright blue, you are working with the *Default* mask. It is not necessary to define a Default mask.

General Buttons

Fringes
Data
Load
Save

Fringes - displays one frame of the video monitor in the image area. Functions as a toggle with the Data button.

Data - displays current measurement data in the image area. When "on", the Fringes button is "off".

Load - Opens the File Handler, which is used to select a saved mask file to load.

Save - Opens the File Handler, which is used to save a mask file. A mask file can contain one or more mask types.
Note: Test, Ref., and Acq. masks must first be defined with the Define button before they can be saved.

Defining Masks

When a mask is defined, its "type" button is highlighted in bright blue. You can define an Acquisition mask, a Test mask, and a Reference mask and then save them all together in one mask file. The Define and Undef. buttons are nonfunctional with the Default mask. The Default mask does not have to be defined before it can be saved.

If you have not defined an Acquisition mask, a Test mask, or a Reference mask, then what you save will be a Default mask. When a Test mask is defined, the Default mask is disabled.

1. Create the desired figures; only colored figures are included in analysis.
2. Select the desired mask type by clicking on the Acq., Test, or Ref. button with the left mouse button. After a mask is defined, the mask button will turn bright blue.
3. Click on the Define button with the left mouse button.

Hints for Defining Multiple Masks

First, start with a gray unfilled screen, and create all the figures together on the screen; remember that only filled (colored) figures are used in the analysis. Then, fill and unfill the figures you want for a particular mask type and define it. Continue to define the other masks in the same fashion, filling and unfilling the figures as desired. Verify your definitions with the Show button as described below. Remember to save your defined masks with the Mask Editor's Save button.

Showing Masks

The Show button allows you to view each defined mask to confirm what has been defined. A mask must be defined before show will work. Only one mask is shown at a time in the image window. Colored areas are included in the analysis.

1. Select the mask type by clicking on the Acq., Test, or Ref. button with the left mouse button.
2. Press the Show button with the left mouse button. As long as the button remains pressed, the selected mask will show in the image area. Release the mouse button.

Undefining Masks

1. Select the mask type by clicking on the Acq., Test, or Ref. button with the left mouse button.
2. Click on the Undef**.** button with the left mouse button. The selected mask button will revert to its original blue color.

Removing Masks

Click the Clear button with the left mouse button to erase all figures and all defined masks.

Saving Mask Files

Saving will store all *defined* masks or the Default mask to a specified file name. To save masks, click the left mouse button on the Mask Editor's Save button.

1. In the File Handler, click on the Current Selection box.
2. Type in a name for the mask file, ending with ".mas" and press [Enter]. If you want to save the file to a specific directory, click the File Handler's Dirs button and specify the directory before entering the name of the file.
3. Click the File Handler's Done button.

Loading Mask Files

Masks must already exist before they can be loaded. To reload a previously-saved mask file, click the left mouse button on the Mask Editor's Load button.

1. In the File Handler, click on the name of the mask file you want to load.
2. If you want to load the file from a specific directory, click the File Handler's Dirs button and specify the directory before clicking the file.

Automatic Mask File Loading

With the Auto Load Masks and Masks File controls an application can be setup to automatically load a specified mask file. The Auto Load Masks control activates the auto load function and the Masks File control specifies the name of the mask file to load. These controls are available in the Control window with the New Control → Masks command.

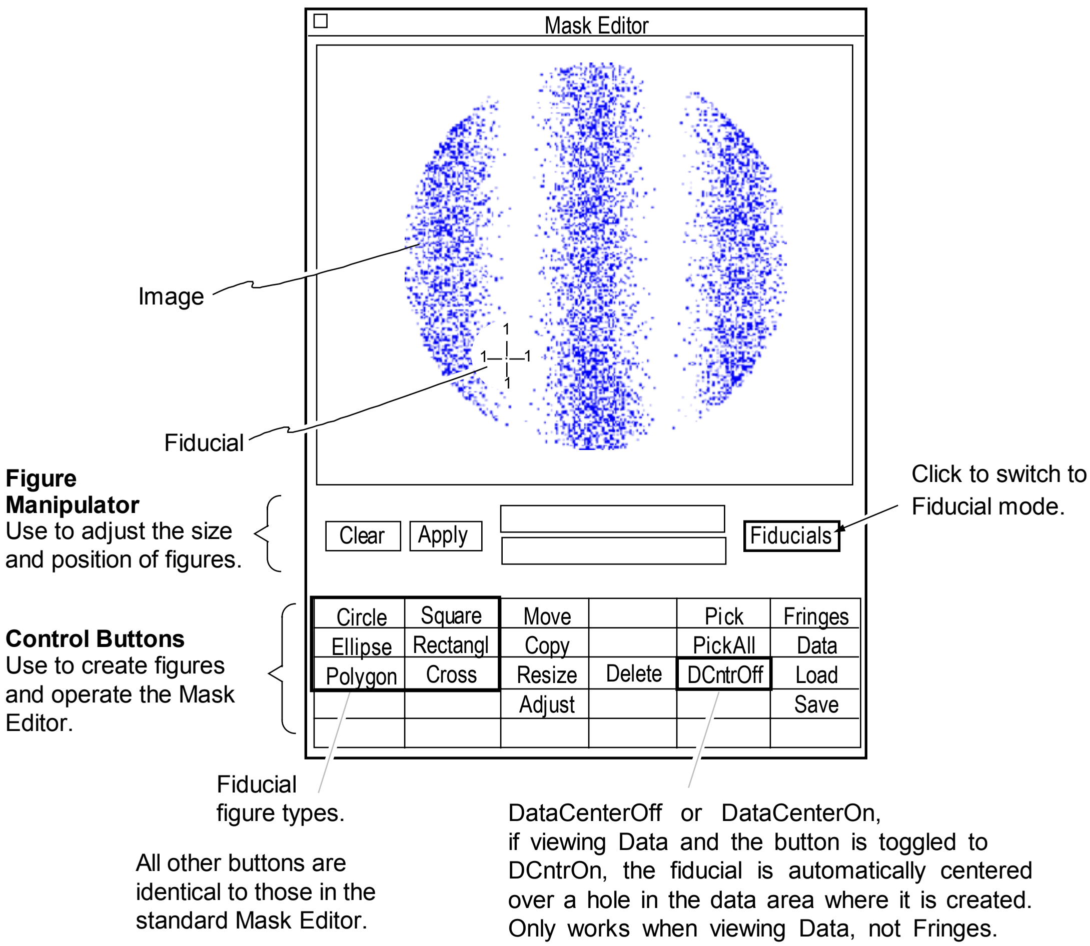
Making Automatic Default Masks

With the Auto Aperture, Aperture OD (%), and Aperture ID (%) controls you can automatically create a circular Default mask. The circular mask is centered over the data set. The Aperture ID (%) control specifies the inner diameter as a percentage of the data set; data inside this diameter is excluded. The Aperture OD (%) control specifies the outer diameter as a percentage of the data set; data outside this diameter is excluded.

When the Auto Aperture control is set to On, the automatic aperture mask function is active and any existing Default mask is automatically cleared so a new circular Default mask can be created. The automatic aperture mask function is not compatible with the Test and Reference masks; an error message appears if you try to use this feature with these masks. The automatic aperture mask function is compatible with the Acquisition mask.

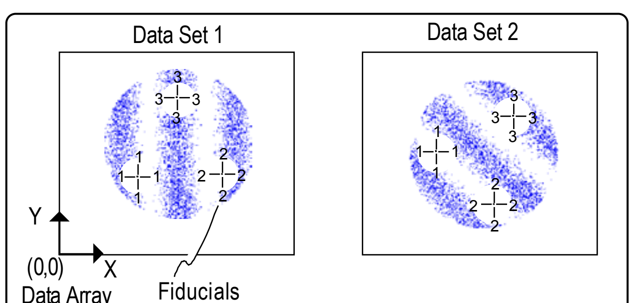
The Mask Editor Fiducial Mode

The Mask Editor has a fiducial mode of operation. The fiducial mode is used to define reference points on the data. Modes are toggled by clicking the Masks/Fiducials button in the Mask Editor.



What are Fiducials?

Fiducials are reference or data location markers that are used as an alignment aid or to compare two data sets. When comparing data sets, fiducials on one data set are compared to a similar set of fiducials on the second data set; if necessary, the second data set is translated, rotated, and scaled until the fiducials align.



When one data set with fiducials is subtracted or added to a second data set, the data is rotated, translated, and scaled until the fiducials align.

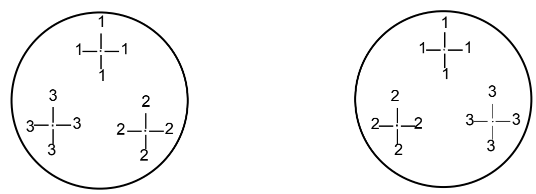
Fiducials are useful in evaluating optical systems and as an alignment aid in tests in which one part must be critically aligned to another. They may also be used as an alignment aid in certain test setups, such as in the Three Flat Application.

Creating Fiducials

A fiducial is created using tools similar to those used to define a mask figure. A fiducial may be a circle, square, ellipse, polygon, square, rectangle, or cross. The most common fiducial shape is a cross. The fiducial should be drawn over a permanent mark or feature on the test part. When possible, try to match the fiducial shape to the feature.

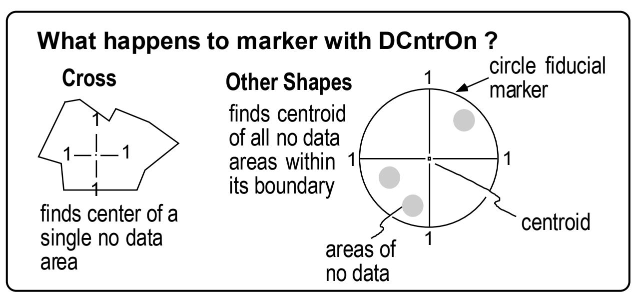
If data sets are being compared, at least two fiducials must be created for each of the data sets. This makes it possible for the software to handle translation and rotation. When three fiducials are defined, the software also performs isomorphic and/or anamorphic scaling. Isomorphic scales both axes equally; anamorphic scales to the best fit.

Any number of fiducials may be created, but only the first seven are used for calculations. Fiducials must be placed on both data sets in the same numerical sequence. This is necessary in order to have the software scale, translate, and rotate data correctly.



Fiducials assigned to two data arrays in which numerical order is not followed. This will produce a significant out-of-tolerance error.

1. Click on the Mask Data button. Then click on the Mask Editor's Masks button to switch to the Fiducial mode.
2. Before defining fiducials, determine whether or not the feature on the part is most visible in fringe or data mode. The default mode is fringe. To display data, click the Fringe button to toggle it to Data. (When displaying data, you can use the DCntrOn button so created fiducials are centered to holes in the data. If the button is DCntrOff, the fiducial will go where you put it.)
3. Click on the Cross button (or the most applicable shape button for the fiducial) with the left mouse button. Position the pointer over the image area. Click the left mouse button to create the fiducial marker. Repeat for additional markers.



4. To move the fiducial marker, click the Move button, position the cursor over the center of the marker, press and hold the left mouse button, drag the mouse to move the marker, then release the button when the fiducial is at the desired location.

Moving, Copying, Resizing, Deleting or Adjusting Fiducials

Fiducials are moved, copied, sized, deleted, and adjusted like figures.

Saving and Loading Fiducials

Fiducials are saved and loaded like mask files. With one exception, the file name should end with “.fid”.

> **Note:** The fiducial locations of up to seven fiducials are saved with measurement data, when data is saved with the Save Data button. The fiducial figures and their placement on the camera array are saved with the Mask Editor Save button.

What Can Fiducials Be Used For?

Simple Alignment Aid Create at least two fiducials for the test part, and save the fiducials. One fiducial mark should serve as a zoom guide; the second fiducial is an alignment mark that is aligned to some permanent feature or mark on the test part. Make a measurement and save the data. After additional manufacturing processes, the part can be realigned and zoomed to the saved fiducials, which are displayed on the video monitor. Measure the part again. You can directly compare the results of different measurements.

Tracking the Progress of a Part Create at least three fiducial marks for the test part; the fiducials should be located over holes in the data. Data holes can be created by sticking wax or targets to the part; these items will show up in the data as areas of no data. Measure the part and save the data. After additional manufacturing processes, place the part in the test setup, and create similar fiducial marks over the same features. Measure the part again. Set the Alignment control to Fiducials and the Alignment Scaling control to Anamorphic. Click the Subtract Data button and enter the name of the first data set. Subtracting the first data set from the second will show you what changed by the manufacturing processes.

Match Part Place the “perfect” or ideal part in the test setup. Create at least three fiducial marks over features that can be identified in all parts being measured. Measure the part and save the data. Place the “test” part in the test setup and create similar fiducial marks. Measure the test part. Set the Alignment control to Fiducials and the Alignment Scaling control to Anamorphic. Click the Subtract Data button and enter the name of the “perfect” data set. This will show you the difference between the test part and the perfect part.

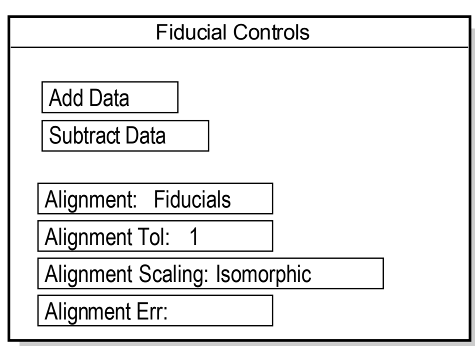
Fiducial Controls and Buttons

In order to compare data sets with fiducials you need to create buttons and controls in a Control window. A sample window is shown after the table.

To create a Control window, select the New Control Window command from the Application Window menu. You might want to rename the window to "Fiducial Controls". Buttons are created in Control window with the New Button → Manipulate command. Fiducial controls are created in Control window with the New Control → Manipulate command. The attribute is created with the New Attribute → Miscellaneous command.

Item	***Description***
Add Data button	Click to add a named file from the existing data set. You must enter the file name.
Subtract Data button	Click to subtract a named file from the existing data set. You must enter the file name.
Alignment	Selects the type of alignment done when subtracting data with fiducials. Settings are Fiducials or None. Click it to select Fiducials.
Alignment Tol	Specifies the pixel tolerance allowed when aligning fiducials. Enter a numeric value. This control is used in conjunction with the Alignment Scaling control.
Alignment Scaling	Selects how fiducials are aligned. Settings are Isomorphic or Anamorphic. Isomorphic scales both axes equally. Anamorphic scales to the best fit.
Alignment Err	Displays the fiducial actual alignment error in pixels. This is an Attribute only.

Sample Control Window configured with fiducial controls



Special Functions

Section

8

Have you ever wanted to automate a measurement, define a test pattern, or have more control over the instrument? MetroPro provides these tools and more.

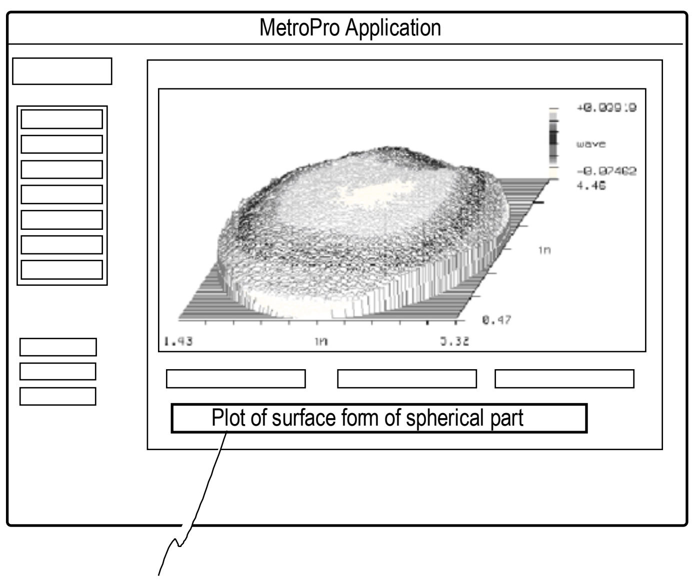
This section provides an alphabetical listing of specialized features found in MetroPro. Some features may include a special control panel designed to perform a specific function, or it may be a group of controls used together to execute a larger task.

Annotation

An Annotation box is used to enter display text in a window. Any entry in the Annotation box is not saved with the data file. Annotations are used for display and printing purposes only. To have text saved with the data file use the Comment control instead. To create an Annotation box, access the window's menu and select the New Annotation command.

To enter text, click on the Annotation box with the left mouse button. An entry field appears, in which you may type whatever you want; press [Enter] to complete the entry.

The width of the Annotation automatically adjusts as text is entered. To change the type style of the text, select the Annotation menu's Font command.



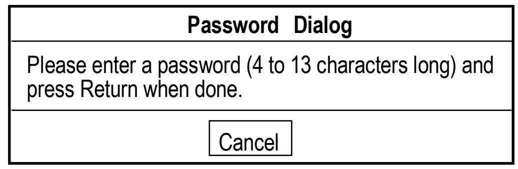
Annotation used to add textual comment to a window.

Application Locking

Applications may be locked so controls or windows can't be changed. When an application is locked, there are no menus, icons can't be opened, and items can't be moved. Even if MetroPro is restarted, locked settings are preserved. However, controls and buttons work if they are visible, and the application can be opened and closed.

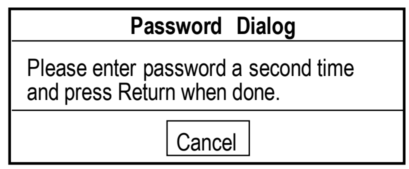
Locking an Application

1. Configure the application in the condition you wish to lock it.
2. Press CTRL-shift-L. A message box asks "Lock Application?" Press [Enter] for YES. A password dialog box appears.

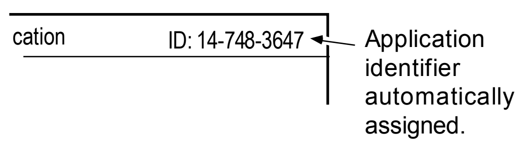


3. Using the keyboard, enter a password. After the password is entered once, another dialog box appears.

   Legal characters are letters and numbers; *not* allowed are special characters (i.e. dashes, underlines, spaces, and periods). Select a password that you can remember.

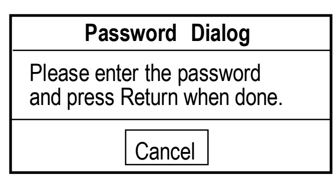


4. Enter the password a second time. When the application is locked, it is given a unique ID number. This number is displayed on the right side of the application title bar. The number helps to distinguish between multiple locked applications.



Unlocking an Application

1. Press CTRL-shift-L. A message box asks "Unlock Application?" Press [Enter] for YES. A password dialog box appears.
2. Enter your password. The application is unlocked and the ID number disappears.



Auto Sequence Function

MetroPro has the ability to automatically make a number of measurements and automatically save data. Various sequence of events can be controlled, from the number of measurements, the type of sequence, the auto saving of data files, to the time delays for events. A series of items are used together to command auto sequence functions.

The auto sequence function is useful for:

- Making a series of automatic measurements and saving data.
- Determining instrument repeatability and drift.
- Monitoring a surface over a period of time to study temperature effects or distortion after a manufacturing process.

Auto Sequence Controls

The auto sequence controls are available in a Control window. Most of the controls are created with the New Control → Auto Sequence command.

Item	***Function***
Auto Seq button	Activates an auto sequence.
Escape key	Cancels the auto sequence function when pressed.
Auto Seq Operation	Determines the auto sequence mode. Measure tells the system to make a series of measurements. Run Pattern uses the current pattern file for a system with a programmable stage.
Auto Seq Max Count	Specifies the number of sequences to make. The Auto Seq Count attribute shows the number of sequences made.
Auto Seq Delay	Specifies a time delay before a sequence starts; in hours, minutes and seconds.
Auto Seq Interval	Specifies a time delay between sequences; in hours, minutes and seconds.
Auto Save Data	Activates automatic saving of measurement data.
Auto Save Data File	Specifies the data file name for auto saved data and selects the auto save data mode. To choose the mode, access the menu for this item and select the Mode command. The Auto-Increment mode automatically saves data files without user input.

Auto Tilt and Focus

Auto focus and auto tilt are available for microscopes equipped with a z-axis motor (focus) and a programmable stage with pitch and roll motors. When properly configured, microscope focus and stage tilt adjustments are performed automatically by the software.

The auto focus and auto tilt techniques vary per instrument. The NewView uses a scanning technique, quickly scanning vertically through the data while capturing and analyzing multiple interference patterns to determine the best focus and tilt location. The Maxim uses a modulation technique or the scanning technique. In the modulation technique, a series of phase modulation acquisitions are performed until fringe contrast is maximized.

The scanning technique, for either the NewView or Maxim, requires a license to work. It is licensed as option "Scan Focus and Tilt" in the MetroPro Edit/View Licenses window. For information on licensing, see the *Getting Started With MetroPro* manual.

The control settings to select the auto focus and auto tilt techniques are as follows:

	Control Settings		
Technique	*Acquisition Mode*	*Focus Mode*	*Auto Tilt Mode*
Scanning	Scan	Scan	Software
Modulation	Phase	Software	Software

Auto Tilt and Focus Controls

The following table provides a summary of the focus and auto tilt controls. These controls are available in a Control window with the New Control → Auto Tilt and the New Control → Focus command, or the New Button → command.

Control/Button	*Function*
Controls related to auto focus	
Focus	This control enables or disables automated focus at the start of a measurement. Settings are On or Off.
Focus button	Click to make an auto focus adjustment based on the current settings of the focus controls.
Focus Depth	Specifies a focus envelope, it only applies to the modulation technique. (unsigned distance)
Focus Light Level Offset Pct	This control specifies an adjustment to the light level for both focus and tilt functions for the scanning technique only. The scanning technique normally requires a little more light than when measuring. Therefore, this control is normally set to a small positive number less than 10. The offset is applied relative to the Light Level Pct control. (signed percentage)

Auto Tilt and Focus Controls (continued)

Control/Button	*Function*
Focus Max Adjust	For the focus function, this control specifies the maximum adjustment allowed from the starting Z position. For the NewView, the Pifoc is used for scans under 47.6 µm, and the z-axis drive is used for scans over 47.7 µm. (unsigned distance)
Focus Min Contrast	Specifies the minimum contrast for focus, it only applies to the modulation technique. Contrast is based on values from 0-100, with 100 being the highest contrast. (percentage)
Focus Min Mod (%)	Specifies the minimum modulation for points to be included in the analysis of interference data. This control is normally set to a small number, as low as 1. This affects both auto focus and auto tilt. (unsigned percentage)
Focus Mode	This control, in conjunction with the Acquisition Mode control, determines how focus is performed. Settings are Software or Scan.

Acquisition Mode	Focus Mode	Auto Technique
Scan	Software	scanning
	Scan	scanning
Phase	Software	modulation
	Scan	scanning

Focus Offset	This control is used for all focus functions. This value is added to the Z axis position calculated for optimal focus. The value used is part dependent. The focus algorithm focuses on the highest portion of the part. This control should be set to a distance halfway between the highest and lowest portions. (signed distance)
Focus Retry Max Adjust	This control is used for the scanning technique only. If the first focus attempt fails due to lack of data, and if this control is set to a value greater than the Focus Max Adjust control, then a second attempt is made using this value. (unsigned distance)
Goto Focus Zero button	Prompts the operator for confirmation, then moves the Z axis to the focus zero position.
Set Focus Zero button	Prompts the operator for confirmation, then sets the current Z axis position as the new focus zero position. Readout values displayed on screen are relative to this zero position. After a stage pattern is run, the z-axis is returned to this zero position. At startup, the initial z-axis position is considered focus zero position until it is set by clicking this button.
Unset Focus Zero button	Prompts the operator for confirmation, then erases the focus zero position.

Auto Tilt and Focus Controls (continued)

Control/Button	*Function*
Controls related to auto tilt	
Auto Tilt	This control enables or disables tilt removal at the start of a measurement. Settings are On or Off.
Auto Tilt button	Click to make the microscope stage perform an auto tilt adjustment based on the current settings of the auto tilt controls.
Auto Tilt Domain	Specifies an area or range of degrees of usable fringes. This control applies only to the modulation technique. (unsigned angle)
Auto Tilt Max Adjust	This control is used for any auto tilt function. Specifies the maximum adjustment allowed from the starting pitch and roll positions. (unsigned angle)
Auto Tilt Min Contrast	Specifies the minimum tilt fringe contrast. Contrast is based on values from 0-100, with 100 being the highest contrast. Fringes with lower contrast than the entered value are considered unacceptable. This control applies only to the modulation technique. (unsigned percentage)
Auto Tilt Mode	This control, in conjunction with the Acquisition Mode control, determines the technique used to remove tilt. When the Acquisition Mode is Phase, the modulation technique is used; when set to Scan the scanning technique is used. Settings are Software (default) or Hardware.
Auto Tilt Pitch Offset	Used for any auto tilt function. The value is added to the stage pitch position calculated for null tilt. (signed angle)
Auto Tilt Pitch Tol	Specifies a tolerance value for the pitch axis. The calculated pitch angle is compared to this value. If the absolute stage pitch value is less than the respective tolerance, no adjustment is performed. (unsigned angle)
Auto Tilt Roll Offset	Used for any auto tilt function. The value is added to the stage roll position calculated for null tilt. (signed angle)
Auto Tilt Roll Tol	Specifies a tolerance value for the roll axis. The calculated roll angle is compared to this value. If the absolute stage roll value is less than the respective tolerance, no adjustment is performed. (unsigned angle)

Auto Tilt and Focus Controls (continued)

Control/Button	*Function*
Go To Tilt Zero button	This button prompts the operator for confirmation, then moves the pitch and roll axes to the tilt zero positions.
Set Tilt Zero button	This button prompts the operator for confirmation, then sets the current pitch and roll axes positions as the new tilt zero positions. Pitch and roll readout values displayed on screen are relative to this zero position. After a stage pattern is run, the pitch and roll axes return to this zero position. At startup, the initial pitch and roll axes positions are considered tilt zero position until it is set by clicking this button.
Unset Tilt Zero button	This button prompts the operator for confirmation, then cancels the use of the tilt zero positions when running a pattern.

Optimizing Auto Tilt and Focus Settings

A Scan Focus Diagnostic data window is available in the generic Microscope type application to help optimize the scan focus and tilt control settings. This data window provides a Filled Plot of the height map acquired during a focus and tilt scan operation. This allows the operator to evaluate if the proper amount and regions of data are acquired.

The Focus Light Level Offset Pct and Focus Min Mod (%) controls are critical for reliable operation. If the scanning technique is used, observe the interference pattern to assess the contrast. If the contrast is low, more light is needed and the Focus Light Level Offset Pct control value should be increased.

Observe the Filled Plot in the Scan Focus Diagnostic data window. If there is not enough data acquired, try lowering the Focus Min Mod (%) control value. For some applications, the Focus Min Mod (%) control value can be increased just enough to eliminate regions of low contrast that should be ignored.

Bitmap Window

This function makes it possible to load and display a bitmap file into a special MetroPro Bitmap Window. This ability is particulary useful if you want to display a part drawing company logo, or other graphic on the screen while acquiring and analyzing data. It can also be used to customize the look of a MetroPro button or icon.

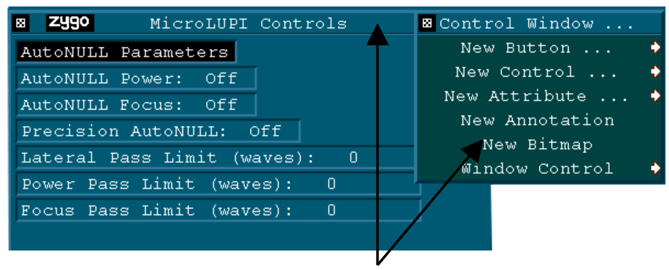
Like other MetroPro windows, it will have a border whose width can be specified.

Bitmap Size

It is important to size the bitmap *before* loading it into MetroPro. The Bitmap Window will be the size of the bitmag image. Once loaded, it cannot be edited for size, contrast, or color adjustments. This must be done in an external image editing program. MetroPro will import the bitmap at whatever pixel size it was saved at. If the bitmap is edited in another program and size is adjusted by changing resolution (dpi), MetroPro will still import it according to its pixel size.

Loading the Bitmap

Access New Bitmap by right-clicking in the title bar of a Control, Data, or Process Window. Click on New Bitmap in the pull-down menu. When prompted, enter the title of the bitmap. The bitmap must reside in the MetroPro working directory, typically C:\users\zygo..



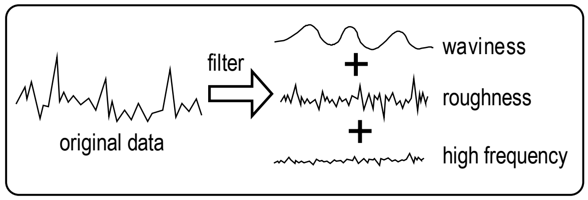
Right click in the title bar.
Then left click New Bitmap.

Once a Bitmap Window is added to a MetroPro application, you may load a different bitmap by right clicking the Bitmap Window title bar and selecting File…and specifying a new file name.

Bitmaps on Buttons and Icons

A bitmap may be displayed on a MetroPro button (e.g. Measure, Analyze, Load Data) or an icon (Measure Cntrl, Analyze Cntrl, Pattern Cntrl). Right click the button or icon and select Bitmap→File…

Filtering

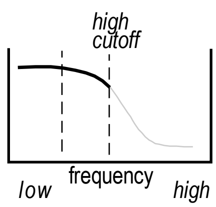
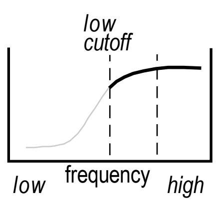
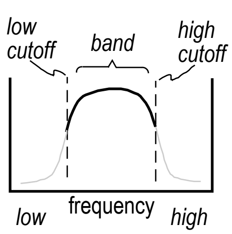
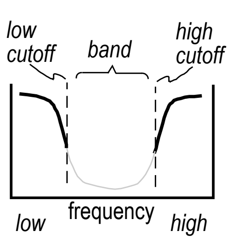


By digital filtering of the test data, the surface characteristics of the test part are broken down into waviness, roughness, and high frequency results. Both map and profile data can be filtered. Use caution when filtering data, as it modifies the original data and can drastically alter the test results. To observe the effects of filtering, make the first measurement with the Filter control Off; then change the filter controls, press the Analyze button, and observe the outcome. For many applications, click the Analyze Cntrl icon to find the filter controls.

The terms frequency and wavelength as they relate to filtering are shown here:

Waviness	Roughness	High Frequency
low	← frequency →	*high*
long	← wavelength →	*short*

Summary of Filtering Functions

Filter	*Chart*	*Description*
Off	-	All data is unfiltered.
Low Pass		Low frequency or waviness data is highlighted. The effect varies based on the Filter Type control. Average, Median, and 2 Sigma work in conjunction with the Window Size control; the larger the size the greater the effect. FFT Fixed lets you set the cutoff.
High Pass		High frequency or roughness data is emphasized. The effect varies based on the Filter Type control. Average, Median, and 2 Sigma work in conjunction with the Window Size control; the larger the size the greater the effect. FFT Fixed lets you set the cutoff.
Band Pass		Data in the center of the band is analyzed. The Filter Type control must be set to FFT Fixed or FFT Auto. FFT Fixed lets you set the cutoff locations with the Filter High/Low Wavelen (or Freq) controls. In FFT Auto, the software arbitrarily sets the cutoffs as a starting point; you should switch to FFT Fixed and enter your own cutoffs. The exact filter values to enter vary due to the test part, the instrument's optics, and your testing criteria.
Band Reject		Data in the center of the band is rejected. The Filter Type control must be set to FFT Fixed or FFT Auto. FFT Fixed lets you set the cutoff locations with the Filter High/Low Wavelen (or Freq) controls.

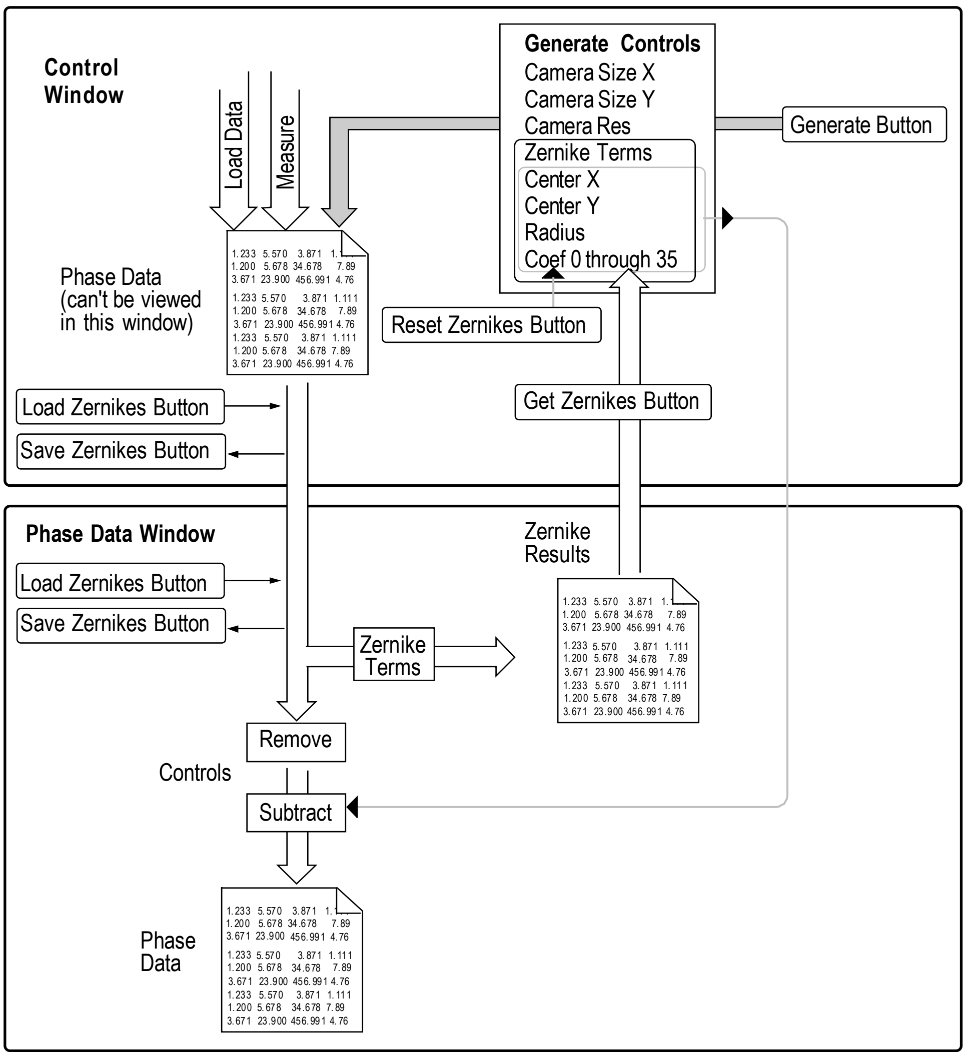
Generate Function

A group of controls and buttons are used together to create and manipulate Zernike polynomials. Most of the controls and buttons are available in the Control window and created with the New Control → Generate command.

The generate features can be used to:

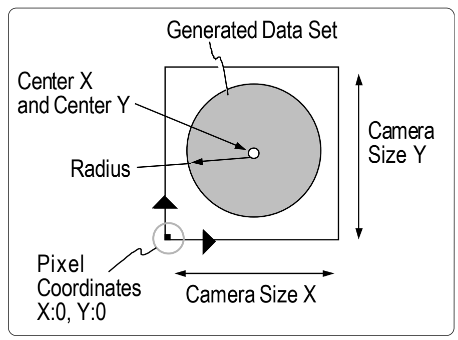
- create or generate a theoretical wavefront without an actual test part.
- subtract specific aberrations from an existing data set.
- compare a measured wavefront with a design wavefront.

Generate Overview



The Generate Controls

Item	*Function*
Generate button	Creates a data set based on the settings of the generate controls.
Save Zernikes button	Opens the File Handler, which is used to specify a file name and save the file.
Load Zernikes button	Opens the File Handler, which is used to select the Zernike file to load.
Get Zernikes button	Obtains Zernike terms and characteristics from a current data file in the default data window.
Reset Zernikes button	Resets the Center X, Center Y, and Radius controls to -1, and Coef controls to 0.
Camera Size X	Specifies the number of camera pixels in the x-dimension.
Camera Size Y	Specifies the number of camera pixels in the y-dimension.
Camera Res	Specifies the lateral dimension between camera pixels.
Center X	Specifies the location in the x-axis of the center of generated data; -1 places it at the center of the camera size.
Center Y	Specifies the location in the y-axis of the center of generated data; -1 places it at the center of the camera size.
Coef 0 through Coef 36	Specify the coefficients that comprise the Zernike data.
Radius	Specifies the size of the generated data as the number of pixels from the center; -1 fills the camera size.
Subtract	When set to Gen Zern, the current generated Zernike data is subtracted from the current wavefront data when the Analyze button is clicked..
Zernike Terms	Specifies the number of Zernike terms used when data is generated.



Using the Generate Function to Subtract Aberrations

1. Measure the test part as usual.
2. Click the Get Zernikes button to capture the Zernikes from the data.
3. Note the significant shape you want to subtract from the data. Zero out the Coef controls that are insignificant. To do this, position the cursor over the Coef control, click the left mouse button; enter all zeroes with the keyboard, then press [Enter].
4. Click the Generate button to create a generated Zernike data set.
5. Set the Subtract Control box to Gen Zern.
6. Click the Analyze button, so the data is reanalyzed with the generated data subtracted from the current data.
7. To save the generated data, click the Save Zernikes button. Click the Current Selection box, type in a name for the file, ending with ".zfr", then press [Enter]. Click Done to close the File Handler. Note that the settings of the Radius or Center controls are not preserved with Zernike data.

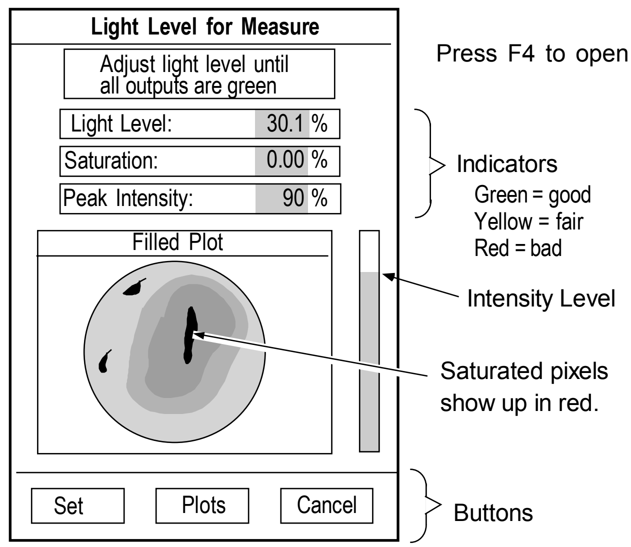
Light Level Control

The proper light level is critical to obtaining an accurate measurement.

Key	**Function**
F4	Open Light Level Window to manually set light level.
F5	Automatically set light level.

The Light Level Dialog

1. Adjust the instrument for proper focus as described in the operation manual.
2. Press the F4 key to open the window.
3. Use the numeric keypad to adjust levels until all indicators are green. Saturation causes data dropout.
4. Click the Set button or press [Enter] to change the light level. To cancel light level adjustment, click the Cancel button or press the [Escape] key.



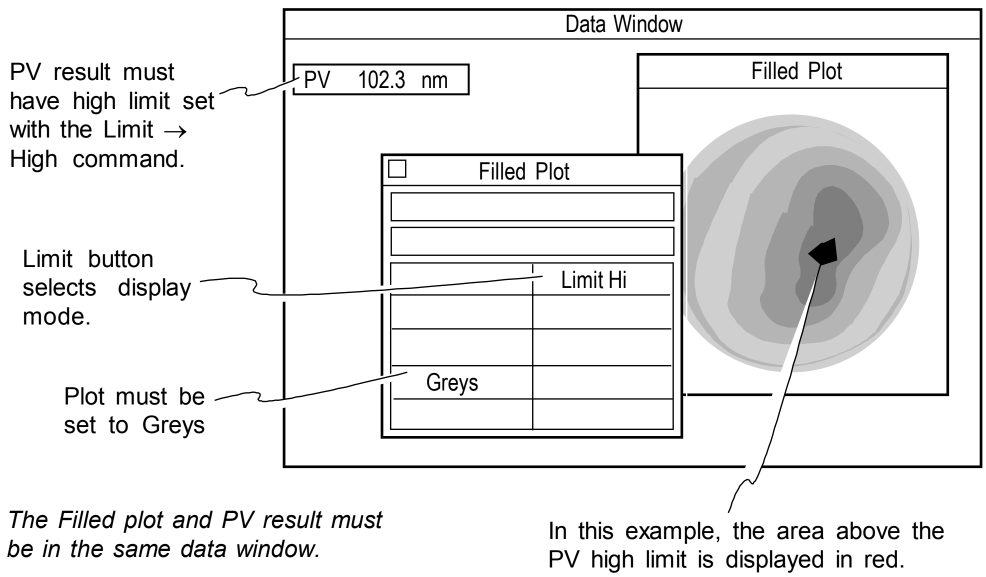
The Light Level Keys

These keys adjust the light level for the instrument. To set the light level, use the Light Level dialog, press F5 for automatic control, or enter a value in the Light Level Pct control.

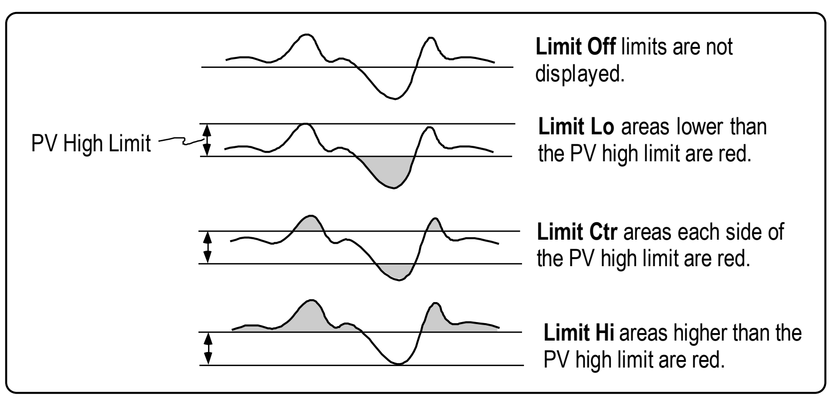
Key	**Function**
* /	Coarse up and down.
+ -	Fine up and down.
1 2 3 …	Adjust level in 10% steps, 1 = 10%, 4 = 40%, 9 = 90%, 0 = 100%
Tab	Toggle between last two light settings.
Esc	Exit Light Level dialog.

Limit Function

The limit function displays areas outside user set limits as red when the plot color is set to grey; it is applicable to the Filled Plot, Oblique Plot, and 3D Plot. The following conditions are necessary for the limit function: 1) works only with PV result, 2) the PV result must have limits set with the Limits → High command, 3) the PV result must reside in the same data window as the plot, 4) the plot color must be grey, and 5) limits must be activated in the plot Controller.



The plot Controller Limit button has four choices: Limit Off, Limit Lo, Limit Ctr (center), or Limit Hi. Depending upon the limit value entered in the PV result and the Limit button setting, red areas may be shown in the plot.



Displaying Limits in a Filled, Oblique, or 3D Plot

1. If the data window does not contain a PV result, create one using the New Result command.
2. Using the PV result box menu, select the Limits → High command and enter a value.
3. Open the plot Controller by clicking on the plot with the middle mouse button.
4. Click the plot Controller Limit button, with the left mouse button, to select the way limits are displayed.
5. To update the plot, click the Controller's Update button.
6. To preserve the plot settings, click the Controller's Set button.
7. To preserve your changes, save the application with the Application Window menu Re-save Application command.

Using Limits in a Result

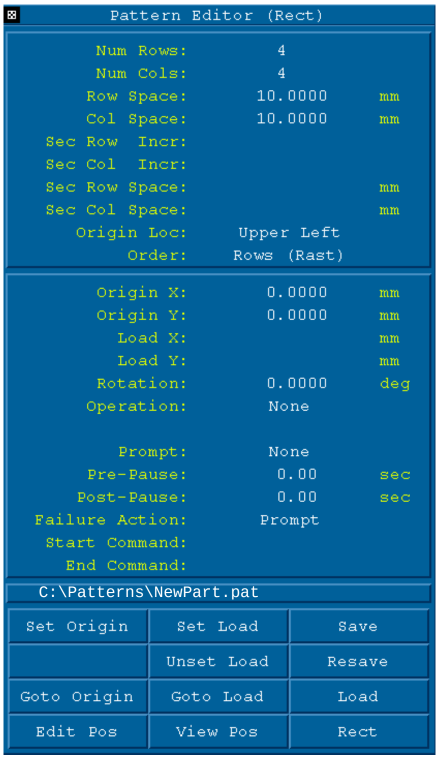
The Limits command is used to specify what is an acceptable value for a numeric result box; it is accessed with the box's menu. If limits are specified for a result, the result box is green when the value is acceptable, and red when the value exceeds the limit. This serves as a visual indicator that the value has passed or failed a set limit.

The Limits → High command is used to enter the high limit; thus the result box turns red when the measured value exceeds this limit. The Limits → Low command is used to enter the low limit; thus the result box turns red when the measured value is smaller than this limit. Both high and low limits can be entered for a result.

1. To enter a limit for a result, position the pointer over the result box and press the right mouse button to access its menu. Choose the Limits command, enter a numeric value with the keyboard and press [Enter]. Note that zero (0) is an acceptable limit setting.
2. To turn the limit function off, select the Limits command, delete all characters and press [Enter].

Pattern Editor

The Pattern Editor and associated software controls provide for creating, editing, saving, and loading stage control pattern files. Pattern files direct the movement of programmable stages. Click the Edit Pattern button to open the Pattern Editor.



Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

Variable controls based on pattern type.

Common controls (described under “Common Controls – Pattern Editor”)

Displays the pathname of the file for the current pattern.

Buttons (described below).

Buttons - Pattern Editor

Set Origin Sets current stage coordinates as the first pattern position. Set*Origin denotes a location is set as the origin.
Note: The origin for an R-Theta Stage is always at the center of the stage (0,0).

Goto Origin Drives the stage to the first pattern position.

Edit Pos Open the Position Editor window, which is used to edit pattern positions.

Set Load Sets current stage coordinates as the load position. Set*Load denotes a load position is set.

Unset Load Erases the set load position.

Goto Load Drives the stage to the pattern position for loading parts.

View Pos Open the Position Status Window.

Save Open the File Handler, which is used to save the pattern file.

Resave Resaves the pattern to the current pathname, avoiding the filename selection dialog.

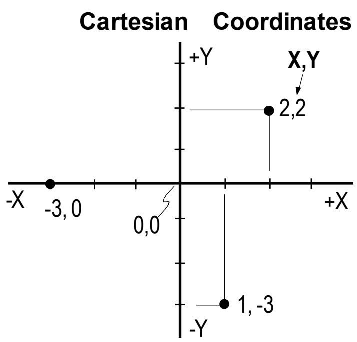
Load Open the File Handler to specify a pattern file to load.

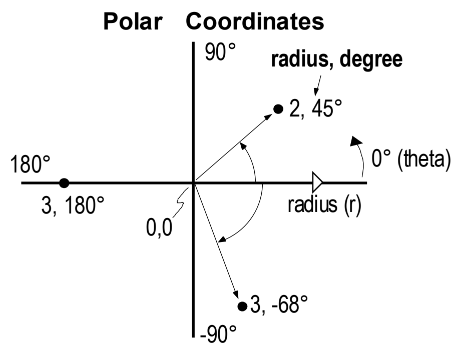
Rect Selects the pattern type. Also referred to as the "Mode" button.

Coordinate Systems - Pattern Editor

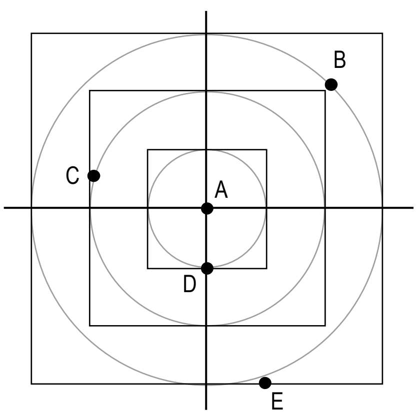
The X-Y programmable stage is based on a Cartesian coordinate system. The R-Theta programmable stage is based on a polar coordinate system.

Any of the pattern types - Rectangular, Circular, or FreeRect, can be used with either programmable stage. The type of pattern is selected with the Pattern Editor's "Mode" button. A rectangular pattern is based on a Cartesian coordinate system. A circular pattern is based on a polar coordinate system.



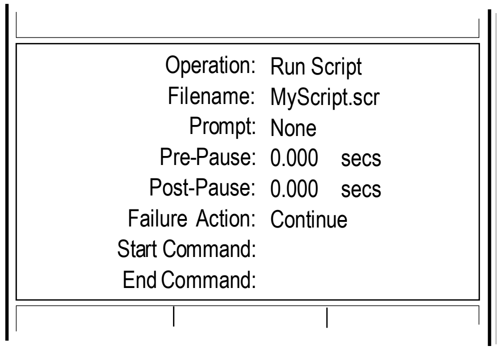


An example showing both Cartesian and polar coordinates superimposed is shown below.



Position	*Cartesian*	*Polar*
A	0, 0	0, 0
B	2.1, 2.1	3.0, 45°
C	-1.9, 0.6	2.0, 163°
D	0.0, -1.0	1.0, -90°
E	1.0, -3.0	3.1, -71°

Common Controls - Pattern Editor



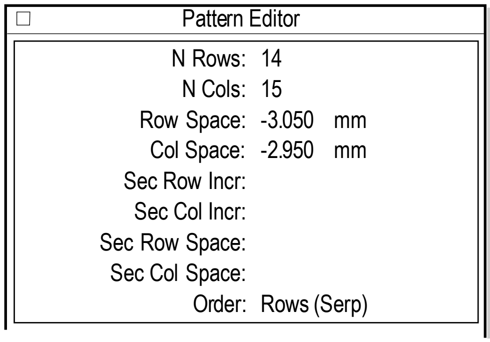
Portion of Pattern Editor common to all pattern types

Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

Control	***Function***
Operation	Selects what is done at each pattern point. Measure takes a measurement at each point. Set to None when checking pattern spacing. Run Script executes the MetroScript file specified after Filename.
Filename	Specifies the name of the script file when Operation is set to Run Script. Only appears when applicable.
Prompt	Selects when the operator is prompted at each pattern position. A prompt shows the current position and waits for the user to respond. Choices are Before, After, Before & After, or None (default).
Pre-Pause	Specifies a time delay before the measurement.
Post-Pause	Specifies a time delay after the measurement before the stage moves to the next position.
Failure Action	Selects what is done when there is a measurement error. Prompt asks the user what to do. Retry repeats the measurement and aborts the pattern if it fails again. Continue ignores the error and goes to next position; the error position is not measured.
Start Command	Specifies a command that is executed before the start of a pattern.
End Command	Specifies a command that is executed when the pattern ends. An example is sending the data or a report file to another computer.

Rectangular Pattern Controls - Pattern Editor

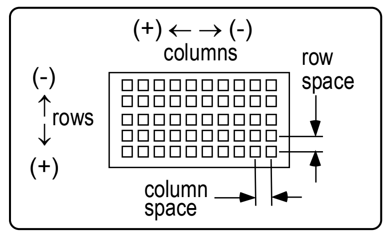
A rectangular pattern specifies points based on a Cartesian coordinate system. These controls are displayed when the Pattern Editor's "Mode" button is set to Rect.

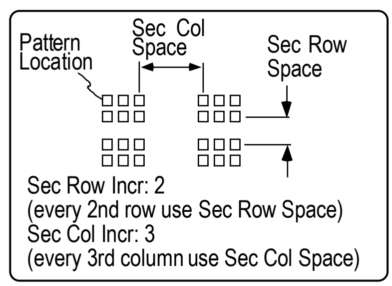


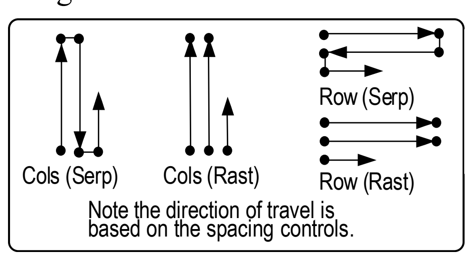
Rectangular Pattern Controls

Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

Control	***Function***
N Rows	Sets the number of horizontal rows in the pattern.
N Cols	Sets the number of vertical columns in the pattern.
Row Space	Specifies the distance between each horizontal row. The direction of motion depends on the sign.
Col Space	Specifies the distance between each vertical column. The direction of motion depends on the sign.
Sec Row Incr	Specifies which rows use secondary row spacing.
Sec Col Incr	Specifies which columns use secondary column spacing.
Sec Row Space	Specifies the distance between each row in the secondary pattern. The sign determines motion direction.
Sec Col Space	Specifies the distance between each column in the secondary pattern. The sign determines motion direction.
Order	Selects how the pattern is run. Serp = Serpentine Rast = Raster

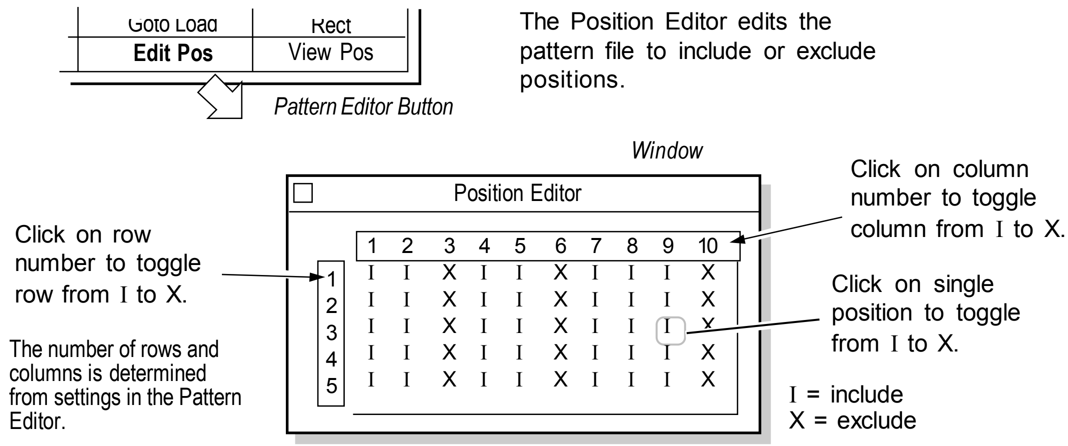






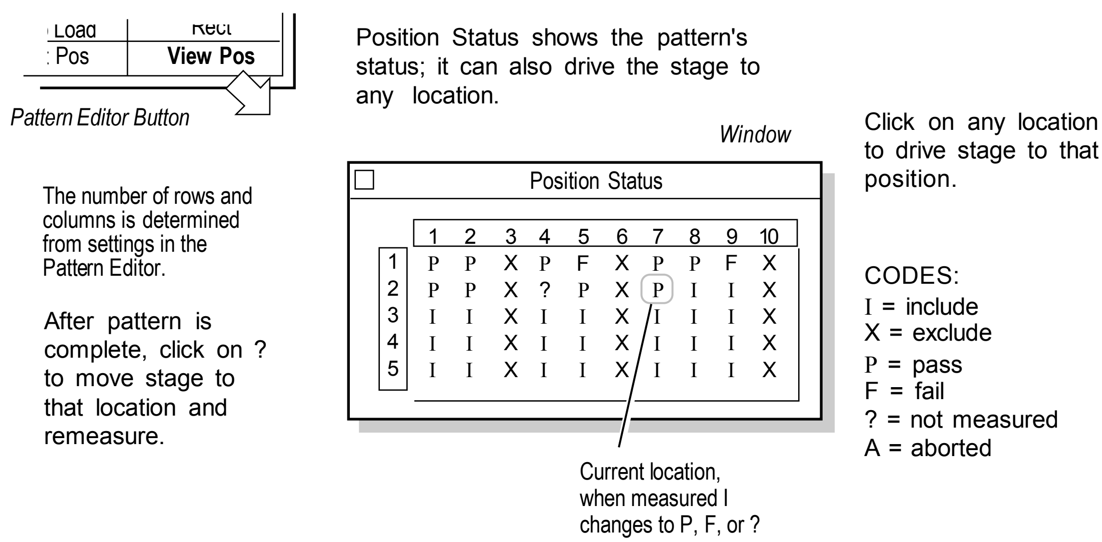
Rectangular Patterns - Position Editor

To open the Position Editor window click the Pattern Editor's Edit Pos button or the Edit Pattern Pos button. The Position Editor is used to edit the pattern to include or exclude pattern locations.



Rectangular Patterns - Position Status

To open the Position Status window click the Pattern Editor's View Pos button or the View Pattern Pos button. The Position Status window shows the current status of the pattern; click on a location to drive the stage that position.



Rectangular Patterns – Align Pattern (Determining the Rotation Value)

This function provides for semi-automatic calculation of how much the stage is rotated in the X and Y axes. Once the rotation value is determined, it is factored into the pattern during the Run Pattern operation. The rotation value may be copied to a Circular or FreeRect pattern, but a rectangular pattern must be used for set up. Align Pattern may only be used on systems with programmable stages.

The rotation value may be based upon the row coordinates, column coordinates, or both. The programmable stage must be able to access the pattern origin. During the alignment, movement to all the pattern coordinates may not be possible. When this happens, the folllowing error message is generated: “One or more invalid coordinates.”

1. Be sure that a valid pattern file has been loaded.
2. Open the Pattern Editor.
3. Select Rect as the pattern type.
4. Check that the origin location is set correctly.
5. Click the Align Pattern button (or Control→New Button→Pattern Align→Pattern). A dialog box with the following message is displayed:

> **Message**
>
> The following dialogs will guide you through the process of aligning the current Rect pattern.
>
> Click ‘Cancel’ if the pattern has not been edited to specify at least the following values
>
> Num Rows
> Num Col
> Origin Loc
>
> Click ‘Ok’ to continue
>
> OK Cancel

6. To continue, click OK.
7. The system will prompt you to move the stage to the origin location. Click the Goto Origin button.
8. Use the joystick to move to the last column and click OK.
9. Click Yes in response to the Calculate column Spacing and Row Spacing prompts.

   Note: The View Pos button is in the main Pattern Editor window.

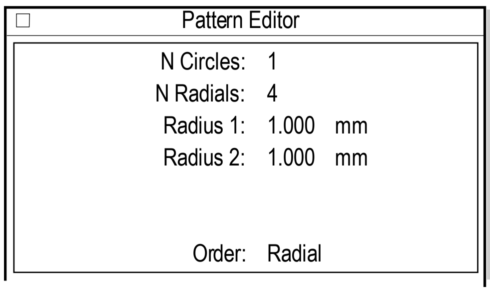
   Hint: When checking position status, select None for Operation type. This will enable you to view every position without making a measurement at each position.

10. Select Both as the alignment type. Follow the prompts to move to the last row/last column.

11. Click Done to complete the Align Pattern routine. A value should be displayed in the Rotation control. This value may be copied to a Circular or FreeRect pattern.

Circular Pattern Controls - Pattern Editor

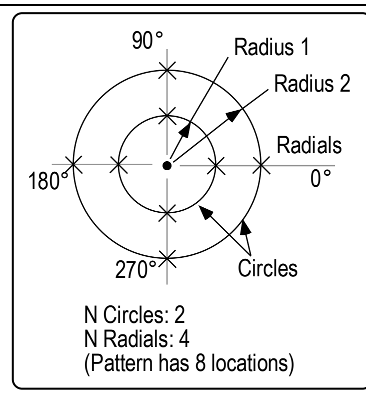
A circular pattern specifies points in a polar coordinate system. The center of each circular pattern is assumed to be the center of the theta axis. These controls are displayed when the Pattern Editor's "Mode" button is set to Circ.

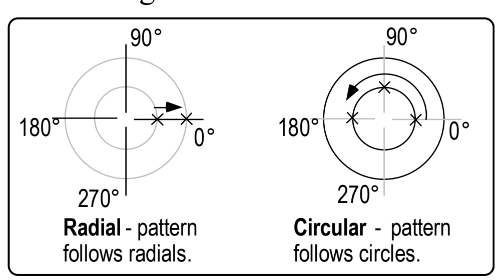


Circular Pattern Controls

Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

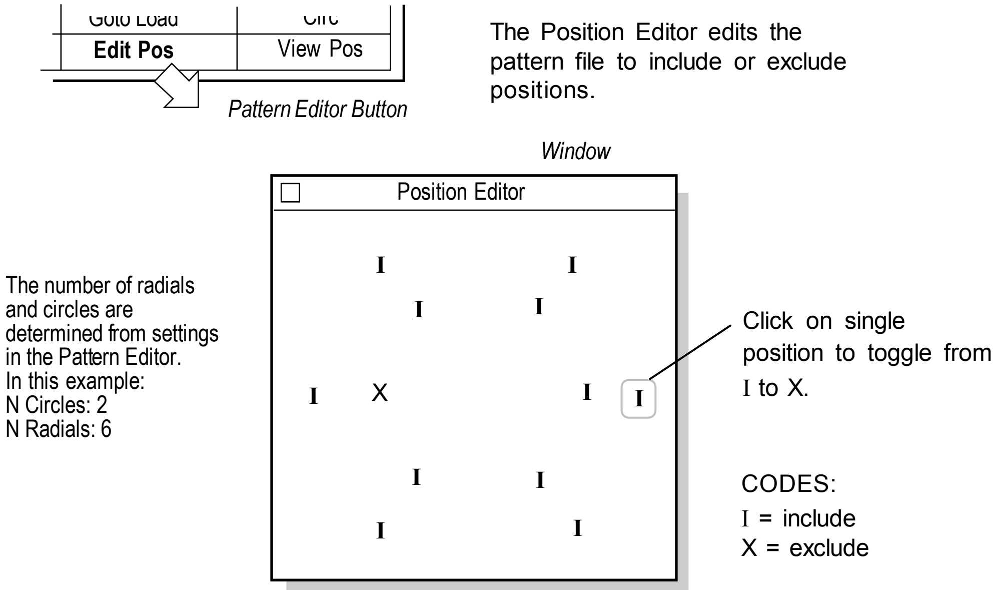
Control	*Function*
N Circles	Sets the number of circles in the pattern.
N Radials	Sets the number of equally spaced measurement points around each circle. For example, a setting of 4 places measurements at 90 degree intervals.
Radius 1	Specifies the dimension for the first measurement circle. If N Circles is 3 or more, additional measurements are made at equally spaced locations between Radius 1 and Radius 2.
Radius 2	Specifies the dimension for the last measurement circle. If N Circles is 1, Radius 2 is ignored.
Order	Selects how the circular pattern is executed. Choices are Radial or Circular. Radial starts at the 0 degree mark and jumps between radii. Circular starts at the 0 degree mark and completes one circle before going to the next.





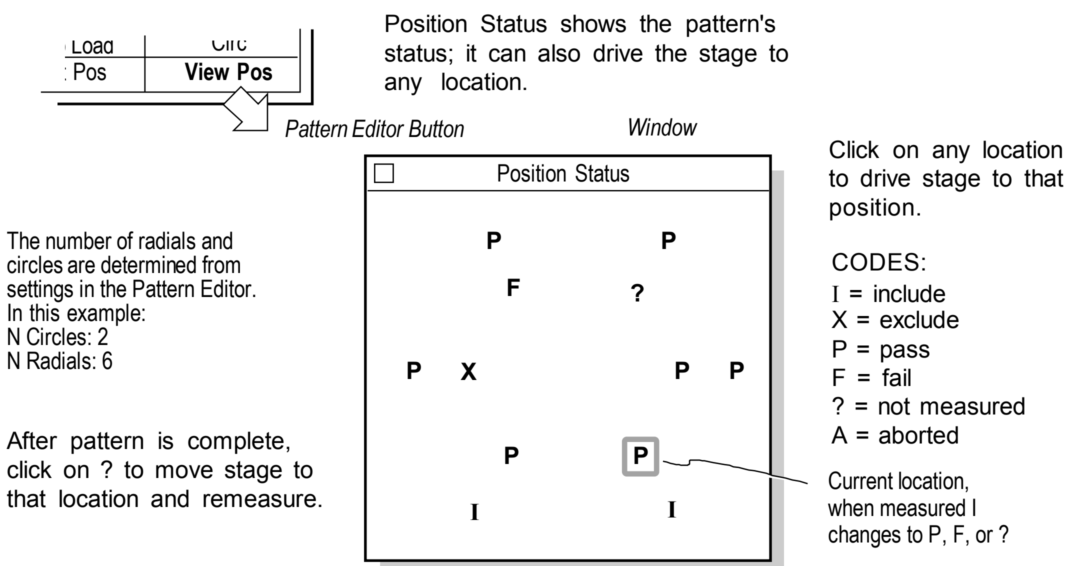
Circular Patterns - Position Editor

To open the Position Editor window click the Pattern Editor's Edit Pos button or the Edit Pattern Pos button. The Position Editor is used to edit the pattern to include or exclude pattern locations.



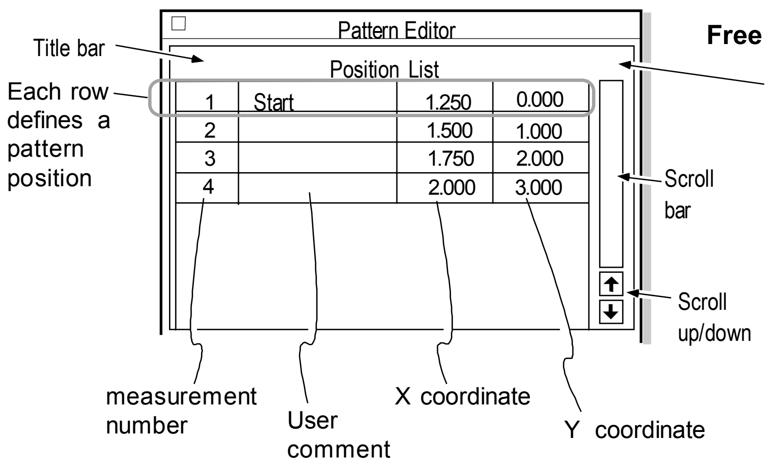
Circular Patterns - Position Status

To open the Position Status window click the Pattern Editor's View Pos button or the View Pattern Pos button. The Position Status window shows the current status of the pattern; click on a location to drive the stage that position.



FreeRect Pattern Controls - Pattern Editor

A free pattern specifies pattern positions in an X and Y Cartesian coordinate system; it can be used with all programmable stages. These controls are displayed when the Pattern Editor's "Mode" button is set to FreeRect. The Position List is empty when first opened.



Free Pattern Controls

Position List
Shows the X and Y coordinates of pattern positions. It is empty when first opened.

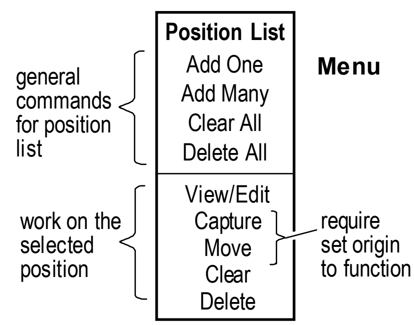
Adding Positions (on-line) - FreeRect Pattern

On-line refers to when the programmable stage is present. There are two basic ways of adding positions. One is to step the stage through each measurement location and select the Add One command at each location. Another way is to add many positions with the Add Many command, then move the stage to each measurement location and select the Capture command.

1. Drive the programmable stage to the desired position.
2. Move the cursor over the Position List title bar, press the right mouse button and select the Add One command. The current stage location is automatically entered in this position.
3. Repeat the above steps until all positions are added.

or

1. Move the cursor over the Position List title bar, press the right mouse button, and select the Add Many command.
2. Drive the stage to the desired position.
3. Select a position in the Position List by clicking on it with the left mouse button.
4. Press the right mouse button and select the Capture command. (Note: the pattern origin must be set for Capture to work.)

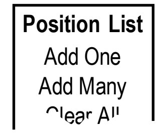


Add One	Adds one pattern position.
Add Many	Adds the specified number of pattern positions.
Clear All	Erases information from all positions.
Delete All	Removes all pattern positions.
View/Edit	Opens the Position Editor.
Capture	Captures the stage location for the selected position.
Move	Moves the stage to the selected position.
Clear	Erase information from the selected position.
Delete	Remove the selected position.

Adding Positions (off-line) - FreeRect Pattern

Off-line refers to when the programmable stage is not present.

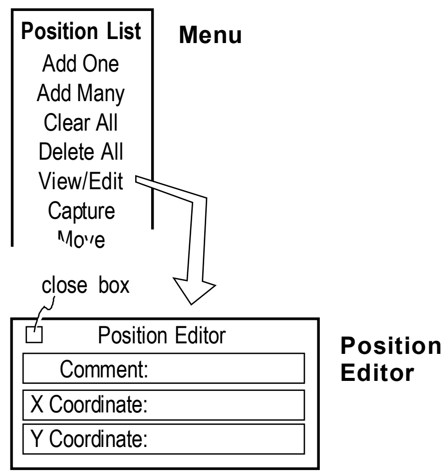
1. Move the cursor over the Position List title bar, press the right mouse button and select the Add One or Add Many command. Positions are added with coordinates of 0, 0.



Editing Positions - FreeRect Pattern

There are two basic ways of editing positions. One is to select the View/Edit command and enter information in the Position Editor. Another way is to move the stage to the measurement location and select the Capture command.

1. Select a position in the Position List by clicking on it with the left mouse button. Press the right mouse button and select the View/Edit command.
2. In the Position Editor, edit applicable information by clicking on a line and typing the comment or coordinate position. Click the close box to close the Editor.



or (not available when off-line)

1. Drive the stage to the desired position.
2. Select a position in the Position List by clicking on it with the left mouse button. Press the right mouse button and select the Capture command. (Origin must already be set.)

Changing the Order of Positions in the Position List - FreeRect Pattern

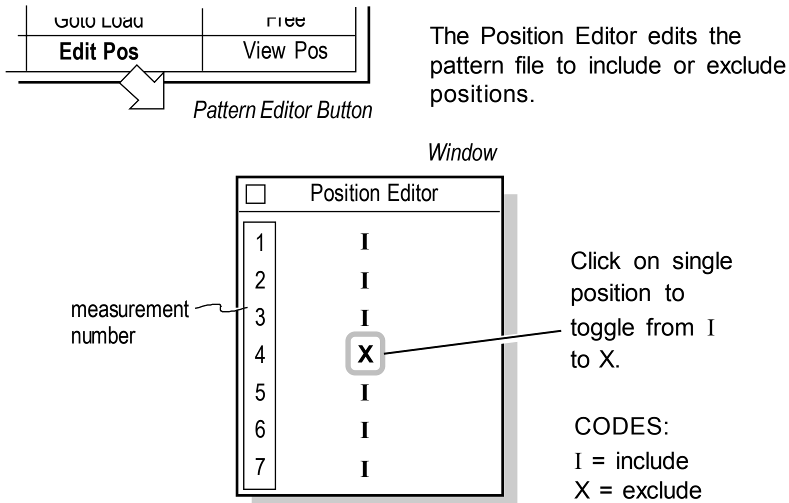
1. Move the cursor over the position in the Position List you want to move. Press the left mouse button and drag the position to its new location, then release the mouse button. Measurement numbers are automatically renumbered.

Deleting Positions from the Position List – FreeRect Pattern

1. To remove all pattern positions, move the cursor over the Position List title bar, press the right mouse button, and select the Delete All command.
2. To remove one pattern position, select a position in the Position List by clicking on it with the left mouse button. Then press the right mouse button and select the Delete command.

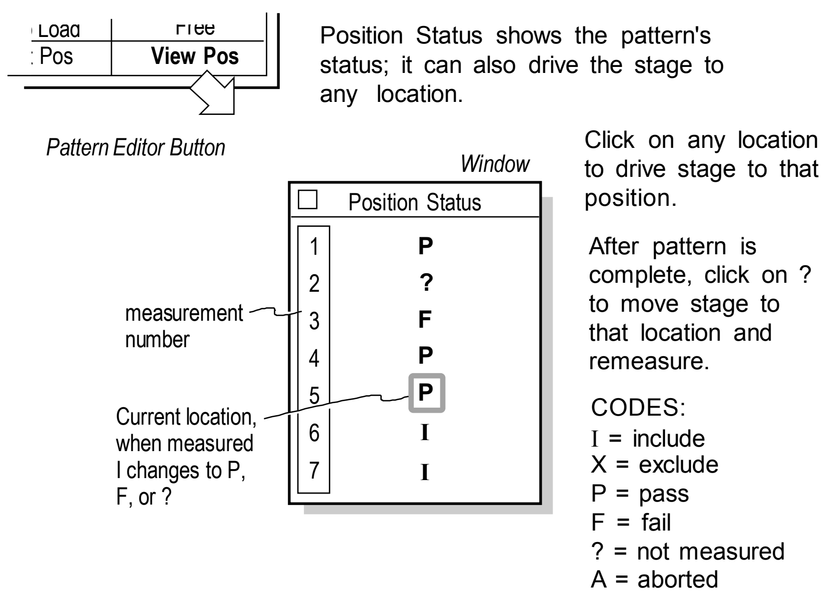
FreeRect Patterns - Position Editor

To open the Position Editor window click the Pattern Editor's Edit Pos button or the Edit Pattern Pos button. The Position Editor is used to edit the pattern to include or exclude pattern locations.



FreeRect Patterns - Position Status

To open the Position Status window click the Pattern Editor's View Pos button or the View Pattern Pos button. The Position Status window shows the current status of the pattern; click on a location to drive the stage to that position.



FreeRect Align Pattern (Determining the Rotation Value

The following steps cover alignment of a FreeRect pattern. This procedure may also be used for a normal rectangular pattern as long as alignment positions are selected.

1. Before using this procedure, be sure the stage has been homed, and AutoCalibrate has been run.
2. Open the Pattern Editor and use the Load button to open a valid pattern.
3. Click on the EditPos button and open the Position Editor. Use the middle mouse button to click on the position(s) that will be used as alignment positions. They will be highlighted yellow. Alignment positions do not have to be included in the pattern.

For a pattern with one alignment position, follows steps 4 through 7. For a pattern with 2 or more alignment positions follows step 8 through 13.

4. For one alignment position, click the Align Pattern button. The following dialog box is displayed. Follow the screen prompts.

Message	
The following dialog will guide you through the process of adjusting ONLY THE ORIGIN of the current pattern.	
Click 'Ok' to continue. Click Cancel to abort.	
OK	**Cancel**

5. To continue, click OK.
6. The system moves the stage to the location where it thinks the position is. You may need to use the X/Y joystick to adjust the position so that fringes are visible. Click OK. The pattern's origin is automatically updated and "Pattern Alginment Complete" is displayed.
7. Click the Save button to save the aligned pattern.
8. For two or more alignment positions, click the Align Pattern button. The following dialog box is displayed. Follow the screen prompts.

Message	
The following dialog will guide you through the process of adjusting the ORIGIN and ROTATION of the current pattern.	
Click 'Ok' to continue. Click Cancel to abort.	
OK	**Cancel**

9. To continue, click OK.
10. The system moves the stage to the location where it thinks the first position is. You may need to use the X/Y joystick to adjust the position so that fringes are visible. At each position the system temporarily calculates and updates the rotation value. The same process is repeated for all of the alignment positions.

11. After the stage has been moved to the last alignment position, the pattern's origin and rotation will be automatically updated and a message indicating "Pattern Alignment Complete" will be displayed.
12. Click the Goto Origin button to check the first position.
13. Click on the Save button to save the aligned pattern.

Creating a Pattern - Pattern Editor

This procedure provides a generic approach to creating and using a pattern file. Multiple pattern files can be created and saved.

1. Click the Edit Pattern button to open the Pattern Editor.
2. Select the pattern type with the Pattern Editor's "Mode" button.
3. Enter values for the applicable Pattern Editor controls, as shown in previous sections.
4. Define Origin and Load. Using the motion controller, drive the stage to the first pattern position and set the origin by clicking the Set Origin button. Then drive the stage to the location for loading parts and click the Set Load button.
5. Make a trial pattern test run. Set the Pattern Editor's Operation control to None. Click the Run Pattern button.
6. To save your defined pattern file, click the Pattern Editor's Save button. In the File Handler, click on the Current Selection field, type in a file name ending, with ".pat", and press [Enter], then click Done to close the File Handler.
7. Click the Auto Load Pattern control to On. Enter the name of the pattern in the Pattern File control.
8. Save your changes to the application. If it is a supplied application from Zygo, select the Save Application command from the Application Window menu. In the File handler, enter a name for the file, ending with ".app", and press [Enter], then click the Done button.

Configuring MetroPro for the Programmable Stage - Pattern Editor

MetroPro must be configured for the programmable stage and the Pattern Editor to function properly. Configuration procedures are included in case it becomes necessary to reinstall or update the programmable stage configuration file.

Perform the appropriate procedure, as based on the operating system, after MetroPro is installed and the equipment is up and running. MetroPro configuration file names are listed in the following table.

.

Instrument	Stage	File Name
NewView 100/200	2-axis: 6-inch XY stage w/increased speed	xy15.cfg
NewView 100/200	5-axis: 6-inch XY stage w/increased speed, tip/tilt stage, and Z stage	xy20.cfg
NewView 100/200	5-axis: 6-inch XY stage, tip/tilt stage and Z stage	xy22.cfg
NewView 5000	5-axis: 6-inch XY stage, tip/tilt stage, and Z stage	xy31.cfg
NewView 5000	3-axis: 6-inch XY stage, and Z stage	xy32.cfg
NewView 5000	2-axis: 6-inch XY stage	xy33.cfg
GPI	2-axis: tip/tilt stage	xy34.cfg
Mesa	2-axis: tip/tilt stage	xy36.cfg
Large Aperture		
GPI-18”	tip/tilt	xy37.cfg
Downward MESA	tip/tilt and Z	xy38.cfg
MicroLUPI	5-axis: XY stage, Z stage, XY lower stage	xy52.cfg
Maxim XR/GP	Z Stage	z01.cfg
NewView 5000	Z Stage	z02.cfg
NewView 100/200	5-axis: fast X, slow Theta, tip/tilt and Z	rt06.cfg
NewView 100/200	2-axis: fast X and slow Theta	rt07.cfg
NewView 5000	2-axis: X and Theta	rt08.cfg
NewView 5000	3-axis: X, Theta, and Z	rt14.cfg
NewView 5000	5-axis: X, Theta, tip/tilt and Z	rt15.cfg

Note: In the following procedure “xxxx.cfg” denotes the configuration file for a particular stage; substitute the correct file name from the previous table.

Configuring the Motion Controller for the Programmable Stage

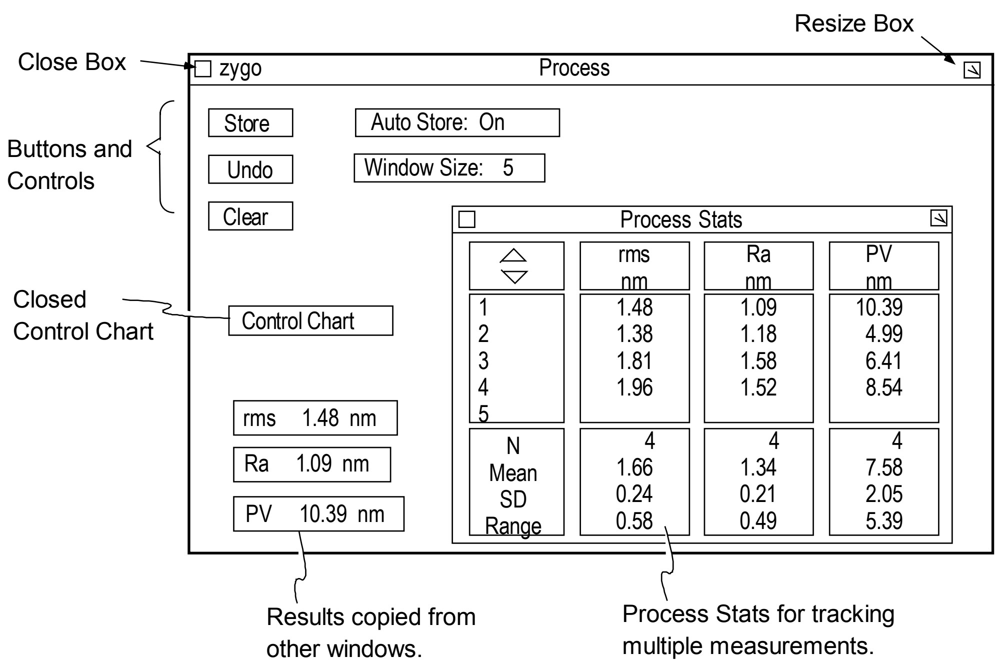
1. Exit MetroPro.
2. Open Windows NT Explorer. Go to the "MetroPro\cfg" directory. Open the calibration file; it is the name of the computer and ends with ".1". If it does not open immediately, select Notepad as the application to read the file.
3. Find the line that begins with "MotionCtrlr". Check to see that the appropriate configuration file is listed. If necessary, edit the line as follows:
   `MotionCtrlr XXXX.cfg com2`
4. If changes were made to the file, save the file and exit Notepad. If no changes were made to the calibration file, skip this step.
5. Open an MS-DOS prompt window.
6. Switch directories by typing: `cd c:\metropro\cfg`
7. Load information into the Motion Controller memory by typing:
   `mc_update com2: XXXX.cfg` [Enter]

8. Reset the Motion Controller: press the Motion STOP button; press and hold the AXIS SELECT button and release the Motion STOP by turning it clockwise.
9. Open MetroPro and click the Home Stage button.

Process Window

The Process window is used to gather and organize result boxes from different data windows into one window for display. The Process window also contains buttons and controls that interact with Control Charts and Process Stats. The Process window can display Control Charts and Process Stats made from results from different data windows.

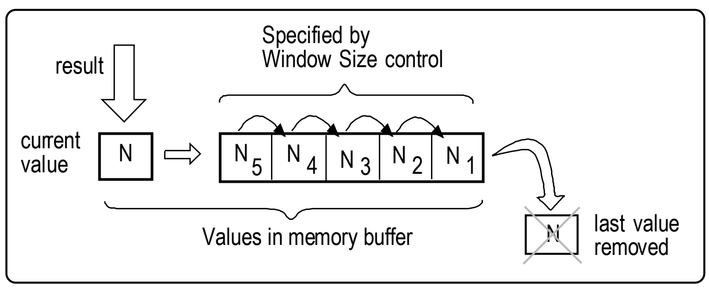
The Process window is created with the Application window menu New Process Window command. You can use more than one Process window. The Process window is a "display" window, its contents cannot be saved. To save or output the results of numerous measurements, use the Report window.



Item	*Function*
Store button	Places the current displayed result value into buffer memory; adds value to Process Stats and Control Charts.
Undo button	Removes the last entered result values from buffer memory; removes value from Process Stats and Control Charts.
Clear button	Erases all values from buffer memory; clears all values from Process Stats and Controls Charts.
Auto Store	When On, values are stored in buffer memory as measurements are made; Process Stats and Controls Charts are updated with each measurement. When Off, values are not placed in memory.
Window Size	Specifies the size of the buffer memory or the number of values for each results. Controls the number of measurements on Control Charts and the number of values used in Process Stats.

How Result Information is Handled in the Process Window

Multiple measurement result values are stored in temporary memory. The temporary memory buffer for a result is activated when it is created. The number of values stored for one result is determined by the Window Size control. As new values are added at the front, older results drop out.



Creating a Process Window

When first created, the Process window contains three buttons and two controls; it does not contain any results, Control Charts, or Process Stats.

1. Create the Process Window by selecting the Application Window menu New Process Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk.
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.

4. Move the mouse to position the box inside the Process window and release the mouse button. The box appears at this location.

5. The cursor remains for further copying. To copy additional results repeat steps 3 and 4.

6. When done copying output boxes, click the right mouse button.

   Note: Since you can mix results from different data windows you must be careful not confuse results with the same names from different windows. You can change the name of a result with the result menu's Name command.

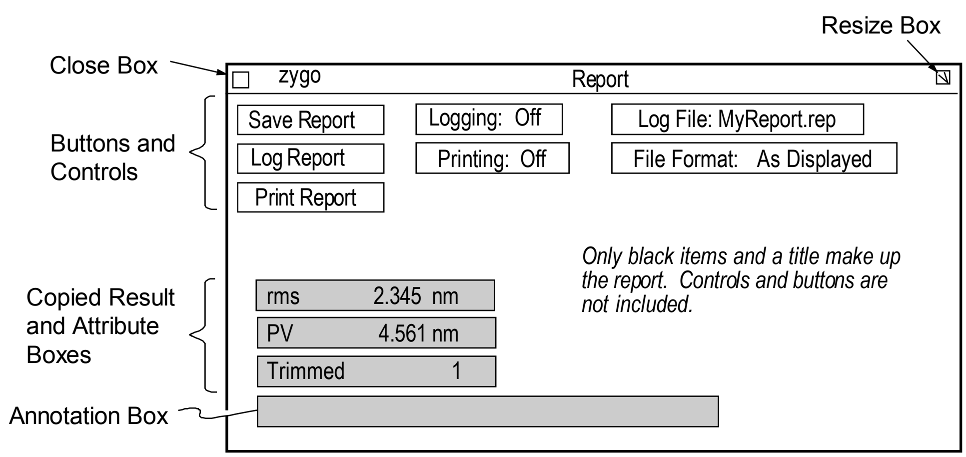
7. To display statistical information about the all the results gathered into the window select the New Result → Process Stats command.

8. To save your work, select the Re-save Application command from the Application Window menu.

Report Window

The Report window is used to compile Result boxes and Attribute boxes from data and control windows into one window for the purpose of creating a report file. The report file can be saved, logged (appended) after each measurement, and output to a printer or another computer. The Report window is useful when you want to consolidate many results together from different data windows.

The Report window is created with the Application Window menu New Report Window command. You can have more than one Report window.



Item	***Function***
Save Report button	Click to open the File Handler, which is used to save the contents of one report window under a specified name.
Log Report button	Adds the contents of the report window to the report file specified by the Log File control.
Print Report button	Outputs the contents of the report window to a printer.
Logging	When On, the contents of the report window is saved (appended) to the file, named by the Log File control, after each measurement.
Log File	Specifies the name of the report file to which measurement results are appended to; it should end with ".rep".
File Format	Selects the format of the report file. Choices are: As Displayed, Comma Separated, or Tab Separated.
Printing	When On, the contents of the report window is output to a printer after each measurement.
Post-Log Command	Specifies a command for post processing.

Creating a Report Window

When first created, the Report window comes equipped with three buttons and four controls, and is exactly 80 characters wide. The HP PaintJet printer can print a maximum of 80 characters wide; if you make the Report window wider, you may lose information when printed.

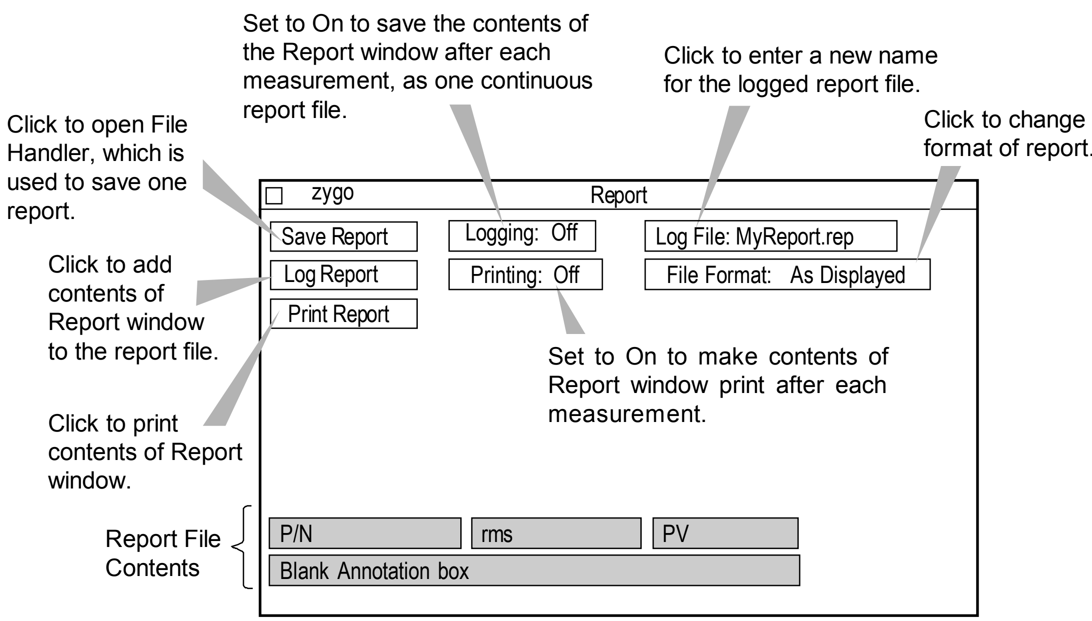
1. Create the Report Window by selecting the Application Window menu New Report Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk .
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.
4. Move the mouse to position the box inside the Report window and release the mouse button. The box appears at this location. Copied Result and Attribute boxes "snap" to an invisible grid. The grid helps keep boxes aligned without overlapping.
5. The cursor remains for further copying. To copy additional results repeat steps 3 and 4.
6. When done copying output boxes, click the right mouse button.

Note: Since you can mix results from different data windows you must be careful not confuse results with the same names from different windows. You can change the name of a result with the result menu's Name command.

7. Customize the boxes in the Report window with their respective menus. You can move the boxes, rename them, or change their layout. You should arrange the order and placement of the boxes into a pleasing arrangement. Use blank Annotation boxes as line spacers.
8. To save your work, select the Re-save Application command from the Application Window menu.

Using the Report Window

The Report window may be used in a number of ways, including: saving individual reports, logging selected reports, logging a series of reports, and logging reports and sending the reports to a printer at the same time.



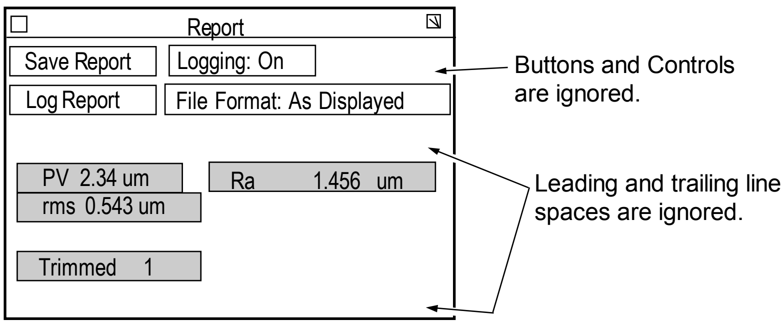
Saving a Report File

1. Click the Save Report button. In the File Handler, click the Current Selection box, enter a name for the report, ending with ".rep", then press [Enter]. Click the Done button to close the File Handler.

The Report File

A report file contains Result and Attribute boxes with their contents along with a one line title. Buttons and control within the Report window are not part of the report file. The report file does not contain font or type style information on the boxes; it only contains the information inside the boxes in plain ASCII text.

The contents of the report file depend upon a number of factors, including: what Result and Attribute boxes are in the window, their placement within the window, and the setting of the File Format control.



File Format	***Sample Output***

As Displayed	`Zygo MetroPro Report`
	`  PV    2.34 um     Ra     1.456 um`
	`  rms   0.543 um`
	
	`  Trimmed     1`

Comma Separated	`"Zygo MetroPro Report"`
	`"PV",2.34," um ","Ra",1.456," um "`
	`"rms",0.543," um "`
	`"                             "`
	`"Trimmed",1`

Tab Separated	`"Zygo MetroPro Report"`
	`"PV"   2.34   " um "   "Ra"   1.456   " um "`
	`"rms"   0.543   " um "`
	`"                             "`
	`"Trimmed"   1`

Specialized Report Functions

Add the contents of a window to the report by entering **@W (string)** in an Annotation box within the Report window. Where (string) refers to the name of an existing Stats or Zernike window in MetroPro.

> **Note:** The Stats or Zernike window must be open for @W to function correctly.

Special Codes for Controls

In certain measurement situations, it is desirable to have a control's value be derived from another control or attribute. For example, Lot Number, Part Number, Part Serial Number, Pattern File and Within Field Pattern File information may be included in one or more of the following MetroPro controls: Auto Save Data File, Auto Save Data Dir, Log File (in a Report Window), and Log Dir (in a Report Window).

Most control values are set by the operator (or scripts) and are preserved when the application is saved. Controls affect the operation of the next measurement or pattern run. The following table identifies the special codes which can be used to embed values of other controls into certain file and directory name controls.

Control Name	Type of Entry	Code
Lot Num	Text	@LN
Lot Num	Text	@L[1]
Part Num	Text	@PN
Part Num	Text	@P[1]
Part Ser Num	Text	@SN
Part Ser Num	Text	@S[1]
Pattern File	Text	@PF[2]
Within Field Pattern File	Text	@WF[2]

1 These single character codes were available in previous releases (Log File Control only) and are supported for backward compatibility.
2 The @PF and @WF codes strip the ".pat" extension from the filename.

Embedding Values from Attributes

An attribute's value is not set by the operator, but is cleared and set during certain operations. In many cases, an attribute is simply set at the end of an operation with the value of the control of the same name. Attributes show information about the previous measurement or pattern run.

The following table lists the special codes which can be used to embed values of attributes into certain file and directory name controls.

Attribute Name	Type of Entry	Code	When Cleared & Set
Lot Num	Text	@ln	Cleared at start of data acquisition. Set at end of data acquisition before analysis.
Part Num	Text	@pn	Cleared at start of data acquisition. Set at end of data acquisition before analysis.
Part Ser Num	Text	@sn	Cleared at start of data acquisition. Set at end of data acquisition before analysis.
Pattern File	Text	@pf[1]	Set by pattern run before first stage movement.
Within Field Pattern File	Text	@wf[1]	Set by a script.
Pattern Row	Integer	@pr[2]	Set during pattern run.
Pattern Col	Integer	@pc[2]	Set during pattern run.

1. The @pf and @wf codes strip the ".pat" extension from the file name.
2. The @pr and @wr codes can be immediately followed by a format specification enclosed by two '!' characters.

For example:

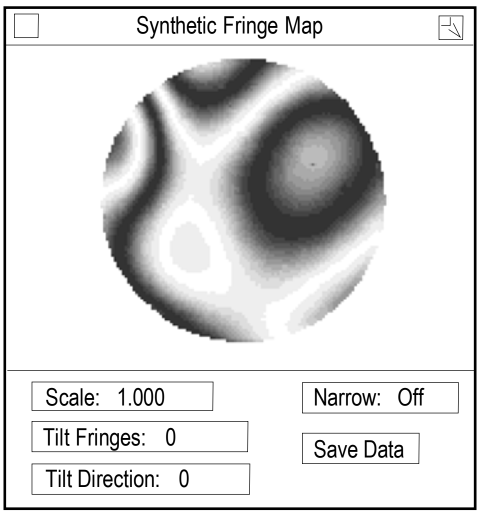
@pr!%4d! embeds the pattern row number with a minimum field width of four, left-padded with blanks.

@pc!%03d! embeds the pattern column number with a minimum field width of three left-padded with zeroes.

Synthetic Fringes

MetroPro can create synthetic or virtual fringes from the phase data. Fringes are only created when there is valid phase data. The number of fringes, the orientation, and the density are selectable. Synthetic fringes can be used as an aid in viewing surface detail of a smooth part by increasing the scale.

The Synthetic Fringe window is created with the Application Window menu New Data Window command. To display the fringes, use the window's menu to create a Filled Plot.



Scale Multiples or divides the number of fringes per wave. Less than1 divides, greater than 1 multiplies.

Tilt Fringes Adds the number of fringes to the cavity.

Tilt Direction Specifies the orientation of the tilt fringes. Numeric entry in degrees.

Narrow Reduces the width of the dark fringes. On or Off.

Save Data Click to open the File Handler so manipulated fringe data can be saved.

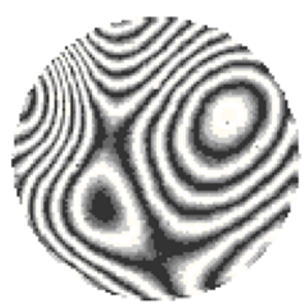
Click the Analyze button to update the plot when settings are changed.

Examples of Synthetic Fringes

The examples shown below are derivatives of the above original.

Scale: 1.000
Tilt Fringes: 5
Tilt Direction: 0

Scale: 0.5
Tilt Fringes: 0
Tilt Direction: 0



Scale: 5
Tilt Fringes: 0
Tilt Direction: 0

System Error Function

The system error subtraction function is used to improve measurement accuracy by subtracting instrument aberrations during the analysis cycle.

There are two methods you can use to create a system error file: the static method or the step and measure method. In both cases, it is necessary to use a component of known high quality. Microscope users should use a test part of ≤ 2 angstroms rms surface. Interferometer users should use a test optic whose quality is at least two times better than the transmission element. MESA users should use the Zygo Reference Flat.

> **Note:** The system error file is specific to the instrument's optical components and software settings. Whenever the objective is removed, a transmission element replaced, or software setting changed, the file should be remade. In addition, a new system error file should be made whenever environmental conditions change.

Static Method of Creating a System Error File

1. If necessary, create the Subtract Sys Err and Sys Err File controls in a Control window using the New Control → System Error command.
2. Set the Subtract Sys Err control to Off.
3. Focus the instrument on the known high quality test part and null the interference pattern. If necessary, create the Phase Avgs or Intens Avgs controls in a Control window using the New Control → Phase Processing command. Then enter “8” in the average control.
4. Click the MEASURE button. Click the Save Date button. In the File Handler, click the Current Selection box, enter a name for file that has an inherent meaning, such as “SysErrFile.dat” and press [Enter], then click Done to close the File Handler.
5. Click the left mouse button on the Sys Err File control and enter the name of the reference file named above. Set the Subtract Sys Err control to On. Subsequent measurements will have system errors subtracted from the data.

Step and Measure Method of Creating a System Error File

Moving the test part between phase averages moves the errors contributed by the test part to different places so their magnitude in the system error file is reduced due to averaging.

1. If necessary, create the Subtract Sys Err and Sys Err File controls in a Control window using the New Control → System Error command.
2. Set the Subtract Sys Err control to Off.
3. If necessary, create the Phase Avgs, Phase Avg Pause, Intens Avgs, and Remove controls in a Control window using the New Control → Phase Processing command.

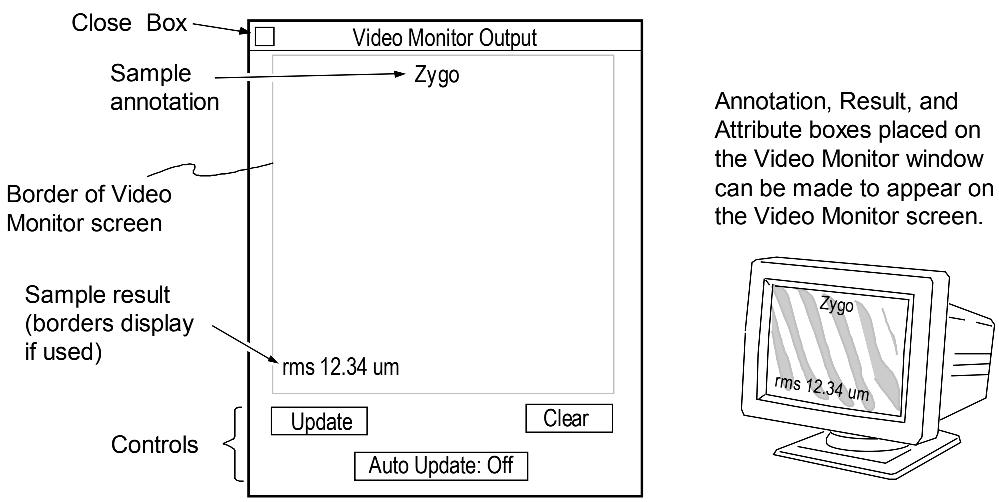
    Note: For Microscopes: Set the Remove control to "Plane."
    For Interferometers: Select PST and TLT in the Remove Window.
    This eliminates the influence of surface form from the averaging calculations.

4. Click the left mouse button on the Phase Avgs control and enter at least "8" (for eight phase averages). Do the same for the Intens Avgs control. Set the Phase Avg Pause control to On.
5. Focus the instrument on the known high quality test part and null the interference pattern. Click the MEASURE button.
6. During the measurement cycle between each phase average cycle, the software will respond "Paused before phase averaging iteration of * of *. Press a mouse button." At this point, slightly move the test part in the X or Y axis (or rotate the part) and click one of the mouse buttons to continue. Repeat until the measurement is complete.
7. Click the Save Date button. In the File Handler, click the Current Selection box, enter a name for file that has an inherent meaning, such as "SysErrFile.dat" and press [Enter], then click the Done button to close the File Handler.
8. To turn off the averaging function, enter 0 in the Phase Avgs and Intens Avgs controls. Set the Phase Avg Pause control to Off.
9. Click the left mouse button on the Sys Err File control and enter the name of the reference file named above. Set the Subtract Sys Err control to On. Subsequent measurements will have system errors subtracted from the data.

Video Monitor Window

The Video Monitor window is used to compose results and text you want to display on the Video Monitor screen. This is particularly useful when you are using a video printer to make a copy of the Video Monitor screen. The Video Monitor window is created with the Application Window menu New Video Monitor Window command.

When created, the Video Monitor window is equipped with two buttons and a control; these controls do not appear on the video monitor screen. Results and text can be placed anywhere within the bordered area in the window. Many applications supplied by Zygo include a Video Monitor window already complete with text and results.



Item	*Function*
Update button	Click to send the contents of the Video Monitor window to the video monitor screen.
Clear button	Click to clear the video monitor screen of information.
Auto Update	Determines if the contents of the Video Monitor window are output to the video monitor screen after each measurement. Settings are On or Off.

Creating a Video Monitor Window

1. Create the Video Monitor window using the Application Window menu New Video Monitor Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk .
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.
4. Move the mouse to position the box inside the Video Monitor window and release the mouse button. The box appears at this location.
5. The cursor remains for further copying. To copy additional results repeat steps 3 and 4.
6. When done copying output boxes, click the right mouse button.
7. Use the New Annotation command to create an Annotation box for special text to display on the video screen.
8. Customize the boxes in the Video Monitor window with their respective menus. You can move them, change or add a border with the Border command, or change the type style with the Font command.
9. Click the Update button to see what the boxes look like on the Video Monitor.
10. If you always want the Video Monitor to display results and text, turn the Auto Update control to On by clicking it with the left mouse button.
11. To save your work, select the Re-save Application command from the Application Window menu.

Responding to Error Messages

Some of the conditions that cause errors can be corrected by finding the error message in the listing provided in this appendix and following the recommendations.

If you experience serious problems that cause MetroPro to quit, refer to the last page of this appendix. If you continue to experience problems or if you are not sure about the error message you are getting, contact Zygo.

Error Message Listing

The following is an alphabetical list of MetroPro error messages. This list is not meant to be a complete error message listing. This listing is meant to provide help in understanding common errors and messages. Sometimes the action required to fix the error is provided in the message itself, in which case the error is not listed here. Error messages are displayed in Dialog boxes. Click the OK button to acknowledge the message.

Acquisition mask is required.

The application requires that you define an Acquisition mask. See the appropriate application documentation for more information.

Acquisition window is too large.

The acquisition window (Acquisition mask) is too large. This occurs when using an instrument with a high resolution camera when the Phase Res control is set to High X. Change the Phase Res control to High or define a smaller Acquisition mask.

Active instrument is not an interferometer.

Occurs when the selected instrument is not an interferometer and the user initiates an operation that is only appropriate for an interferometer. Example: auto-focus on a scanner. Select instrument with Instrument control.

Application is incompatible with this version of MetroPro.

This is likely to occur when you have loaded a new version of MetroPro but have not converted your existing applications.

Application license is invalid.

Occurs when the user attempts to measure or to load data using an application which requires a license.

Auto aperture and test mask cannot be used together.

These features are mutually exclusive. Either use the auto aperture mask or your own Test mask.

Auto focus and tilt are not available in this application.

Call Zygo if you have a new automation requirement.

Auto mask and test mask cannot be used together.

These features are mutually exclusive. Either use the auto loaded mask or your own Test mask.

Auto mask radius value is unreasonable.

The auto mask radius is either too large or too small.

Auto mask requires lateral calibration.

The instrument must be calibrated for the auto mask feature to work. Use the Calibrator as described under “Calibration” in the reference section.

Auto save data failed.

Data was not saved during an auto save operation. This may have happen because the disk is full or the destination directory has permissions set to disallow writing.

Auto tilt is incompatible with AGC or PZT calibration.

Currently, AGC and PZT calibration must be off when using Auto Focus.

Automatic tilt adjustment failed.

The system is unable to find the correct tilt position, Reset Tilt Zero parameter.

Calibration aborted.

The Esc(ape) key was pressed during the measurement. Measure the part again.

Cannot access DMI.

The distance measuring interferometer is not connected or is not working. This message applies to the MetroPro Radius Scale Application.

Cannot access ramp data files.

Ramp files in directory /usr/local/zygo/lob/ramps do not exist or are not compatible with the instrument serial number.

Cannot adjust light for acquire.

When the Acquisition Mode is Phase, this error is unlikely. It could occur if the AGC algorithm is unable to converge within 63 attempts. When the Acquisition Mode is Fringe, this error occurs if there is insufficient light.

Cannot attenuate light for acquire.

Can occur if a part is highly reflective and the AGC algorithm is confused by camera over-saturation. This error is unlikely.

Cannot calibrate for acquire.

Occurs when the Acquisition Mode is Phase and the Ramp Cal algorithm cannot converge on a ramp gain setting. This error is often caused by unstable fringes caused by mechanical vibration or other improper environmental conditions. This error may also be caused by low contrast fringes. An additional cause may be “high finesse” fringes.

On the GPI xp, low contrast fringes may be caused by mismatched reflectance test and reference surfaces. An example is a corner cube in the single-pass setup without a Dynaflect transmission flat or pellicle (attenuation filter). High finesse fringes on the GPI, are caused by the use of highly reflective test and reference surfaces without a pellicle.

Cannot calibrate.

The following is list of possible problems: invalid length entered, invalid magnification entered, invalid resolution entered, line too short, magnification must be within 50% of nominal, magnification is unreasonable, fringe or phase data from the instrument is required (not loaded or generated data.), there is no active instrument or it is incompatible with this application, no instrument aperture is selected, no objective in current turret position, and no objective selected.

Cannot create file.

Occurs when MetroPro cannot create a new file or over-write an existing file. The destination directory or file has permissions set to disallow writing. The owner of the file or directory (or the super-user) can use the HP-UX “chmod” command to change the permissions.

Cannot do automatic focus adjustment.

Incorrect stage type.

Cannot do automatic tilt adjustment.

Incorrect stage type or there is no active motion controller for this instrument.

Cannot find cube sectors.

This message applies to the MetroPro Corner Cube Application if an incorrect number of regions of phase data are found. Six regions are required for single-pass, three for double-pass.

This error may be caused if the Auto Mask figures do not align well with the sector images. Correct alignment of part. Increase Mask Spacing control value. Consider using manual masking.

This error may be caused if dropouts divide a sector into multiple regions of phase data. Increase Min Area Size control value. Increase Trim control values. Use manual masking to isolate one region of phase data per sector.

Cannot find right ABS, center rail, left ABS or TPC.

Select proper slider type and use acquire mask if more than one slider is present in field of view.

Cannot find stage home position.

Stage is incorrectly configured (i.e., the config file does not a match the stage), the limits have not been defined, the system could not locate the home position, or there is a mechanical problem. Reset MetroPro application and re-home the stage.

Cannot find third rail.

This message applies to 2 and 3 Rail Applications when only two regions of phase data corresponding to two rails are found and the Slider Type control is set to Three Rails. Adjust focus. Lower Trim control values. Lower Min Area Size control value. Increase Max Area Size control value.

Cannot find third rail.

This message applies to 2 and 3 Rail Applications when only two regions of phase data corresponding to two rails are found and the Slider Type control is set to Three Rails. Adjust focus. Lower Trim control values. Lower Min Area Size control value. Increase Max Area Size control value.

Cannot focus with this objective.

Auto focus for the Maxim•GP requires a 2.5X objective, a Zygo Motion Controller and a motorized Z-axis.

Cannot focus.

Part is too far from Focus Range control value.

Cannot goto focus zero position.

Zero position has not been set.

Cannot goto stage tilt zero position.

Zero position has not been set.

Cannot initialize motion controller.

Emergency Stop button may be depressed or power is not applied to Motion Controller.

Cannot read file.

You do not have proper permission to read the file or the file type is not MetroPro compatible. The owner of the file or directory (or the super-user) can use the HP-UX "chmod" command to change the permissions.

Cannot set focus zero position.

Axis is not configured for virtual home. Make sure that there is a focus zero position set.

Cannot set stage tilt zero position.

Axis is not configured for virtual home. Make sure that there is a focus zero position set.

Cannot unset focus zero position.

Axis is not configured for virtual home. Make sure that there is a focus zero position set.

Cannot unset stage tilt zero position.

Axis is not configured for virtual home. Make sure that there is a focus zero position set.

Cannot write file.

Disk is full or you don't have proper write permission for this directory. The owner of the file or directory (or the super-user) can use the HP-UX "chmod" command to change the permissions.

Could not keep up with frame grabber.

Retry or use a smaller Acquisition mask. This error occurs primarily when usiung the high resolution (640x480) Camera Mode with HP 715/33 and 715/50 System Processors.

Data file corrupted.

Occurs when MetroPro attempts to read a file recognized as a data file but the file is missing essential information.

Error in communication with motion controller.

Incorrect or no response from motion controller to the host. Items to check include: power to the motion controller, and the firmware version of the motion controller and the host for compatibility. Reset power to the motion controller, perform a hard reset on the motion controller (the red stop button on the front panel), reset MetroPro, and re-home the stage.

Error in license file.

/usr/local/zygo/lib/xxxxAyyyyy.lic does not agree with issued license parameters. Check parameters or call Zygo for new license.

Error initializing instrument.

There is a hardware error on the instrument board. Reset power to the Electronic Enclosure and check the cables. This could be a possible communications error. Also, there could be a conflict in the config file. Check the version numbers between MetroPro and Electronic Enclosure firmware.

Error initializing system board 1.

EISA frame grabber error. Try to reboot the system to see if the board is recognized. If it is not, then try to reseat the EISA board and reboot the system. If this fails call Zygo.

Fringe contrast is too low.

Occurs when the Acquisition Mode is Fringe and the fringe contrast is low. On the GPI xp, low contrast fringes may be caused by mismatched reflectance test and reference surfaces.

Fringes too closely spaced.

Occurs when the Acquisition Mode is Fringe and the fringes are too closely spaced. Try readjusting (nulling) the instrument. This message applies to the Static Fringe Application.

Hardware Failure.

Occurs when there is some problem accessing the interferometer hardware, either when MetroPro is started or when a measurement is attempted. Call Zygo.

ID Module required.

Older versions of MetroPro required an HP ID Module to measure or to use applications.

Improper default mask.

Occurs if the default mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

Improper mask.

Occurs if a mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

Improper test mask.

Occurs if the test mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

Improper reference mask.

Occurs if the reference mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

Incorrect stage type.

The motorized stage is not a Zygo supported stage.

Instrument power off or hardware problem.

Make sure that the instrument power is on then try clicking the software Reset button.

Intensity data is not available.

Occurs when intensity data is required for processing of phase data but intensity data is not available. Currently, only the Pole Tip Recession application requires intensity data (when the Pole Tip Search control is set to Intensity). The error could occur when analyzing phase data that was created by some other program.

Internal error.

Severe unexpected internal error. Note conditions and call Zygo.

Lateral calibration required.

One of the features you are trying to use requires lateral calibration; units other than pixels are needed. Perform calibration.

License number … is inconsistent.

You have entered an invalid license key code in the Edit/View License window. Try entering the key code again or call Zygo.

Mask not defined.

You must define this mask before it can be shown.

MetroPro license is invalid.

Occurs when the user attempts to measure or to load data using a version of MetroPro which requires a license. You must enter a valid license key code obtained from Zygo in the Edit/View License window.

No figures exist.

You must create one or more figures before you can do this operation.

No figures picked.

You must pick one or more figures before you can do this operation.

No valid data points.

Occurs when masking, trimming, and/or filtering deletes all phase data points.

Not a data file.

Occurs when MetroPro attempts to read a file expected to be a data file but the file contents are unrecognized.

Not a masks file or requires conversion.

The file is not recognized as a mask file or it is was created by an older version of MetroPro.

Not an application file or requires conversion.

The file is not recognized as an application or it is an older application not compatible with the current version of MetroPro.

Not enough data or hogout width is unreasonable.

Hogout width must be greater than slider width.

Not enough data.

Occurs when masking, trimming, and/or filtering leaves too few phase data points.

Not enough fringes.

Occurs when the Acquisition Mode is Fringe and there are too few fringes. Readjust the instrument.

Only one rail found.

This message applies to 2 and 3 Rail Applications when only one region of phase data is found. Adjust focus. Lower Trim control values. Lower Min Area Size control value. Increase Max Area Size control value.

Option license is invalid.

Occurs when the user attempts to measure or to load data using an optional MetroPro application that requires a license. You must enter a valid license key code obtained from Zygo in the Edit/View License window.

Out of memory.

Not enough RAM in HP System Processor. It is also possible to have a programming error. Note the conditions and call Zygo.

Overflow.

Internal software number representation overflow. Note conditions and call Zygo.

Premature end-of-file.

Occurs when MetroPro attempts to read a file that is missing essential information. The file is corrupted and is not readable.

PZT power supply trip.

Occurs during a phase measurement if the current to the piezoelectric transducers exceeds a limit. Click the Reset button and retry. If this error occurs often, call Zygo.

Region too complicated.

May occur if a region of phase data consists of a maze of twisty threads of points. This error is unlikely.

Stage home position is unknown.

Stage has not been set to home position since starting MetroPro. A reference (home) is required after a hard reset. Home stage.

Stage movement is out of range.

The pattern, based on an origin, is greater than the stage limits, greater than the stage, or the origin must be moved.

System error data phase resolution is mismatched.

The system error data file must be created using the same phase resolution as the current data set. See Phase Res control and System Error Function in this manual.

Test and reference masks are required.

The analysis to be performed requires test and reference mask definition. Load or create a test and reference mask.

Test and reference masks intersect.

Occurs in certain applications which require that the Test and Reference masks do not intersect. Adjust the masks so that the figures do not intersect. This message applies to the Pole Tip Recession Application.

There are no results to show in a Stats Window.

There must be results present in the window before opening a Stats window. The Stats window uses the results to determine what result columns to create.

There is no active instrument.

Occurs if a measurement is attempted when the Instrument control is set to None. It is usually caused by a problem accessing the interferometer hardware. MetroPro only recognizes hardware that is accessible at startup time. Make sure the instrument is properly connected and turned on. Then restart MetroPro.

There is no active motion controller for this instrument.

Motion controller setup is missing from the configuration file or there is no motion controller present. Run mc_setup script.

There is no large aperture PZT drive.

Occurs in a GPI xp application if a measurement is attempted with the Aperture control set to Lg Aperture and there is no large aperture piezoelectric transducer power supply.

Too few modulating points for acquire.

Occurs when the Acquisition Mode is Phase and too few points are modulating for the AGC algorithm to function. It is usually caused by poor quality fringes. The AGC algorithm samples points within the Acquisition mask and requires that the number of modulating points found be at least the value specified by the Min Mod Pts control.

Increase light level if part is dim. Lower the Min Mod % control to allow weakly modulating points to pass. Use acquisition cursor on area of interest. If these fail, the part may not be reflective enough or too rough to measure.

Too many regions to connect.

This error occurs when there are too many separate regions of phase data, possibly caused by the filtering of discontinuities. Lower the Discon Filter control value. Change the Discon Action control setting. Increase the Min Area Size control value.

Unable to open directory ….

You do not have proper permission to open and look in this directory or the directory path is invalid. The owner of the file or directory (or the super-user) can use the HP-UX “chmod” command to change the permissions.

Other Messages

You may encounter this error message:

```
Out of memory.
    Attempting recovery.
Too many graphic windows.
    Attempting recovery.
```

These errors are self explanatory. Memory refers to RAM; a graphic window includes plots, the Mask Editor and the Calibrator window. When this happens, the system automatically starts a recovery sequence to restart MetroPro and return it to approximately the same state that existed before the error occurred. As the recovery sequence progresses, read the messages that appear on the screen, and press a mouse button when directed to do so.

Usually the following screen message appears:

```
MetroPro has restarted to recover from an error condition.
   The following information was not preserved:
   - Mask definitions.
   - The objective selection for Microscope applications.
   - The calibration for GPI xp applications.
```

If the application was newly created and was not saved to the hard drive, you will see a message indicating that it cannot be recovered. If the application has been saved, it will be reloaded in the configuration in which it was last saved. Also, an attempt is made to recover unsaved measurement data.

You should find out the exact cause of your problem and correct the situation. You may have to restart the computer to reclaim fragmented memory or close graphic windows in the application.

Introduction

This appendix describes the various data formats supported by MetroPro. When data is saved in MetroPro with the Save Data button, it is saved as a binary file. When data is saved in MetroPro with the Save Zernikes button, it is saved as CODE V Zernike data. Conversion utilities supplied with MetroPro allow you to convert between binary data files and a number of other file types as listed below.

Data files can be saved in MetroPro, converted using the conversion utilities, and then exported to other programs or computers for further analysis. Data files can also be created on other systems and then imported into MetroPro for analysis.

> **Note:** Keep in mind that the Report window in MetroPro allows you to save numeric results and measurement attributes as a Report file for later transfer.

This appendix *does not* describe the hardware connection between the computer and other systems. Nor does this appendix discuss the use of communication software to facilitate data transfers. Due to the innumerable interface scenarios, cabling and data transfer software are the user's responsibility.

This appendix is divided into sections as follows:

- Binary Data File Format
- ASCII Data File Format
- Raw ASCII Data File Format
- CODE V Data File Format
- OSLO Spreadsheet Data File - Zernike Information
- ZEMAX Grid Sag Data File Format
- SDF Data File Format
- XYZ Data File Format
- Converting Data File Formats

Binary Data File Format

This section describes the format of a data file created via the Save Data button in MetroPro. A binary data file is made of three parts: header, intensity data, and phase data. The header consists of system attribute information, intensity information, and connected phase information. At least one of the data sets will always be present. Multiple-byte fields are stored with the most significant byte first, and string fields (character) are null-terminated. Floating-point numbers (real) are stored in the IEEE standard format.

A binary data file contains some specially defined data types. These were created to more accurately reflect the data. The special data types are as follows:

int16: signed 16-bit integer

int32: signed 32-bit integer

uint16: unsigned 16-bit integer

Binary Data File Header Summary

The following table describes the fields in the header part of a binary data file. For each field, the table gives its location in bytes, its size in bytes, its data type, and the name of the data it holds.

Bytes	***Size in bytes***	***Type***	***Name***
1-4	4	int32	Magic Number
5-6	2	int16	Header Format
7-10	4	int32	Header Size
11-12	2	int16	SoftwareType
13-42	30	char	SoftwareDate
43-44	2	int16	MajorVers
45-46	2	int16	MinorVers
47-48	2	int16	BugVers
49-50	2	int16	IntensOriginX
51-52	2	int16	IntensOriginY
53-54	2	int16	IntensWidth
55-56	2	int16	IntensHeight
57-58	2	int16	NBuckets
59-60	2	uint16	IntensRange
61-64	4	int32	Number of Bytes - Intensity
65-66	2	int16	PhaseOriginX
67-68	2	int16	PhaseOriginY
69-70	2	int16	PhaseWidth
71-72	2	int16	PhaseHeight
73-76	4	int32	Number of Bytes - Phase
77-80	4	int32	TimeStamp
81-162	82	char	Comment

Bytes	***Size in bytes***	***Type***	***Name***
163-164	2	int16	Source
165-168	4	real	IntfScaleFactor
169-172	4	real	WavelengthIn
173-176	4	real	NumericAperture
177-180	4	real	ObliquityFactor
181-184	4	real	Magnification
185-188	4	real	CameraRes
189-190	2	int16	AcquireMode
191-192	2	int16	IntensAvgs
193-194	2	int16	PZTCal
195-196	2	int16	PZTGainTolerance
197-198	2	int16	PZTGain
199-202	4	real	PartThickness
203-204	2	int16	AGC
205-208	4	real	TargetRange
209-210	2	-	Spare (not used)
211-214	4	int32	MinMod
215-218	4	int32	MinModPts
219-220	2	int16	PhaseRes
221-224	4	int32	MinimumAreaSize
225-226	2	int16	DisconAction
227-230	4	real	DisconFilter
231-232	2	int16	ConnectionOrder
233-234	2	int16	DataSign
235-236	2	int16	CameraWidth
237-238	2	int16	CameraHeight
239-240	2	int16	SystemType
241-242	2	int16	SystemBoard
243-244	2	int16	SystemSerial
245-246	2	int16	InstrumentId
247-258	12	char	ObjectiveName
259-298	40	char	PartNum
299-300	2	int16	CodeVType
301-302	2	int16	PhaseAvgs
303-304	2	int16	SubtractSysErr
305-320	16	-	Spare (not used)
321-360	40	char	PartSerNum
361-364	4	real	RefractiveIndex
365-366	2	int16	RemoveTiltBias
367-368	2	int16	Remove Fringes
369-372	4	int32	MaxAreaSize
373-374	2	int16	SetupType

Bytes	*Size in bytes*	*Type*	*Name*
375-376	-	-	Internal use only
377-388	4	real	PreConnectFilter
381-384	4	real	Wavelength2
385-386	2	int16	WavelengthFold
387-390	4	real	Wavelength1
391-394	4	real	Wavelength3
395-398	4	real	Wavelength4
399-406	8	char	WavelengthSelect
407-408	2	int16	FdaRes
409-428	20	char	ScanDescription
429-430	2	int16	NFiducials
431-434	4	real	Fiducial1X
435-438	4	real	Fiducial1Y
439-442	4	real	Fiducial2X
443-446	4	real	Fiducial2Y
447-450	4	real	Fiducial3X
451-454	4	real	Fiducial3Y
455-458	4	real	Fiducial4X
459-462	4	real	Fiducial4Y
463-466	4	real	Fiducial5X
467-470	4	real	Fiducial5Y
471-474	4	real	Fiducial6X
475-478	4	real	Fiducial6Y
479-482	4	real	Fiducial7X
483-486	4	real	Fiducial7Y
487-490	4	real	PixelWidth
491-494	4	real	PixelHeight
495-498	4	real	ExitPupilDiam
499-502	4	real	LightLevelPct
503-506	4	int32	CoordsState
507-510	4	real	XPos
511-514	4	real	YPos
515-518	4	real	ZPos
519-522	4	real	XRot
523-526	4	real	YRot
527-530	4	real	ZRot
531-532	2	int16	CoherenceMode
533-534	2	int16	SurfaceFilter
535-562	28	char	SysErrFile
563-570	8	char	ZoomDescr
571-834	264	-	Spare (not used)

Binary Data File Header Field Descriptions

Magic Number This 4-byte integer field indicates whether or not the file is a valid MetroPro file. The file is valid only if the value is -2011495569 (881B036F hex).

Header Format This 2-byte integer indicates the format of the header. This document is only valid for format 1.

Header Size This 4-byte integer is the size of the header in bytes. This value should always be 834.

SoftwareType This 2-byte integer field indicates what program created the data file. The programs are: unknown (0), MetroPro (1), MetroBASIC (2), and d2bug (3).

SoftwareDate This 30-character string contains the time and date that the program was created.

MajorVers, MinorVers, BugVers These 2-byte integers contain the version numbers of the program that created the data file.

IntensOriginX, IntensOriginY These 2-byte integers are the coordinates of the origin of the intensity data matrix. They refer to positions in the camera coordinate system. The origin of the camera coordinate system (0,0) is located in the upper left corner of the video monitor.

IntensWidth, IntensHeight These 2-byte integers are the width (columns) and height (rows) of the intensity data matrix. If no intensity data matrix is present, these values are zero.

NBuckets This 2-byte integer is the number of buckets of intensity data that are stored. Currently, MetroPro stores one bucket of intensity data. If no intensity data is present, this value is zero.

IntensRange This unsigned 2-byte integer is the maximum possible value of an intensity data point.

Number of Bytes - Intensity This 4-byte integer is the number of bytes of intensity data stored. This value is:

IntensWidth * IntensHeight * NBuckets * (size of 1 data value)

PhaseOriginX, PhaseOriginY These 2-byte integers are the coordinates of the origin of the connected phase data matrix. They refer to positions in the camera coordinate system. The origin of the camera coordinate system (0,0) is located in the upper left corner of the video monitor.

PhaseWidth, PhaseHeight These 2-byte integers are the width (columns) and height (rows) of the connected phase data matrix. If no phase data is present, these values are zero.

Number of Bytes - Phase This 4-byte integer is the number of bytes of connected phase data stored. This value is:

PhaseWidth * PhaseHeight * (size of 1 data value)

TimeStamp This 4-byte integer is the system representation of the date and time the data was measured or generated. It is the number of seconds since 0:00:00 January 1, 1970.

Comment This 81-character string is a user-entered remark line.

Source This 2-byte integer indicates the source of the data. A value of 0 indicates that the data was obtained from an instrument reading. A value of 1 indicates that the data was generated.

IntfScaleFactor This 4-byte real number is the interferometric scale factor. It is the number of waves per fringe as specified by the user.

WavelengthIn This 4-byte real number is the wavelength, in meters, at which the interferogram was measured.

NumericAperture This 4-byte real number is 1 / (2 * f-number).

ObliquityFactor This 4-byte real number is a phase correction factor required when using a Mirau objective on a microscope. A value of 1.0 indicates no correction factor was required.

Magnification This 4-byte real number is reserved for future use.

CameraRes This 4-byte real number is the lateral resolving power of a camera pixel in meters/pixel. A value of 0 means that the value is unknown.

AcquireMode This 2-byte integer indicates the setting of the Acquisition Mode control. The settings are: phase (0), fringe (1), or scan (2).

IntensAvgs This 2-byte integer is the number of intensity averages performed. Values of 0 or 1 indicate no averaging.

PZTCal This 2-byte integer indicates whether or not the modulation amplitude was automatically adjusted during acquisition. A value of 1 indicates adjustment; a value of 0 indicates no adjustment.

PZTGainTolerance This 2-byte integer specifies a PZT error range if PZT calibration was adjusted.

PZTGain This 2-byte integer specifies the modulation amplitude value used during data acquisition.

PartThickness This 4-byte real number is the thickness, in meters, of the part measured. Currently, this value only applies to calculating homogeneity.

AGC This 2-byte integer indicates whether or not automatic gain control was performed during data acquisition. A value of 1 indicates AGC was used; a value of 0 indicates AGC was not used.

TargetRange This 4-byte real number is the acceptable tolerance limits of the light intensity used during AGC.

MinMod This 4-byte integer is the minimum value of modulation needed to calculate a phase value. MinMod is equal to 10.23 * MinMod(%). MinMod(%) is a user setting indicating a percentage of full modulation each camera pixel must have in order to be accepted as a valid data point.

MinModPts This 4-byte integer is the minimum number of data points required to pass MinMod criteria during AGC.

PhaseRes This 2-byte integer indicates the resolution of the phase data points. A value of 0 indicates normal resolution, with each fringe represented by 4096 counts. A value of 1 indicates high resolution, with each fringe represented by 32768 counts.

MinimumAreaSize This 4-byte integer is the minimum number of contiguous data points required for a valid data region. Any smaller regions are deleted.

DisconAction This 2-byte integer indicates the action taken when the system encountered discontinuities in phase data. The discontinuity actions are: delete regions (0), filter regions (1), and ignore (2).

DisconFilter This 4-byte real number specifies the degree to which discontinuities were removed when DisconAction was filter. Valid values range from 0 (none) to 100 (all).

ConnectionOrder This 2-byte integer field is the order in which separate regions of phase data are processed. The order may be by location (0) or size (1).

DataSign This 2-byte integer indicates the sign of the data. The data sign may be normal (0) or inverted (1).

CameraWidth, CameraHeight These 2-byte integers are the width (columns) and height (rows) of the usable camera field in pixels.

SystemType This 2-byte integer indicates the type of system used to make the measurement. The system may be: Mark IVxp (1), Maxim•3D (2), Maxim•NT (3), GPI-XP (4), NewView (5), Maxim•GP (6), NewView/GP (7), Mark to GPI conversion (8), or none (0), if the data was software generated.

SystemBoard This 2-byte integer indicates which system board was in use when the data measurement was taken. Valid values range from 0 to 7.

SystemSerial This 2-byte integer shows the serial number of the instrument.

InstrumentId This 2-byte integer indicates the instrument unit number. Valid values range from 0 to 7.

ObjectiveName This is an 11-character string. For the microscopes, this field indicates the objective in use when the measurement was taken. For the GPI, this field indicates the aperture in use when the measurement was taken. If the data was generated, this field is blank.

PartNum This 39-character string is a user-entered identifier of the part measured.

CodeVType This 2-byte integer indicates whether the phase data represents a wavefront (0) or a surface (1). This information is used by the CODE V program.

PhaseAvgs This 2-byte integer is the number of phase averages performed.

SubtractSysErr This 2-byte integer indicates whether or not the system error was subtracted from the phase data. A value of 1 indicates that it was subtracted; a value of 0 indicates it was not subtracted.

PartSerNum This 39-character string is a user-entered serial number for the part measured.

RefractiveIndex This 4-byte real number is the index of refraction as specified by the user. Currently, this value is used only in the calculation of corner cube dihedral angles.

RemoveTiltBias This 2-byte integer indicates whether or not the tilt bias was removed from the phase data. The values are: (1) removed or (0) not removed.

Remove Fringes This 2-byte integer indicates whether or not fringes were re-moved from intensity data. The values are: (1) removed or (0) not removed.

MaxAreaSize This 4-byte integer is the maximum number of contiguous data points required for a valid phase data region. Any larger regions are deleted.

SetupType This 2-byte integer is used to identify the different setups used by the Angle Measurement Application.

PreConnectFilter This 4-byte real number is the amount of filtering done to wrapped phase data.

Wavelength2 This 4-byte real number is the value from the Wavelength-In 2 control, if relevant to the measurement.

WavelengthFold This 2-byte integer is set to 0 when two wavelength folding is off and to 1 when two wavelength folding is on.

Wavelength1 This 4-byte real number is the value from the Wavelength-In 1 control, if relevant to the measurement.

Wavelength3 This 4-byte real number is the value from the Wavelength-In 3 control, if relevant to the measurement.

Wavelength4 This 4-byte real number is the value from the Wavelength-In 4 control, if relevant to the measurement.

WavelengthSelect This 7 character string is the value from the Wavelength Select control, if relevant to the measurement.

FdaRes This 2-byte integer indicates the setting of the FDA Res control for a measurement when the Acquisition Mode control is set to Scan.

ScanDescription This 19 character string is a description of the scan for a measurement when the Acquisition Mode control is set to Scan. A sample string is “5 um bipolar”.

NFiducials This 2-byte integer indicates the number of fiducials defined.

FiducialNX, FiducialNY (N = 1 to 7) These 4-byte real numbers are fiducial coordinates in the camera coordinate system. The origin of the camera coordinate system (0, 0) is located in the upper left corner of the video monitor.

PixelWidth, PixelHeight These 4-byte real numbers are the effective camera pixel dimension (spacing) in meters. They affect the scaling of Mask Editor figures. If zero, default values are assumed. These values are not the same as LateralRes.

ExitPupilDiam This 4-byte real is the exit pupil diameter setting used during data acquisition.

LightLevelPct This 4-bytereal is the light level percent user during data acquisition.

CoordsState This is a 4-byte integer.

XPos, YPos, ZPos, XRot, YRot, ZRot These are 4-byte real numbers.

CoherenceMode This 2-byte integer is the coherence mode setting used during data acquisition.

SurfaceFilter This 2-byte integer is the surface filter setting used during data acquisition.

SysErrFile This 27-character string is the user-entered name of the file containing the system error data.

ZoomDescr This 7-character string is the value of the image zoom used during data acquisition.

Binary Data File Intensity Data

After the header information is the intensity data. Each data point is an unsigned 2-byte integer. The data is written in row-major order, and acceptable values are from 0 to the value specified in IntensRange. An invalid point is indicated by a value ≥ 64512. The number of intensity data points is:

$$IntensWidth * IntensHeight * Nbuckets$$

Binary Data File Connected Phase Data

After the intensity data is the connected phase data. Each data point is a signed 4-byte integer. The data is written in row-major order, and acceptable values are in the range from -2097152 to +2097151. An invalid point is indicated by a value ≥ 2147483640. The number of connected phase data points is:

$$PhaseWidth * PhaseHeight$$

The phase data points are in internal units representing a scaled number of fringes.

To convert a phase data value to waves: $Wave = zygo\left(\frac{S * O}{R}\right)$

To convert a phase data value to heights: $Height = zygo\left(\frac{S * O * \lambda}{R}\right)$

Where:

zygo = the connected phase data value
S = IntfScaleFactor
O = ObliquityFactor
λ = WavelengthIn
R = 4096 for normal PhaseRes or 32768 for high PhaseRes

ASCII Data File Format

This section describes the format of a Zygo ASCII data file. The file is made up of three parts: header, intensity data, and phase data. Each part is followed by a line containing a sharp (#) character. At least one of the data sets must be present. A Zygo ASCII data file is created by using the dat_to_asc conversion utility.

ASCII Data File Header Information

The header consists of 13 required lines of information. Line 1 is a string constant (not enclosed in quotes). The remaining lines contain named fields.

Line	*Field Name*
1	Zygo ASCII Data File - Format 2
2	SoftwareType MajorVers MinorVers BugVers SoftwareDate
3	IntensOriginX IntensOriginY IntensWidth IntensHeight NBuckets IntensRange
4	PhaseOriginX PhaseOriginY PhaseWidth PhaseHeight
5	Comment
6	PartSerNum
7	PartNum
8	Source IntfScaleFactor WavelengthIn NumericAperture ObliquityFactor Magnification CameraRes TimeStamp
9	CameraWidth CameraHeight SystemType SystemBoard SystemSerial InstrumentId ObjectiveName
10	AcquireMode IntensAvgs PZTCal PZTGain PZTGainTolerance AGC TargetRange LightLevel MinMod MinModPts
11	PhaseRes PhaseAvgs MinimumAreaSize DisconAction DisconFilter ConnectionOrder RemoveTiltBias DataSign CodeVType
12	SubtractSysErr SysErrFile
13	RefractiveIndex PartThickness
14	ZoomDesc

ASCII Data File Header Field Descriptions

Each header field in an ASCII data file is described below. The types of fields are: integer, real, and string. The integer fields are always whole numbers. The real fields may be whole numbers, decimal, or exponential notation. The string fields are fixed-length (blank padded) and enclosed in double-quotes (“ ”).

SoftwareType This integer indicates what program created the data file. The programs are: unknown (0), MetroPro (1), MetroBASIC (2), and d2bug (3).

MajorVers, MinorVers, BugVers These integers contain the version numbers of the program that created the data file.

SoftwareDate This 30-character string contains the time and date that the program was created.

IntensOriginX, IntensOriginY These integers are the coordinates of the origin of the intensity data matrix. They refer to positions in the camera coordinate system. The origin of the camera coordinate system (0,0) is located in the upper left corner of the video monitor.

IntensWidth, IntensHeight These integers are the width (columns) and height (rows) of the intensity data matrix. If no intensity data is present, this value is zero.

NBuckets This integer is the number of buckets of intensity data that are stored. Currently, MetroPro stores one bucket of intensity data. If no intensity data matrix is present, this value is zero.

IntensRange This unsigned integer is the maximum possible value of an intensity data point.

PhaseOriginX, PhaseOriginY These integers are the coordinates of the origin of the connected phase data matrix. They refer to positions in the camera coordinate system. The origin of the camera coordinate system (0,0) is located in the upper left corner of the video monitor.

PhaseWidth, PhaseHeight These integers are the width (columns) and height (rows) of the connected phase data matrix. If no phase data is present, these values are zero.

Comment This 81-character string is a user-entered remark line.

PartSerNum This 39-character string is a user-entered serial number for the part measured.

PartNum This 39-character string is a user-entered identifier of the part measured.

Source This integer indicates the source of the data. A value of 0 indicates the data is from an instrument; 1 indicates that the data was generated.

IntfScaleFactor This real number is the interferometric scale factor. It is the number of waves per fringe as specified by the user.

WavelengthIn This real number is the wavelength, in meters, at which the interferogram was measured.

NumericAperture This real number is 1 / (2 * f-number).

ObliquityFactor This real number is a phase correction factor required when using a Mirau objective on a microscope. A value of 1.0 indicates no correction factor was required.

Magnification This real number is reserved for future use.

CameraRes This real number is the lateral resolving power of a camera pixel in meters/pixel. A value of 0 means that the value is unknown.

TimeStamp This integer is the system representation of the date and time the data was measured or generated. It is the number of seconds since 0:00:00 January 1, 1970.

CameraWidth, CameraHeight These integers are the width (columns) and height (rows) of the usable camera field in pixels.

SystemType This integer indicates the type of system used to make the measurement. The system may be: Mark IVxp (1), Maxim•3D (2), Maxim•NT (3), GPI-XP (4), NewView (5), Maxim•GP (6), NewView/GP (7), Mark to GPI conversion (8), or none (0), if the data was software generated.

SystemBoard This integer indicates which system board was in use when the data measurement was taken. Valid values range from 0 to 7.

SystemSerial This integer indicates the serial number of the instrument.

InstrumentId This integer indicates the instrument unit number. Valid values range from 0 to 7.

ObjectiveName This is an 11-character string. For the microscopes, this field indicates the objective in use when the measurement was taken. For the GPI, this field indicates the aperture in use when the measurement was taken. If the data was generated, this field is blank.

AcquireMode This integer indicates the setting of the Acquisition Mode control. The settings are: phase (0), fringe (1), or scan (2).

IntensAvgs This integer is the number of intensity averages performed. Values of 0 or 1 indicate no averaging.

PZTCal This integer indicates whether or not the modulation amplitude was automatically adjusted during acquisition. A value of 1 indicates adjustment; a value of 0 indicates no adjustment.

PZTGain This integer specifies the modulation amplitude value used during data acquisition.

PZTGainTolerance This integer specifies a PZT error range if PZT calibration was adjusted.

AGC This integer indicates whether or not automatic gain control was performed during data acquisition. A value of 1 indicates AGC was used; a value of 0 indicates AGC was not used.

TargetRange This real number is the acceptable tolerance limits of the light intensity used during AGC.

LightLevel This integer is the light level setting used during data acquisition.

MinMod This integer is the minimum value of modulation needed to calculate a phase value. MinMod is equal to 10.23 * MinMod(%). MinMod(%) is a user setting indicating a percentage of full modulation each camera pixel must have in order to be accepted as a valid data point.

MinModPts This integer is the minimum number of data points required to pass MinMod criteria during AGC.

PhaseRes This integer indicates the resolution of the phase data points. A value of 0 indicates normal resolution, with each fringe represented by 4096 counts. A value of 1 indicates high resolution, with each fringe represented by 32768 counts.

PhaseAvgs This integer is the number of phase averages performed.

MinimumAreaSize This integer is the minimum number of contiguous data points required for a valid data region. Any smaller regions are deleted.

DisconAction This integer indicates the action taken when the system encountered discontinuities in phase data. The discontinuity actions are: delete regions (0), filter regions (1), and ignore (2).

DisconFilter This real number specifies the degree to which discontinuities were removed when DisconAction was filter. Valid values range from 0 (none) to 100 (all).

ConnectionOrder This integer specifies the order in which separate regions of phase data were processed. The order may be by location (0) or by size (1).

RemoveTiltBias This integer indicates whether or not the tilt bias was removed from the phase data. A value of 1 indicates it was removed; a value of 0 indicates it was not removed.

DataSign This integer indicates the sign of the data. The data sign may be normal (0) or inverted (1).

CodeVType This integer indicates whether the phase data represents a wavefront (0) or a surface (1). This information is used by the CODE V program.

SubtractSysErr This integer indicates whether or not the system error was subtracted from the phase data. A value of 1 indicates that it was subtracted; a value of 0 indicates it was not subtracted.

SysErrFile This 14-character string is a user-entered name of the file containing the system error data.

RefractiveIndex This real number is the index of refraction as specified by the user. Currently, this value is used only in the calculation of corner cube dihedral angles.

PartThickness This real number is the thickness, in meters, of the part measured. Currently, this value is only relevant to the calculation of homogeneity.

ZoomDescr This 7-character string is the value of the image zoom used during data acquisition.

ASCII Data File Intensity Data

Each data point is an integer. The data is written 10 data points per line in row-major order. Acceptable values are from 0 to the value specified in IntensRange. An invalid point is indicated by a value ≥ 64512. A line containing only a sharp character (#) is output after the data. The number of intensity data points is:

$$IntensWidth * IntensHeight * NBuckets$$

ASCII Data File Connected Phase Data

Each data point is an integer. The data is written 10 data points per line in row-major order. Acceptable values are in the range from -2097152 to +2097151. An invalid point is indicated by a value ≥ 2147483640. A line containing only a sharp character (#) is output after the data. The number of connected phase data points is:

$$PhaseWidth * PhaseHeight$$

The phase data points are in internal units representing a scaled number of fringes. To convert a value to waves, multiple by (S * O)/R, where:

S = IntfScaleFactor
O = ObliquityFactor
R = 4096 for normal PhaseRes or 32768 for high PhaseRes

ASCII Data File Programming Notes

This section provides notes for persons writing programs to create Zygo compatible ASCII data files.

- The string fields must be blank-padded to the indicated fixed length.
- If a data set is not present, its concluding line containing a sharp character must still be present.
- Many of the fields in the header can be assigned null values since they are not used in calculations. Null values are zero for numeric fields or blanks for string fields. The following paragraphs indicate which fields must have true values.
- The IntensOriginX, IntensOriginY and PhaseOriginX, PhaseOriginY coordinates must be non-negative.
- The IntensWidth, Height and NBuckets values must correctly indicate the number of points in the intensity data matrix.
- The PhaseWidth, PhaseHeight values must correctly indicate the number of points in the phase data matrix.
- The CameraWidth, CameraHeight fields must describe a camera coordinate system that encloses the intensity and phase data matrices. The maximum values are (512,512).
- In order that phase values be correctly analyzed, the IntfScaleFactor, ObliquityFactor, WavelengthIn, and PhaseRes fields must have true values.
- In order that intensity values be correctly analyzed, the IntensRange field must have a true value.
- If lateral dimensions are to be reported in units other than pixels, the CameraRes field must have a true value.
- In order to obtain correct encircled energy and MTF cutoff frequency results, the NumericAperture field must have a true value.

ASCII Data File Example

Following is an example data file containing tiny 6x6 intensity and phase data matrices. Note that line 5 containing the Comment field is truncated.

```
Zygo ASCII Data File - Format 1
1 1 6 6 “Thu May 23 15:36:21 EDT 1991 “
122 118 6 6 1 1023
122 118 6 6
“
“     “
“     “
0 0.5 6.328e-07 0 1 0 0 671819076
262 235 1 0 5555 0 “Sm Aperture”
0 0 1 1686 3 1 0.1 40 71 50
0 0 20 1 0 0 0 0 0
0 “   “
0 0
```

Header Fields

```
#
404 414 414 423 434 448 422 431 435 442
452 459 459 460 456 458 465 470 464 453
449 445 456 474 459 462 457 450 444 457
453 444 440 425 421 430
```

Intensity Data Matrix

```
#
2530 2566 2606 2649 2698 2751 2693 2731 2773 2812
2868 2913 2860 2905 2944 2990 3036 3094 3030 3072
3121 3161 3207 3261 3206 3255 3298 3337 3381 3423
3356 3410 3452 3503 3548 3592
#
```

Phase Data Matrix

Raw ASCII Data File Format

This section describes the format of a Zygo Raw ASCII data file. This format contains no header information and bare measurement data in row order of the data matrix. A Zygo ASCII data file is created by using the dat_to_raw_asc conversion utility.

Composition of a Raw ASCII File

First Line	The total number of data points.
Subsequent Lines	The matrix data is listed as: column number (x), row number (y), and data value (z). These numbers are separated by a space. The number of lines is equal to the number of data points. The data is presented in row-major order.
Second Last Line	Minimum value of all data points.
Last Line	Range of the data; the maximum data value minus the minimum data value.

CODE V Data File Format

This section describes the format of a Zygo CODE V .INT data file. The data file is made of two parts: a header and the appropriate phase or Zernike data. The CODE V file format presented is found on page 2A-336, 'Entering/Changing Data – Interferometric Deformations/Intensity Apodization', from the December, 1988 CODE V Reference Manual, version 7.20. Intensity apodization filter data is *not* handled.

When data is saved in MetroPro with the Save Zernikes button, it is saved as CODE V Zernike data. CODE V phase data is stored using the dat_to_grd conversion utility. The CODE V data files are ASCII files, which means that they are readable and printable.

CODE V Data File Header Information

Because of the limited amount of data stored in the CODE V file, header lines have been developed so that files can be created outside of the MetroPro environment and then read into the system. The header lines *must* appear at the beginning of the file and begin with an exclamation point (!). Imbedded blank lines are *not* allowed. Each header line has a three character identifying label, similar to the CODE V labeling scheme.

There are 2 required lines in the header. The first line of the file *must* be:

! ZYGOGRD *or* ! ZYGOZFR

If this line is not the first line in the file, the file will be considered invalid by MetroPro. All other header lines may appear in any order. The second required header line, which may appear anywhere after the ZYGO line in the header, is the REQ line. The REQ line must be present and complete for the file to be considered valid. All other header lines, if included, must have all data elements present and in the specified order. The header line formats are listed in the following table.

CODE V Data File Header Information (continued)

Label	*Field Name*
REQ	CameraWidth CameraHeight NumericAperture ObliquityFactor CameraRes
SWI	SoftwareType MajorVers MinorVers BugVers SoftwareDate
ACQ	AcquireType
COM	Comment
CON	MinimumAreaSize DisconAction DisconFilter ConnectionOrder
ERR	SubtractSysErr SysErrFile
IAC	IntensAvgs
LLV	AGC TargetRange LightLevel
MAG	Magnification PartThickness RefractiveIndex RemoveTiltBias
MOD	MinMod MinModPts
ONM	ObjectiveName
PAC	PhaseAvgs
PNM	PartNum
PSN	PartSerNum
RMP	PZTCal PZTGainTolerance PZTGain
SGN	DataSign
SRC	Source PhaseWidth PhaseHeight
SYS	SystemType SystemBoard SystemSerial InstrumentId
TMS	TimeStamp

CODE V Data File Header Field Descriptions

Descriptions of each header field in the CODE V data file are identical to those found in the ASCII Data File Header Field Descriptions.

CODE V File Formats

After the header lines, the first line of a CODE V file is an 80-character description. This line will contain the comment text, if any was provided. Otherwise, it will contain 'ZYGO' followed by the software type that stored the data followed by a the date and time the data was stored. The second line contains CODE V parameters. The appropriate data is then listed.

CODE V Phase (Grid) Data

When a CODE V file contains grid data, its parameter line must contain the following elements:

GRD x_size y_size SUR/WFR WVL val SSZ val [NDA val]

While the entries on the line are order independent, the values associated with each element *must* appear in the order shown. For each label it is assumed that all of the parameters exist and are in the correct order. All of the elements must be present (with the exception of the NDA term, which is optional) for the file to be considered valid. Each element indicates the following data:

1) GRD x_size y_size

   X_size and y_size are integers and represent the number of horizontal (x) and vertical (y) grid points. The total number of data points is x_size * y_size.

2) SUR/WFR

   SUR indicates that the data to follow represents surface data as opposed to WFR, which indicates wavefront data. (FIL is used to indicate intensity apodization filter data, which is *not* supported.) SUR or WFR are selected with the Code V Type control; which is created with the New Control → Miscellaneous → Code V Type command.

3) WVL val

   This real number is used to specify the wavelength, in microns, at which the interferogram was measured.

4) SSZ val

   This real number is the value of the data corresponding to one wave of deformation.

5) NDA val

   This integer is the value of data that is to be interpreted as missing data. This is an optional parameter element. The default value is 32767.

The data points are integers and are output 10 per line with a field width of 7.

CODE V Zernike Data

When a CODE V file contains Zernike polynomial coefficients, its parameter line must contain the following elements:

ZFR num_terms SUR/WFR WVL val SSZ val

While entries on the line are order independent, the values associated with each element *must* appear in the order shown. For each label it is assumed that all of the parameters exist and are in the correct order. All of the elements must be present for the file to be considered valid. Each element indicates the following data:

1) ZFR num_terms

   ZFR indicates that the coefficients represent a *Fringe* Zernike polynomial. (ZRN would indicate that the coefficients represent a standard Zernike polynomial; however, regular polynomials are *not* supported.) The number of terms represents the number of coefficients present in the data. While up to 37 terms are supported by CODE V for the *Fringe* Zernike polynomial, only 3, 4, 9, 16, 25, and 36 terms are valid for MetroPro. This is an integer value.

2) SUR/WFR

   SUR indicates that the data to follow represents surface data as opposed to WFR, which indicates wavefront data. (FIL is used to indicate intensity apodization filter data, which is *not* supported.) .) SUR or WFR are selected with the Code V Type control; which is created with the New Control → Miscellaneous → Code V Type command.

3) WVL val

   This real number is used to specify the wavelength, in microns, at which the interferogram was measured.

4) SSZ val

   This real number is the value of the data corresponding to one wave of deformation.

The coefficients are real numbers and are output 6 per line with a field width of 12 and a precision of 4.

Scaling CODE V Data

Because CODE V uses 16 bits and MetroPro uses 24 of 32 bits to represent phase data, there is a possibility that Zygo data may represent a value that is outside of the CODE V range of valid values. To deal with this, data is scaled down before being written if any of the values in the data set fall outside of the -32767 through +32767 CODE V valid range. MetroPro scales its data using the following algorithm:

1) Select the appropriate ZYGOCIRCLE value based on the Phase Res.
2) Divide the ZYGOCIRCLE value by the IntfScaleFactor to establish the initial scale size and set initial scaling to 0.
3) Establish whether or not any data values fall outside of the CODE V value range.
4) If none do, continue. Else, establish the scaling factor by identifying the minimal amount of shift needed to bring all of the data within the valid data range. Adjust the scale size value by a factor of 2 for every shift necessary.
5) Shift data before writing.

Converting CODE V Files to MetroPro Files

The following are a few notes to be aware of when converting CODE V files to MetroPro files:

1) If no comment line (COM) is included in the header, the 80-character description line will be placed in the comment field.
2) If no source line (SRC) is included in the header, the source field will be set to generated (1).
3) Header fields of unknown or unnecessary values should be set to 0.
4) Phase resolution will be set to normal (Lo).
5) Apodization filter data files (FIL) are not handled by MetroPro.

CODE V Data File Examples

Two examples of Zygo CODE V .INT data files are provided; they are shown vertically for sake of clarity. The grid file contains a tiny 6x6 phase data matrix. The Zernike file shows the format for 36 terms. Note that the COM lines are truncated.

Denotes Code V grid data

Header Lines

Data

```
! ZYGOGRD
! REQ 262 235 0 1
! TMS 671819076
! SWI 1 1 6 6 "Thu May 23 15:36:21 EDT 1991 "
! COM "
! SRC 0 6 6
! MAG 0 0 0 0
! ACQ 0
! IAC 0
! RMP 1 3 1686
! LLV 1 0.1 40
! MOD 71 50
! CON 20 1 0 0
! SGN 0
! SYS 1 0 5555 0
! ONM "Sm Aperture"
! PNM "                                   "
! PAC 0
! ERR 0 "                   "
! PSN "                                   "
Zygo MetroPro Wed May  1 11:35:27 1991
GRD 6 6 SUR WVL 0.6328 SSZ 8192.000000 NDA -32768
  2530  2566  2606  2649  2698  2751  2693  2731  2773  2812
  2868  2913  2860  2905  2944  2990  3036  3094  3030  3072
  3121  3161  3207  3261  3206  3255  3298  3337  3381  3423
  3356  3410  3452  3503  3548  3592
```

Denotes Code V Zernike data

```
!  ZYGOZFR
! REQ 262 235 0 1 0
!  TMS  671819076
! SWI 1 1 6 6 "Thu May 23 15:36:21 EDT 1991 "
! COM "
! SRC 0 6 6
! MAG 0 0 0 0
! ACQ 0
! IAC 0
! RMP 1 3 1686
! LLV 1 0.1 40
! MOD 71 50
! CON 20 1 0 0
! SGN 0
! SYS 1 0 5555 0
! ONM "Sm Aperture"
! PNM "                                               "
! PAC 0
! ERR 0 "                  "
! PSN "                                               "
Zygo MetroPro Wed May 1 11:35:27 1991
ZFR 36 SUR WVL 0.6328 SSZ 8192.000000
  0.0000    3.0000    6.0000    9.0000   12.0000    15.0000
 18.0000   21.0000   24.0000   27.0000   30.0000    33.0000
 36.0000   39.0000   42.0000   45.0000   48.0000    51.0000
 54.0000   57.0000   60.0000   63.0000   66.0000    69.0000
 72.0000   75.0000   78.0000   81.0000   84.0000    87.0000
 90.0000   93.0000   96.0000   99.0000  102.0000   105.0000
```

Header Lines

Data

Oslo Spreadsheet Data File - Zernike Information

This section describes the contents and layout of a Zygo OSLO spreadsheet buffer data file containing Zernike information. These files are compatible with OSLO series 2 and 3 software.

To create a Zygo OSLO spreadsheet data file, save data in MetroPro with the Save Zernikes button, then use the zfr_to_zrs conversion utility. The spreadsheet file is a binary file and therefore is not readable. Multiple-byte fields are stored with the most significant byte first, and string fields (character) are null-terminated. Floating-point numbers (real) are stored in the IEEE standard format.

The file is made of 2 parts - an 80-character string and a data array of 1200 elements. The array elements are doubles, each taking up 8 bytes.

The string is made of a letter indicating the vector containing the data and the first 78 characters of the comment field. The array is made of 12 100-element vectors, designated ‘a’ through ‘f’ and ‘u’ through ‘z’. The Zygo data is stored into a vector specified by the user. To calculate the starting index for the data, multiply the vector index by 100. The vector indices are: ‘a’ = 0; ‘b’ = 1; ‘c’ = 2; ‘d’ = 3; ‘e’ = 4; ‘f’ = 5; ‘u’ = 6; ‘v’ = 7; ‘w’ = 8; ‘x’ = 9; ‘y’ = 10; ‘z’ = 11. The vector contains 11 parameters followed by the Zernike values as outlined below.

Item	*Index*	*Name*
1	0	Id Number
2	1	Number of Terms
3	2	Wedge Factor
4	3	Wavelength
5	4	Center X
6	5	Center Y
7	6	Radius
8	7	Aperture Type
9	8	X Extent
10	9	Y Extent
11	10	MM per unit
12	11	Coefficients
.	.	Coefficients
.	.	Coefficients
47	46	Coefficients

Oslo Array Element Descriptions

Id Number This element allows the user to include an identifying number with the file. In MetroPro, this number is the part serial number.

Number of Terms This specifies the number of coefficient terms stored in the file. Valid values are 3, 4, 9, 16, 25, and 36.

Wedge Factor This is the number of waves per fringe.

Wavelength This is the wavelength, in microns, at which the interferogram was measured.

Center X, Center Y These are the coordinates of the center of the surface in pixels. For files originated from OSLO, these values should be set to -1. When MetroPro loads the file and generates the surface data, the actual center will default to the center of the user-specified window. When created by MetroPro, the file will normally have the coordinates set to the center of the valid surface data. An exception is if the user manually changes the coordinates to -1 before saving the Zernike data.

Radius This is the radius of the surface in pixels. For files originated from OSLO, this value should be set to -1. When MetroPro loads the file and generates the surface data, the actual radius will be half of the width or height (whichever is less) of the user-specified window. When created by MetroPro, the file will normally contain a radius that is a positive number. An exception is if the user manually changes the radius to -1 before saving the Zernike data.

Aperture Type A value of 1 represents an elliptical part. A value of 2 represents an rectangular part.

X Extent This field represents one-half of the horizontal dimension of the aperture. For circular and square apertures, this field should equal the Y Extent. If the instrument is uncalibrated or if the dimension is unknown, this value will be 0.

Y Extent This field represents one-half of the vertical dimension of the aperture. For circular and square apertures, this field should equal the X Extent. If the instrument is uncalibrated or if the dimension is unknown, this value will be 0.

MM per Unit If both the X and Y extents are not 0, this represents the millimeters per unit of the unit the part size is expressed in. For example, if the size is expressed in inches, this field would be set to 25.4.

Coefficients These are the Zernike coefficient terms. The number of coefficients is equal to the number of terms, and the coefficients are expressed in fringes.

ZEMAX Grid Sag Data File Format

This section describes the format of a Zygo ZEMAX grid sag surface data file. The file has two parts: a header line and the sag data. ZEMAX files are ASCII files, which means that they are readable and printable. MetroPro data files are converted to ZEMAX grid sag files by using the dat_to_zxgrd conversion utility.

ZEMAX Data File Header Information

The first line of the file contains 5 values and has the following format:

x_size y_size x_spacing y_spacing unit_flag

X_size and y-size are intergers that indicate the number of data points in the sag grid surface in the x (width) and y (height) direction. X_spacing and y_spacing are real numbers that indicate the spacing between points in the x and y directions. Unit_flag indicates the units of the data; Zygo data is stored in millimeters (unit_flag = 0)

ZEMAX Data File Format

The remaining x_size * y_size lines of the data file contain 4 real numbers and an integer flag in the following format:

z dz/dx dz/dy d2z/dxdy flag

Z indicates the sag (or height) value. dz/dx and dz/dy are the x and y derivatives of the sag. d2z/dxdy is the cross derivative of the point. Flag indicates the validity of the data in the line; 0 = valid data, 1 = invalid data.

The values for dx, dy, and dxdy are slope calculations, which mean the current z value is compared or subtracted from adjacent z values The data flag is invalid (1) when there are not adjacent data points to determine the slope. This occurs when there is data dropout and on the edge of data.

SDF Data File Format

This section describes the format of a Zygo SDF data file. The file is made op of three parts: header, phase data, and trailer. All sections are followed by a line consisting of an asterisk (*). A semi-colon (;) is used to comment the remaining line. A Zygo SDF data file is created by using the `dat_to_sdf` conversion utility.

SDF Data File Header Information

The header consists of 13 required lines of information. Line 1 is a string constant (not enclosed in quotes). The remaining lines contain information about the measurement system and data file. They have the following format: *record_name* " = " *value.* A list of *record_name*s is shown in the table below.

Information	*ASCII Record Name*	*Binary Data Type*	*Binary Length (bytes)*
Version Number		unsigned char	8
Manufacture's ID	ManufacID	unsigned char	10
Creation Time and Date	CreateDate	unsigned char	12
Last Modification Time and Date	ModDate	unsigned char	12
Number of Points per Profile	NumPoints	unsigned int	2
Number of Profiles	NumProfiles	unsigned int	2
X-Scale	Xscale	double	8
Y-Scale	Yscale	double	8
Z-Scale	Zscale	double	8
Z-Resolution	Zresolution	double	8
Compression Type	Compression	unsigned char	1
Data Type	DataType	unsigned char	1
Check Sum Type	CheckType	unsigned char	1

SDF Data File Header Field Descriptions

Each header field in a SDF data file is described below. The types of the fields are noted in the above table.

Version Number This field must be the first line of the data file. It indicates what version of SDF format was used to generate the data file. The only valid value for this field is "aBCR-1.0".

Z-Scale This is the lateral resolution of the z-axis. Value is in meters.

Manufacture's ID This field specifies what version of MetroPro was used to create the data. The first two characters are MP for MetroPro and the remaining characters are the version number of MetroPro.

Creation Time and Date This is the time and date the original data file was created. It is in the format DDMMYYYYHHMM and zero padding is required (i.e. 0307 for July 3rd versus 37). The hour is in 24 hour format. Therefore, 120719971421 is July 12, 1997 at 2:21PM.

Last Modification Time and Date This field is similar to the *Creation Time and Date* except it represents the last time the SDF file was changed.

Number of Points per Profile This is the number of columns in the data set. This number is stored in a word cannot exceed 65535.

Number of Profiles This is the number of rows in the data set. T his number is stored in a word cannot exceed 65535.

X-Scale This is the lateral resolution between data points along the x-axis. Value is in meters.

Y-Scale This is the lateral resolution between data points along the y-axis. Value is in meters.

Z-Scale This is the lateral resolution of the z-axis. Value is in meters.

Z-Resolution This is the lateral resolution of the z-axis. Value is in meters.

Compression Type This field specifies what type of compression is used on the data. Since no compression is used, this field is zero (0).

Data Type This field what format the data is in. Zygo SDF data file stores its data as unsigned long so this value is always two (2). Any data values equal to maximum value of an unsigned long (4,294,967,295) represent an invalid data point which should not be used in calculations.

Check Sum Type This field is always zero (0).

SDF Data File Data

Each data point is an unsigned long integer. The data is written 10 data points per line in row-major order. Acceptable values are less than 4,294,967,295. The data points values are scaled; to convert to meters, multiply valid the data point value by Z-Scale. A line consisting of only an asterisk (*) is output after the data. The number of data points is:

$$NumPoints * NumProfiles$$

SDF Data File Trailer

The trailer section is used to store additional information not stored in the header. This information consists of every field in the Binary Data File header and is used to ensure proper conversion back to Binary format. Although most fields are optional, the following are required to convert from SDF to Binary: camera_width, camera_height, obliquity_factor, num_aperture, lateral_res, intf_scale_factor, wavelength_in and phase_res. The format of this information if the same as in the header.

SDF Data File Programming Notes

This section provides notes for persons writing programs to read Zygo SDF data files.

- The data file format consists of series of records terminated with CR (#13), LF (#10) or CR+LF.
- Additional “white space” characters (#9, #10, #13, #32) are ignored including those in the data section.
- All real numbers are composed of the following characters ‘0’ … ‘9’, ‘.’, ‘e’, ‘E’, ‘+’, ‘-’.
- All three sections are of the file (header, data, and trailer) are terminated with a single record containing the character ‘*’ (#42). Thus the final ‘*’ record identifies the end of the data file.
- All three sections are of variable length.
- Any record information following a ‘;’ (#59) character is considered a comment and is ignored.
- Elements of the header are given as separate records for readability and ease of file I/O.
- The first record of the data file is always the version number.
- All other records pertaining to the header may be placed in any order in the header section.
- Each record in the header contains three (3) parts: the record ID, a separator (=), and the value.

Sample SDF Data File

```
aBCR-1.0                      ; This is always the first line
ManufacID = MP6.5.6           ; the following records
;                             can be presented in
;                             any order
CreateDate = 210819971517     ; Aug 21, 1997 @ 3:17PM
ModDate = 020219981407        ; Feb 2, 1998 @ 2:07PM
NumPoints = 132
NumProfiles = 169
Xscale = 1.19246e-05
Yscale = 1.19246e-05
Zscale = 9.67234e-12
Zresolution = 9.67234e-12
Compression = 0               ; NONE
DataType = 2                  ; UNSIGNED LONG
CheckType = 0                 ; NONE
*
201658 201855 202180 202237 201903
201983 202030 202194 201937 202100
202365 202366 202260 202583 202624
202904 202322 202875 202645 202927
202991 203169 203354 203555 204347
205257 206923 4294967295      ; last point is a bad data point
1241499 1241611 1241771 1241923 1242201
…
1242252 1242104 1242048 1242157 1242029
*
; Additional Information
operator = Tom Jones
shift = 1
* ; End Of File
```

XYZ Data File Format

This section describes the format of a Zygo XYZ data file. The file is made up of two parts: header and measurement data. The parts are separated by a line containing a sharp (#) character. Using the dat_to_xyz conversion utility creates a Zygo XYZ data file from a Zygo binary data file. Using the xyz_to_dat conversion utility creates a Zygo binary data file from a Zygo XYZ data file.

XYZ Data File Header Information

This section is identical to the Zygo ASCII data file header. See the section in the ASCII Data File Format for more information.

XYZ Data File Connected Phase Data

The data in this section is organized by phase origin. Each line contains three pieces of data. The first two columns contain the row and column location of the data, beginning at the phase origin. The third number on the line can be either the character string "No Data" or a floating-point number corresponding to the measurement in microns. To convert these measurements to 'zygos', use the following formula. (The names in parenthesis refer to the Binary Data Format field names)

The data in the file is in microns. We must convert this to meters, so divide by 10^6.

Multiply the result by the phase resolution (PhaseRes).

Normal resolution (0): use 4096.

High resolution (1): use 32768.

Divide the result by the interferometric scale factor (IntfScaleFactor).

Divide the result by the obliquity factor (ObliquityFactor).

Divide the result by the wavelength at which the interferogram was measured (WavelengthIn).

This can be restated as follows:

Low resolution phase data:

Multiply third column data in by:

(4096/ (IntfScaleFactor*ObliquityFactor*WavelengthIn*1000000))

High resolution phase data:

Multiply third column data by:

(32768/ (IntfScaleFactor*ObliquityFactor*WavelengthIn*1000000))

Convert the result to an integer to be stored in the binary file. This will cause round-off error, but, based on test results, this amounts to a less than one Ångstrom variance from the original data.

XYZ Pixel Resolution

The camera resolution is found on the eighth line of the header (CameraRes) (in meters/pixel). Multiply this number by the appropriate factor to obtain the resolution needed. The horizontal and vertical pixel resolution can be calculated as follows:

CameraRes = 1.81512e-005

To get microns (10^{-6} meters): (.000018512)*(1000000) = 18.512 microns.

The horizontal and vertical pixel resolutions are the same.

A typical output from this converter:

```
Zygo XYZ Data File - Format 1
1 7 3 2 "Thu May 27 10:05:01 1999     "
0 0 560 420 1 255
130 5 413 412
"Xxxxxx Engine Company, Inc.            "
"                                       "
"4001896- Armature & Plunger            "
0 0.5 6.48e-007 0 1 0 1.81512e-005 908907731
560 420 11 0 -15531 0 "2.5X  Mich "
2 0 0 0 0 0 0 28.7912 10 0
0 0 7 1 60 0 0 0 0
0 "               "
1 0
#
130 5 No Data
131 5 No Data
132 5 No Data
133 5 No Data
134 5 No Data
…
330 5 No Data
331 5 2.434588
332 5 2.459188
333 5 2.447323
334 5 2.434904
…
537 417 No Data
538 417 No Data
539 417 No Data
540 417 No Data
541 417 No Data
#
```

XYZ Data File Notes

Be aware that the resultant file will be larger than the original file due to it being ASCII, not binary, and requiring three fields (x,y,z) for the original phase data. Intensity data will be lost when the file is converted back to binary (.dat) format, since it is not maintained in the .xyz file.

Converting Data File Formats

There are several utilities included with MetroPro to convert Zygo data files to and from the file formats described in this Appendix. Binary data files are created when a file is saved after clicking the Save Data button in MetroPro. CODE V .INT Zernike files are created by selecting Save Zernikes in the map test/default data window.

To use a converter utility, open a DOS prompt window, change to the directory where the data files are located, and type the converter name, existing filename (input), and converted filename (output), and then press Enter.

MetroPro Data File Converters

Converter	***Description***
Exporting MetroPro Data	
dat_to_asc *Input Output*	This utility converts the existing binary data file specified as the input file into the ASCII data file specified as the output file.
dat_to_raw_asc *Input Output*	This utility converts the existing binary data file specified as the input file into the raw ASCII data file specified as the output file.
dat_to_grd *Input Output*	This utility converts the existing binary data file specified as the input file into the CODE V .INT grid data file specified as the output file.
dat_to_zxgrd *Input Output width*	This utility coverts the existing binary file data file specified as the input file into the ASCII ZEMAX data file specified as the output file. The width indicates the width of the desired sag grid. Because of the size of MetroPro data files, it is recommended that the ZEMAX file be of a smaller dimension. Width must be an odd number and smaller than the width of the data in the binary data file. Note: ZEMAX versions prior to 5.0 do not handle data files that have dropouts or missing data, or do not fill the entire aperture.
dat_to_sdf *Input Output*	This utility converts the existing binary data file specified as the input file into the sdf data file specified as the output file.
dat_to_xyz *Input Output*	This utility converts the existing binary data file specified as the input file into the XYZ data file specified as the output file.
zfr_to_zrs *Input Output vector*	This utility converts the existing CODE V .INT Zernike data file specified as the input file into the OSLO spread-sheet buffer data file specified as the output file. The vector specifies the vector (or column) in the OSLO spreadsheet where the data will be stored. Valid vector values range from ‘a’ through ‘f’ and ‘u’ through ‘z’. CODE V .INT Zernike files are created by selecting Save Zernikes in the map test/default data window.

MetroPro Data File Converters (continued)

Converter	***Description***
Importing Data into MetroPro	
hdp_to_dat *Input Output*	This utility converts the existing HDP data file specified as the input file into the binary data file specified as the output file. HDP is the data file format used by Zygo prior to MetroPro.
asc_to_dat *Input Output*	This utility converts the existing ASCII data file specified as the input file into the binary data file specified as the output file.
grd_to_dat *Input Output*	This utility converts the existing CODE V .INT grid data file specified as the input file into the binary data file specified as the output file. See also Section 3-5 "Converting CODE V Files to MetroPro Files" in this appendix.
sdf_to_dat *Input Output*	This utility converts the existing SDF data file specified as the input file into the binary data file specified as the output file.
xyz_to_dat *Input Output*	This utility converts the existing XYZ data file specified as the input file into the binary data file specified as the output file.

Note: When converting files into the MetroPro binary data file format the extension ".dat" must be used for MetroPro to recognize the file in the Load Data dialog box.

Summary

This appendix describes specialized options that affect the way MetroPro operates. By using command line options you can for example: cause MetroPro to ignore an instrument, open two applications side-by-side, open a specific application and data file, or load MetroPro in icon form. These options can be temporary or permanent, depending on the way they are implemented.

> **Note:** Use of command line options is for advanced users. Command line options change the way MetroPro operates and may cause confusion between multiple users.

Command Line Options

Every option begins with a plus sign (+) or a minus sign (-). Italicized type indicates optional parameters to enter; substitute the name of a file for the parameter. Be sure to enter the characters (comma, plus sign, or times sign) shown between multiple parameters.

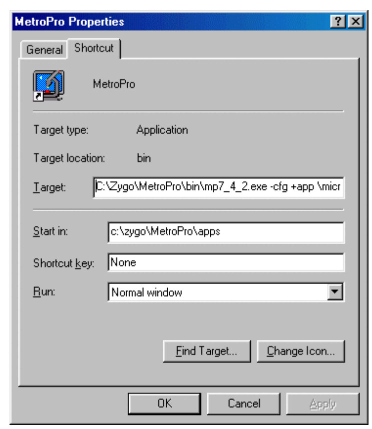
Option	*Description*
-help	Display list of command line options and exit MetroPro.
-app <appName>	Load the application named <appName>, but leave it iconized.
+app <appName>	Load and open the application named <appName>.
+app <appName> [,<datafile.]	Load and open the application named <appName>, then load data from file named *<datafile>*.
-cfg	Ignore configuration file MetroPro.cfg (which is normally read at startup).
+cfg <configFile>	Use configuration file named <configFile> instead of MetroPro.cfg.
+logfile <filename>	Output diagnostic messages to the file named <filename> instead of the default MetroLog.txt.
-logfile	Output diagnostic messages to a console window instead of to a file.
-windowsDialog	Use windows dialog for loading/saving files.
-printgrey	Send grey instead of color images when printing to a printer.
-imagegrey	Send grey instead of color images when printing to a file or a printer.

continued

Option	*Description*
-script <filename>	Set the top-level script file name to<filename> but do not run the script.
+script <filename>	Set the top-level script file name to<filename> and run the script.
-ignore	Ignore any instrument hardware. (This allows multiple MetroPro invocations without conflict. Only one MetroPro invocation at a time should access an instrument.)
-z	Enable diagnostics
+z <number>	Eanble diagnostics option <number>.
-pifoclog	Disable the logging of pifoc diagnostic information.
+pifoclog <number>	Set the maximum size of the pifoc diagnostic log file to *<number>,* which is the number of bytes (a positive integer).

Using a Command Line Option

Start MetroPro and open a specific application.



1. Go to the Program Manager; select the MetroPro program icon and select the File/Copy command (NT version 3.51). Or create a shortcut to the MetroPro executable file (NT version 4.X).
2. Select the copy (or shortcut) and press Alt+Enter.
3. Enter at the Command Line or Target:

   ```
   C:\Metropro\bin\mpX_X_X.exe -cfg +app
   \Path\AppFile
   ```

   Where *Path* is the directory path to the application file *AppFile*. "mpX_X_X.exe" should be the name of the executable file on your system, the X's represent numbers.

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