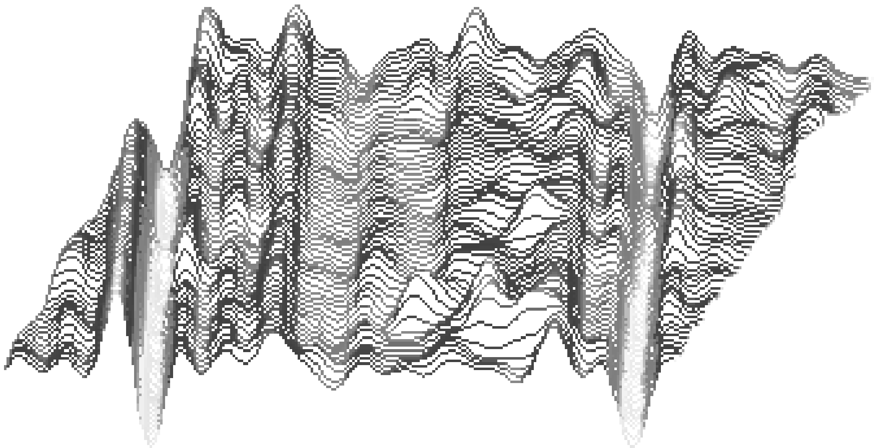
MetroPro™
Surface Texture Parameters



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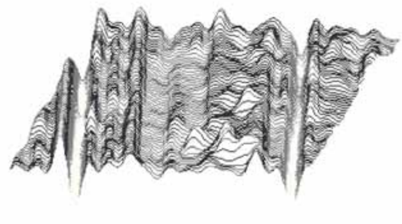
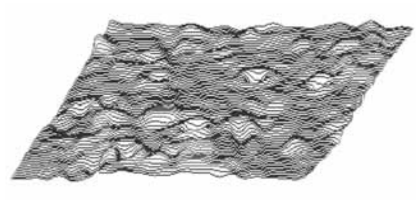
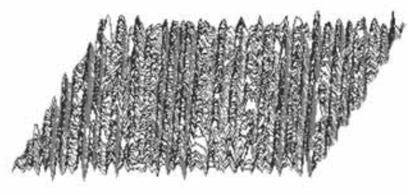
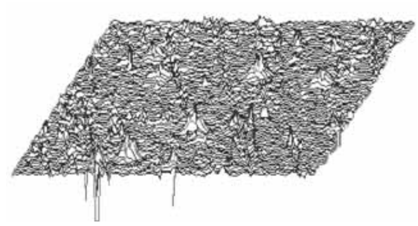








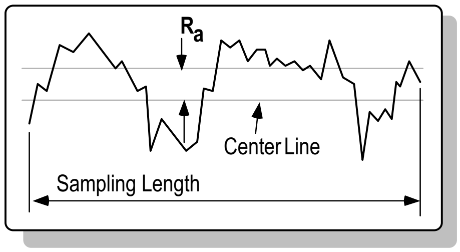
This glossary lists many of the surface texture parameters available in Zygo Corporation's MetroPro software. For additional information, refer to Zygo Corporation's product manuals or contact your local representative.

Roughness Parameters

R_a

The average surface roughness, or average deviation, of all points from a plane fit to the test part surface.
The equation for average roughness is:

$$R_a = \frac{Y_1 + Y_2 + Y_3 \ldots Y_N}{N}$$



R_q (rms)

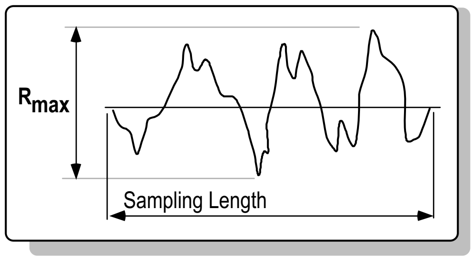
The root-mean-square average of the measured height deviations taken within the evaluation length or area and measured from the mean linear surface. Rq represents the standard deviation of the profile heights and is used in computations of skew and kurtosis.

In mathematical symbols:

$$R_q = \sqrt{\frac{1}{L}\int_0^L y(x)dx}$$

R_y (R_{max})

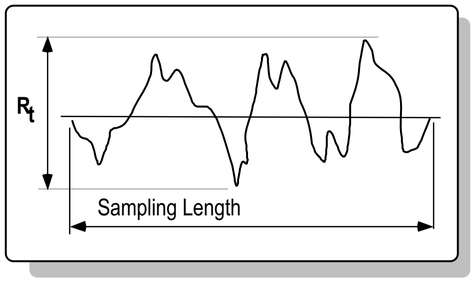
The vertical distance between the top of the highest peak and the bottom of the deepest valley within the sampling length. The maximum of all the peak-to valley (R_t) values.



R_t (PV)

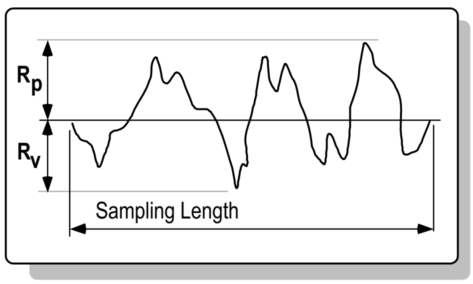
Maximum peak to valley height over the sample. Absolute value between the highest and lowest peaks. The maximum height of the profile is available for profile data and the entire measured data array.
The equation for R_t is:

$$R_t = R_p + R_v$$



R_p (Peak)

The highest peak. The maximum distance between the mean line and the highest point within the sample. It is the maximum data point height above the mean line through the entire data set.



R_v (Valley)

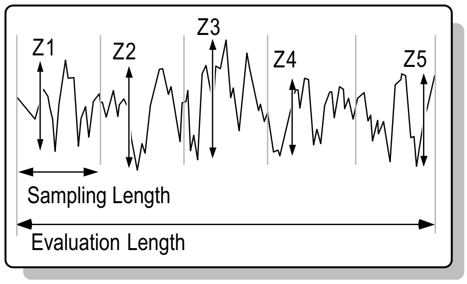
The lowest valley. The maximum distance between the mean line and the lowest point within the sample. It is the maximum data point height below the mean line through the entire data set. See R_p.

Roughness Parameters

R_{tm}

The average peak-to-valley roughness. It is determined by the difference between the highest peak and the lowest valley within multiple samples in the evaluation area. For profile data, it is based on five sample lengths; for three dimensional data, it is based on nine sample areas.
The equation for R_{tm} profile is:

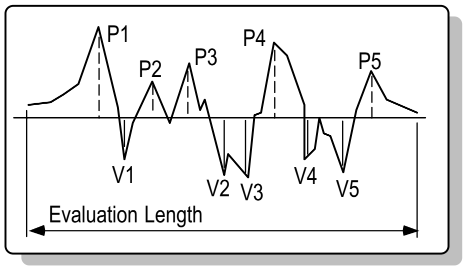
$$R_{tm} = \frac{(Z1 + Z2 + Z3 + Z4 + Z5)}{5}$$



R_z

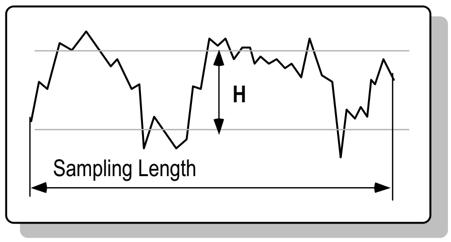
Ten-point height, or the average absolute value of the five highest peaks and the five lowest valleys over the evaluation length. Also known as the ISO 10 point height parameter.
The equation for 10 point height is:

$$R_z = \frac{(P1 + P2 \ldots P5) - (V1 + V2 \ldots V5)}{5}$$



H

Swedish height, or the roughness between two predefined reference lines. The upper line exposes 5% of the data and the lower line exposes 90%. Swedish height is less sensitive to data spikes than R_t.



R_{ku}

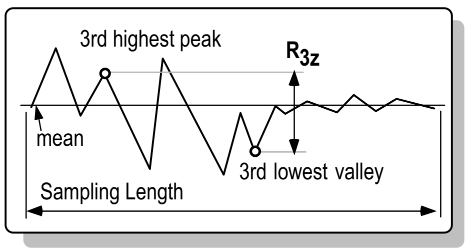
R_{ku} or Kurtosis is a measure of the randomness of profile heights, and of the "sharpness" of a surface. Kurtosis values can range from 0 to 8. A perfectly random surface has a value of 3; the farther the result is from 3, the less random and more repetitive the surface is. Spiky surfaces have a high value; bumpy surfaces have a low value.

Kurtosis is calculated as follows:

$$R_{ku} = \frac{1}{n(R_q)^4} \sum_{i=1}^{i=n} (Y_i)^4$$

R_{3z}

The distance between the third highest peak and the third lowest valley. A peak is a portion of the surface above the mean line and between center line crossings.



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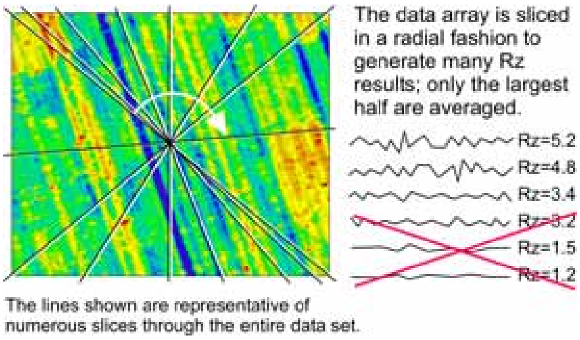
Roughness Parameters

SRz

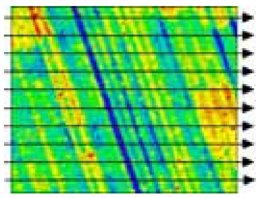
The average of the largest half of many individual Rz results determined by slicing the data array about its center. The data array is sliced in a pinwheel fashion through 360 degrees, resulting in numerous profile slices and Rz results. The Rz results are sorted by magnitude and SRz is calculated by averaging the largest 50% of the Rz values. A line-generation algorithm is used to determine the actual pixel-to-pixel path of each slice; there is no interpolation between pixels.



SRz covers the entire array and due to its radial generation it is lay independent. By averaging many Rz results, it more closely represents surface deviation across the lay and optimizes gage repeatability and reproducibility (GR&R).

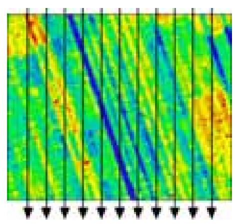
SRzX

The average of many individual Rz results, determined by slicing the data array in the x-axis. The individual Rz results are each based on a profile slice one pixel wide. SRzX is based on the entire array.



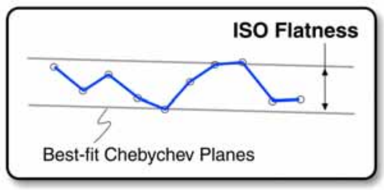
SRzY

The average of many individual Rz results, determined by slicing the data array in the y-axis. The individual Rz results are each based on a profile slice one pixel wide. SRzY is based on the entire array.

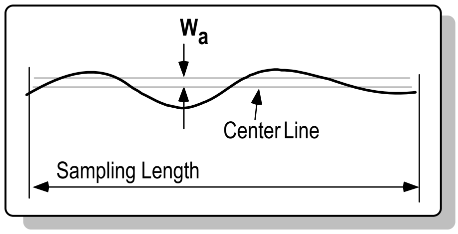
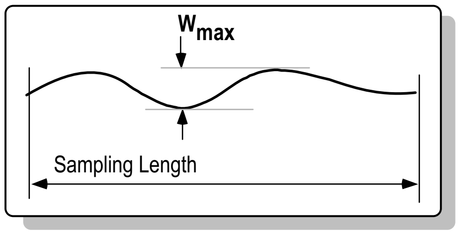


ISO Flatness

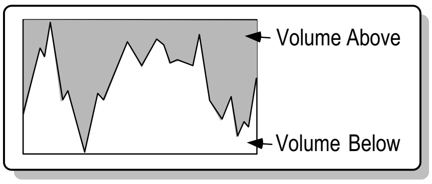
This is a measure of how much a surface deviates from perfectly flat. It is the distance between two parallel planes obtained by applying a Chebychev fit to the surface data. The Chebychev fit is a mathematical technique that effectively uses two parallel planes to "squeeze" the surface data points from both inside and outside, adjusting the angle to minimize the distance between the planes.



Waviness Parameters

W_a	The average surface height, or average deviation, of all points from a plane fit to the waviness data. The equation for average waviness is: $W_a = \frac{Y_1 + Y_2 + Y_3 \ldots Y_N}{N}$	
W_q	The root-mean-square deviation of all points from a plane fit to the waviness data.	In mathematical symbols: $W_q = \sqrt{\frac{1}{\ell}\int_0^\ell y^2(x)dx}$
W_y (W_{max})	The maximum height of the waviness data.	

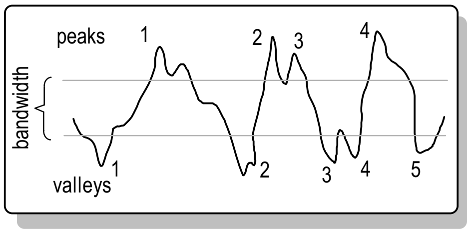
Hybrid Parameters

Δ_a (Slope $_{Ra}$)	The arithmetic average surface slope of the entire data matrix. Slopes are directly related to the reflective properties of the surface. They are useful for controlling cosmetic appearances of surfaces, as well as in controlling reflective surfaces.	In mathematical symbols: $$\Delta_a = \frac{1}{\ell}\int_0^{\ell}\left\|\frac{dy}{dx}\right\| dx$$ Results are available for overall slopes and in just the x or y axes.
Δ_q (Slope $_{rms}$)	The geometric average slope of the entire data matrix. This result is similar to Δ_a except that individual slopes are averaged by the rms method rather than arithmetically, emphasizing more extreme slopes. Results are available for overall slopes and in just the x or y axes.	
Δ_{tm} (Slope $_{Rtm}$)	The average peak-to valley slope of nine sample areas on the entire data matrix. Results are available for overall slopes and in just the x or y axes.	
I_a	The average surface height, or average deviation, of all points from a plane fit to the input data. Input data is the data obtained by the instrument; it includes roughness and waviness information.	
I_q	The root-mean-square deviation of all points from a plane fit to the input data.	
I_y (I_{max})	The maximum height of the input data.	
R_{volume}	The volume of the roughness data as specified by a software as above or below the surface.	
$R_{SurfAreaRatio}$	The ratio of roughness surface area to the planar area occupied by the data.	
$W_{SurfAreaRatio}$	The ratio of waviness surface area to the planar area occupied by the data.	
$I_{SurfAreaRatio}$	The ratio of input surface area to the planar area occupied by the data.	

Spacing Parameters

P_C (Peaks)

Peak count or the number of peaks included in the analysis. A peak is defined as a data point whose height is above a software selected bandwidth.



Peak Density

The number of peaks per unit area.

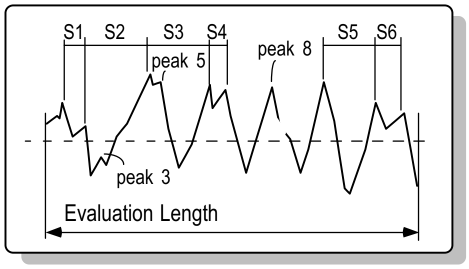
Peak Spacing

The average distance between peaks.

S

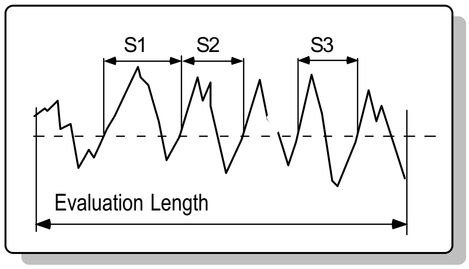
The average spacing between local peaks over the evaluation length. A local peak is the highest point between two adjacent minima.
The average spacing for the example shown is calculated by:

$$S = \frac{S_1 + S_2 + S_3 + S_4 + S_5 + S_6}{6}$$



S_m

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 the mean line. S_m is calculated by summing the peak spacings and dividing by the number of peak spacings.



Summits

The number of summits included in the analysis. A summit is a point that is higher than the four nearest data points by a software set threshold value. The higher the threshold, the fewer and steeper the summits.

Summit Density

The number of summits per unit map area.

Summit Spacing

The average distance between summits.

Valleys

The number of valleys included in the analysis. A valley is defined as a data point whose height is below a software selected bandwidth. See P_C.

Valley Density

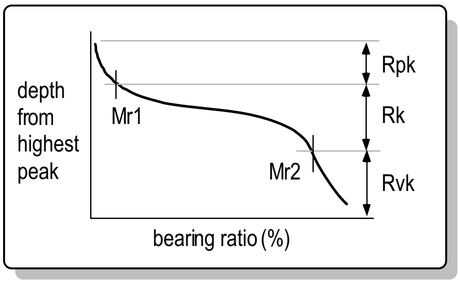
The number of valleys per unit area.

Valley Spacing

The average distance between valleys.

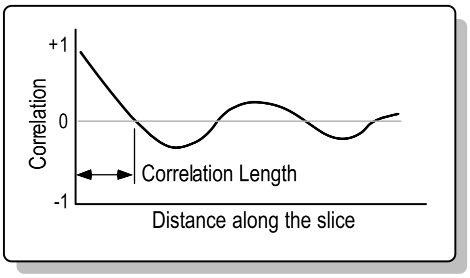
Statistical Parameters

Bearing Ratio (T_p)	Bearing ratio is the ratio (expressed as a percentage) of the length of the bearing surface at any specified depth in the profile to the evaluation length. It is also known as Abbott-Firestone curve or material ratio. It simulates the effect of wear on a bearing surface. Parameters derived from the bearing ratio analysis are listed separately.
R_k	Core roughness depth. The long term running surface which will influence the performance and life of the bearing.
R_{pk}	Reduced peak height. The top portion of the surface that will be worn away in the run-in period.
R_{vk}	Reduced valley depth. The lowest part of the surface that retains lubricant.
H_{tp}	Height between two selectable bearing ratios. It is useful to determine the amount of material removal required in multiple process operations. This parameter is obtained by using software inspectors on the Bearing Ratio plot.
R_{sk}	Skewness, a measure of symmetry of the profile about the mean line. Negative skew indicates a predominance of valleys, while positive skew indicates a "peaky" surface. Bearing surfaces should have negative skew. Skew is calculated as follows: $R_{sk} = \frac{1}{n(R_q)^3} \sum_{i=1}^{i=n} (Y_i)^3$
M_{r1}	Peak material component. The material ratio at which R_{pk} and R_k meet. It represents the upper limit of the core roughness profile. This parameter is derived from the bearing ratio plot.
M_{r2}	Valley material component. The material ratio at which R_{vk} and R_k meet. It represents the lower limit of the core roughness profile. This parameter is derived from the bearing ratio plot.



Statistical Parameters

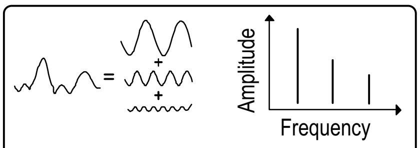
A_1	Material-filled profile peak area. Shows the area of the peaks or amount of material on the surface that will be removed in the run-in period.	This parameter is calculated from other bearing ratio results: $A_1 = \frac{1}{2}(R_{pk})(M_{r1})$
A_2	Lubricant-filled profile valley area. Shows the area of the valleys on the surface that can retain lubricant.	This parameter is calculated from other bearing ratio results: $A_2 = \frac{1}{2}(R_{vk})(100 - M_{r2})$
V_1	Volume 1 - the volume of the material that will be removed during the run-in period. Part of the Bearing ratio analysis.	
V_2	Volume 2 - The potential volume of retained lubricant. Part of the Bearing ratio analysis.	
ACF (Autocovariance)	Autocorrelation function or Autocovariance. Used to determine the periodicity of a surface; it shows the dominant spatial frequencies along a cross section of the test surface. ACF is a measure of “self-similarity” of a profile - the extent to which a surface waveform pattern repeats. If the surface is random, the plot drops rapidly to zero. If the plot oscillates around zero in a periodic manner, then the surface has a dominant spatial frequency. Correlation Length is the length along the x-axis where the autocovariance function first crosses zero.	Autocovariance is calculated by: $ACF = \sum_{i=1}^{N-m} \bullet Y_i \; Y_i + m$



Frequency Analysis

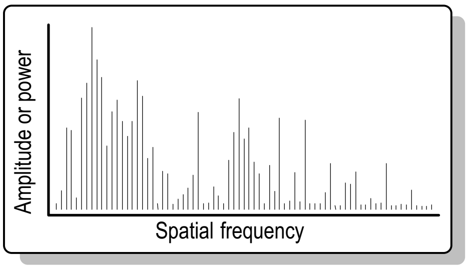
Power Spectrum

Shows a histogram of power and frequencies for profile data. Power is calculated as the square of the amplitude of a sine wave multiplied by the square of the length of the profile.
Plots that fall off quickly at low frequencies show a dominance of waviness. When the plot gradually falls off, the surface is characterized by roughness. Spikes in the plot may denote a spatial frequency due to a machining process.

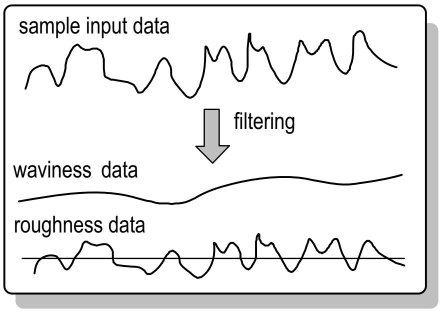


Profile reduced to a summation of sine waves of various amplitudes and frequencies.

The spatial frequency data is obtained from a Fourier analysis of the profile.



Terminology

Correlation Length	The length along the x-axis where the autocovariance function first crosses zero. In a perfectly random surface, correlation length is zero, because no points have any relationship to other points. In a surface with repetitive features, correlation length is one quarter of the period of the dominant pattern.
Cutoff Filter	Determines the wavelength at which the surface structure is differentiated between roughness and waviness data. When filtering is set to auto, MetroPro sets the starting cutoff filter to a fraction of the lateral extent of the data. It is best to use fixed filtering and enter a filtering cutoff value. The exact cutoff filter setting to use varies, based on the test part, the objective, and the testing criteria. Roughness results can vary dramatically whenever the cutoff is changed; therefore, proper selection of the correct filter cutoff is critical to the accuracy of your measurements. 
Evaluation Length	The area from which data is obtained. It is a three dimensional area that corresponds to the objective field of view or a two dimensional profile that corresponds to the length of the slice as defined in the filled plot.
Mean Line	A straight line that is generated by calculating a weighted average for each data point resulting in equal areas above and below the line. Also known as center line.
Roughness	The finer irregularities in the surface texture which are inherent in the production process.
Sampling Length	The area selected for assessment and evaluation of the roughness parameter having the cutoff wavelength. Any surface irregularities spaced farther apart than the sampling length are considered waviness. Also known as cutoff length.
Slope	Slope is combination of height and spacing data and is representative of the angle between data points.
Surface Texture	The topography of a surface composed of certain deviations that are typical of the real surface. It includes roughness and waviness.
Waviness	The component of surface texture upon which roughness is superimposed.

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