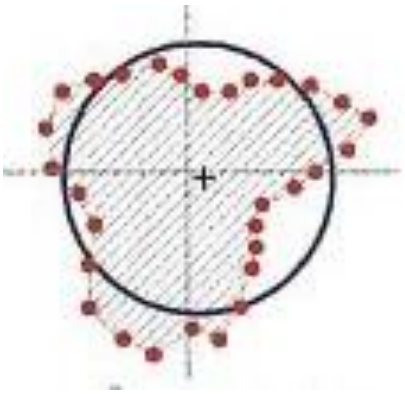
Filters and Outliers

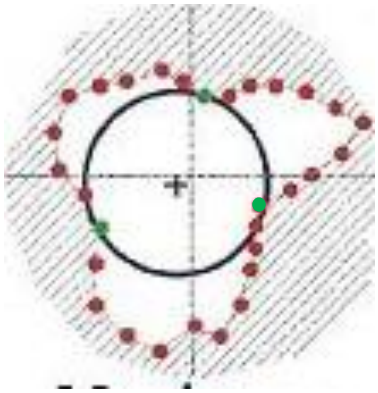
Calypso starts by evaluating all features using the Gauss Least Squares

Let's Review the Evaluation Methods:



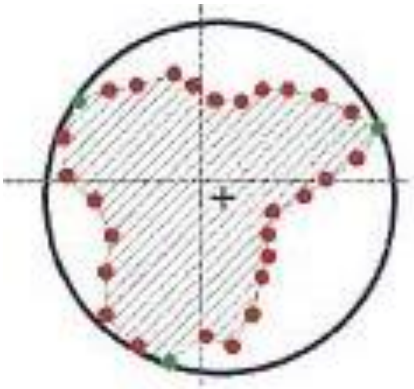
Least Squares

For a Circle, LSQ is the circle created from average of all the data points collected. This method is commonly used for Process Control results. CANNOT BE USED TO EVALUATE FIT OF MATING PARTS!!!



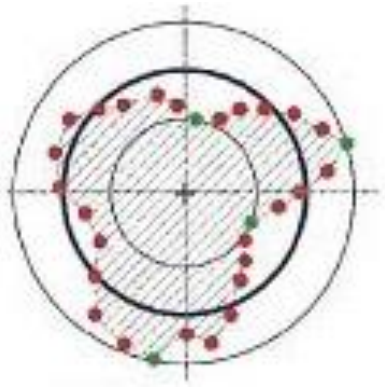
Maximum Inscribed Element

For a Circle, MIE is the smallest circle allowed from the data points collected. This method is commonly used for Functional Test results for bores (ID's). The easiest way to think about MIE is the best fit Pin Gage that goes through the bore.



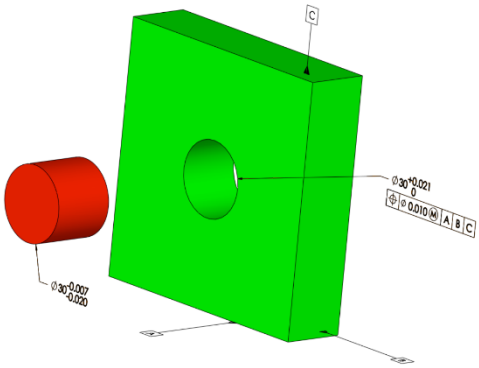
Minimum Circumscribed Element

For a Circle, MCE is the largest circle allowed from the data points collected. This method is commonly used for Functional Test results for shafts (OD's). The easiest way to think about MCE is the smallest Ring Gage that goes over the shaft.



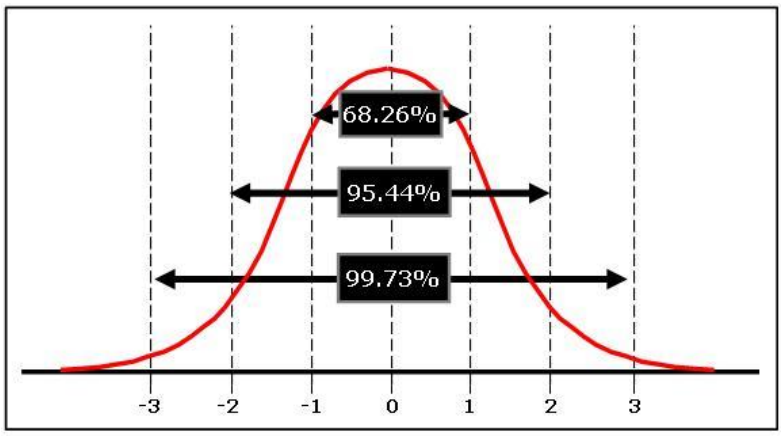
Minimum Zone

For a Circle, MZ is the average of the smallest and largest circle allowed from the data points collected that share a common center. This method is commonly used for Functional Test results of form (Roundness, Cylindricity, Flatness, etc.).



If we need to verify that the RED PIN goes into the GREEN PART BORE we have to use Minimum Circumscribed Element for the PIN (smallest Ring Gage that slides over the PIN) and Maximum Inscribed Element for the BORE (Largest Pin Gage that will pass through the BORE).

When scanning a feature the data dispersion is often described by the normal disruption. The 0 point on this graph is the mean (average) value. 1, 2, 3, and -1, -2, -3 are the standard deviations (s). Being able to see or understand the data this way will help us understand how outlier works in Calypso



Influences on Measurement Results:

Measuring Methods:

Speed

Stylus Ø

Evaluation Methods:

LSQ

MIE

MCE

Filtering:

High Pass

Low Pass

Band Pass

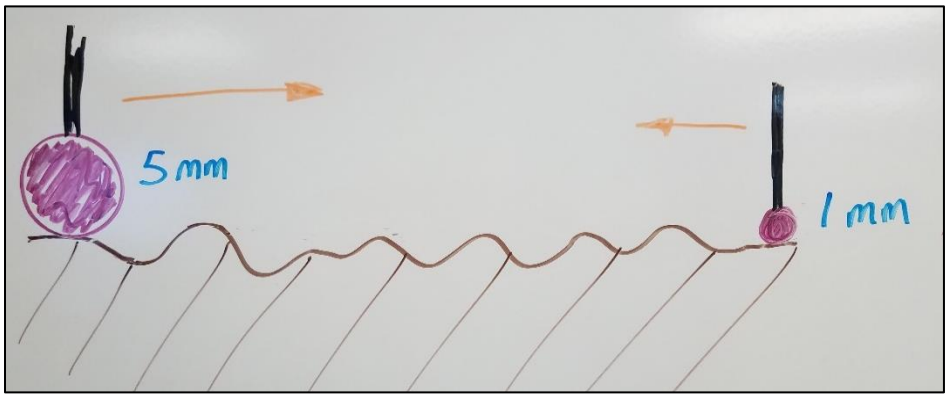
Outlier Elimination:

Delete Outliers to help get rid of "noise" in the data

Delete points next to outlier

Use Pre-Filters to help make sure form errors are NOT recognized and delete as outliers

The Stylus Diameter acts as a natural mechanical filter. In this picture you can see that the 5mm diameter will not fit in all the valleys as it scans the surface. The 1mm diameter will fit in most of the valleys as it scans.



The stylus you use may influences your results!!

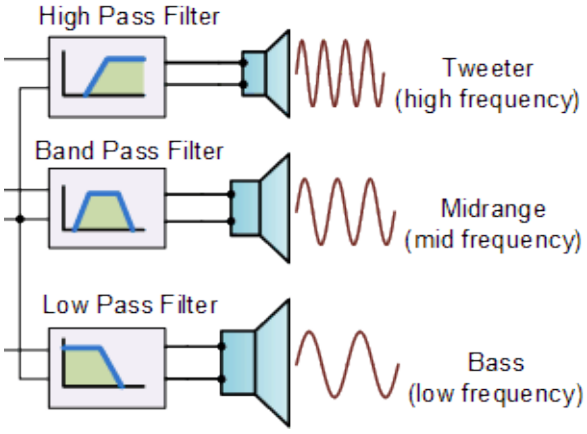
Filtering:

Filtering is used to remove excess data from the scan. It does not reduce or change the number of points. It extracts (filters) outside influences from the data. Filtering in the CMM world separates form errors from surface roughness.

Filter Types: The 3 Filter Types Calypso has available are High Pass, Band Pass, and Low Pass.

High Pass – is surface roughness
Band Pass – is some surface roughness and some form (waviness)
Low Pass – is form

Using a speaker comparison can help visualize what is happening when we filter the data. As the signal comes in to the speaker, the sound (data) is filtered by the 3 separate speakers that make up the speaker.



The tweeter only outputs the high frequency sound, the mid and lows are eliminated

The mid-range speaker outputs the mid frequency sound, the highs and lows are eliminated

The bass (woofer) speaker outputs the low frequency, the mid and highs are eliminated

The speaker doesn't change the data coming in it just uses the data in a different way for each speaker. If you isolated the speakers individually the sound of each would be totally different. This is what we want Calypso to do for use, separate the data so we get only the data we care about to meet the print requirement.

For most features measured with a CMM the Low Pass filter type is used!!

Filter Methods: The 3 Filter Methods Calypso has are Gauss Filter, Spline Filter, and 2 RC Filter.

Gauss Filter – (Gaussian bell curve) Standard filter for coordinate measuring.

Spline Filter – (Polynomial Calculation) Better filter method (than Gauss) just not the standard yet.

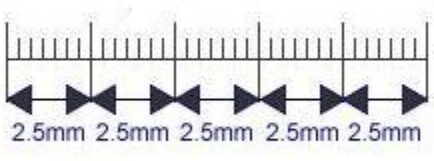
2 RC Filter – Not used any more.

The Calypso Cookbook uses the Gauss Filter method for all features and characteristics as of the writing of this document (Dec 2017).

Minimum Points for Filtering: There MUST be a minimum of 7 points per wave or undulation for filtering to work properly.

Min Point Calculations:

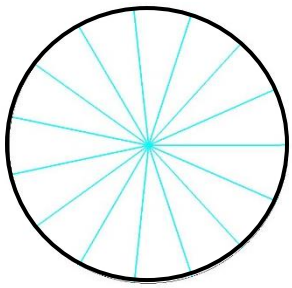
Planes – (length * [7] points per wave) / Cutoff Wavelength



Length of 100mm and a cutoff of 2.5

100*7 / 2.5 = 280 minimum number of points

Circles – Undulations * [7] point per undulation



So in this example we have a circle at 15 UPR

15 * 7 = 105 minimum number of points

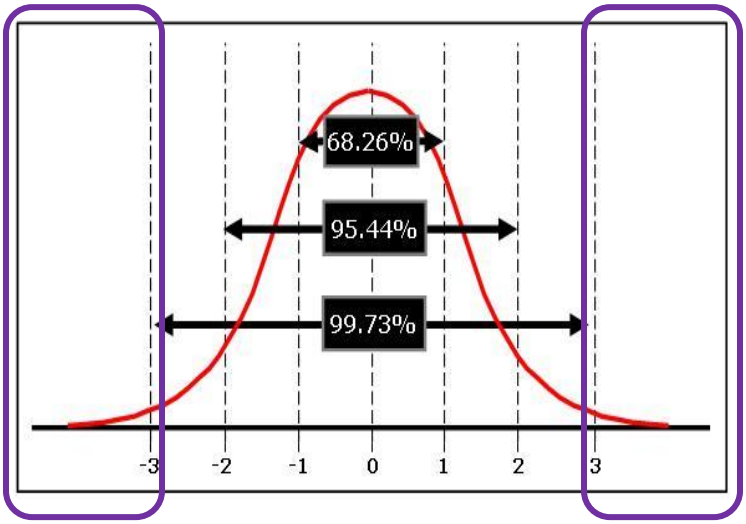
The Calypso Cookbook gives us recommendations for minimum number of points or point spacing on a per feature type.

Outlier Elimination:

Outlier elimination is the removal of data points based on the standard deviation of the feature (bell curve). The Calypso Cookbook standard is ± 3s.

As an example, if we use a factor of 3s, with the features standard deviation at 10µm, every point that deviates by more than 30µm is declared an outlier and removed.

The data to the left of -3s and to the right of +3s is removed.



The problem is that the points near the outliers may also be an outlier like, dirt or chips, so we want to remove some of these points also.

The Calypso Cookbook standard is to remove 5 adjacent points from the outlier point.

Pre-Filter: Pre-Filter is used so that form data like extreme tri-lobing or oval shapes are not consider an outlier and removed (page 67 to show).

The Calypso Cookbook Pre-Filters are:

Planes – Wavelength Lc – 0 to 10mm

Circles – Undulations per Revolution – 10 to 5000 UPR

So with all that how do I get Calypso to do all this filtering and outlier elimnation?

Filter can be done as a Global, feature, or analysis setting.

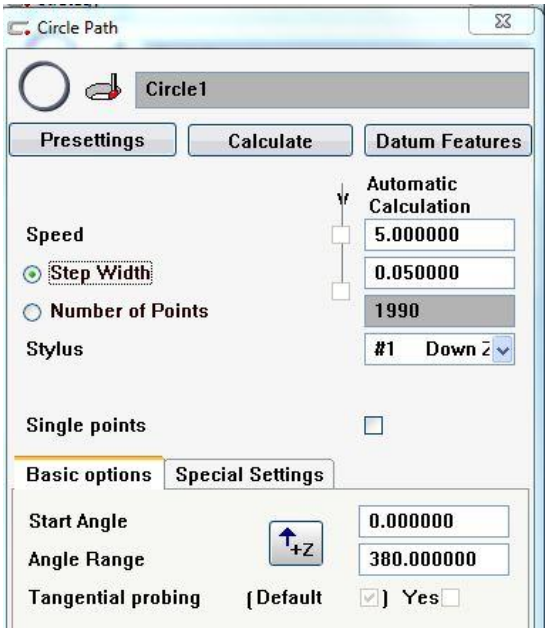
Global: Go to Resource/Save / Load Defaults/Filter Outlier tab. Turning these on here applies to the characteristic side. Because the Calypso Cookbook uses the Features to set our filter and outliers I do not recommend using this setting anymore.

Fetaure – Based: Going to the Feature and selecting the 

button to enter setting. All characteristics using this feature will carry over the filtering setting. This is now the prefered method because of the Calypso Cookbook.

Analysis – Based: Analysis Based is chacteristic based, the filtering is added to the charcateristic (right click on the feature button) and set for that particular charctaristic. This is were the most evaluation methods (LSQ, MIE, MCE) are selected for a particular characteristic.

Let's see how filter and outlier elimnation affects the data. To do this will will be measuring a circle with a diameter of 30.2mm. The scan will be created using the Cookbook settings from page 16 (Z100L-F). Counterclockwise scan at a 2mm immersion depth. Speed of 5mm/sec, Step Width of 0.05 (1270 is min point number we have 1990), at an angle range of 380°. For this test we will not be entering any filter or outlier elimination on the fetaure. All filtering will be done on the charcateristic side.

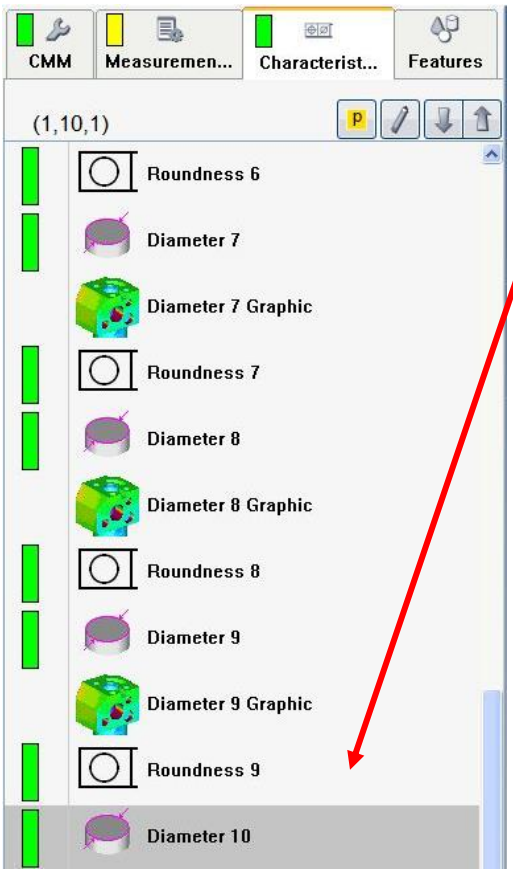


Here is how we are going to apply the Evaluation, Filter, and Outlier

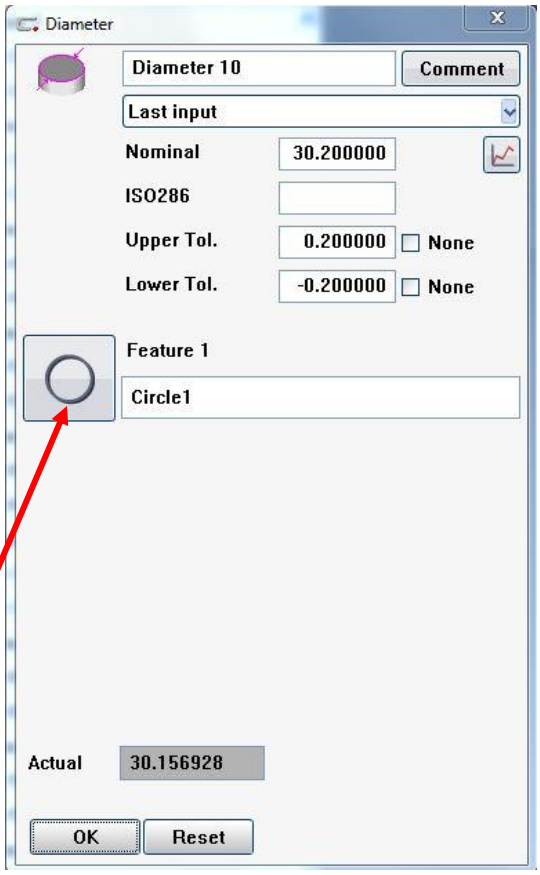
Roundness is being used to help see the "noise" in the data set.

Characteristic	Evaluation	Filter	Outlier
Diameter 1 and Roundness 1	LSQ	NO	NO
Diameter 2 and Roundness 2	LSQ	50 UPR Gauss	NO
Diameter 3 and Roundness 3	LSQ	150 UPR Gauss	NO
Diameter 4 and Roundness 4	LSQ	NO	± 3S, 5 Adjacent Points, 10-5000 UPR Pre-Filter
Diameter 5 and Roundness 5	LSQ	150 UPR Gauss	± 3S, 5 Adjacent Points, 10-5000 UPR Pre-Filter
Diameter 6 and Roundness 6	MIE	NO	NO
Diameter 7 and Roundness 7	MIE	50 UPR Gauss	NO
Diameter 8 and Roundness 8	MIE	150 UPR Gauss	NO
Diameter 9 and Roundness 9	MIE	NO	± 3S, 5 Adjacent Points, 10-5000 UPR Pre-Filter
Diameter 10 and Roundness 10	MIE	150 UPR Gauss	± 3S, 5 Adjacent Points, 10-5000 UPR Pre-Filter

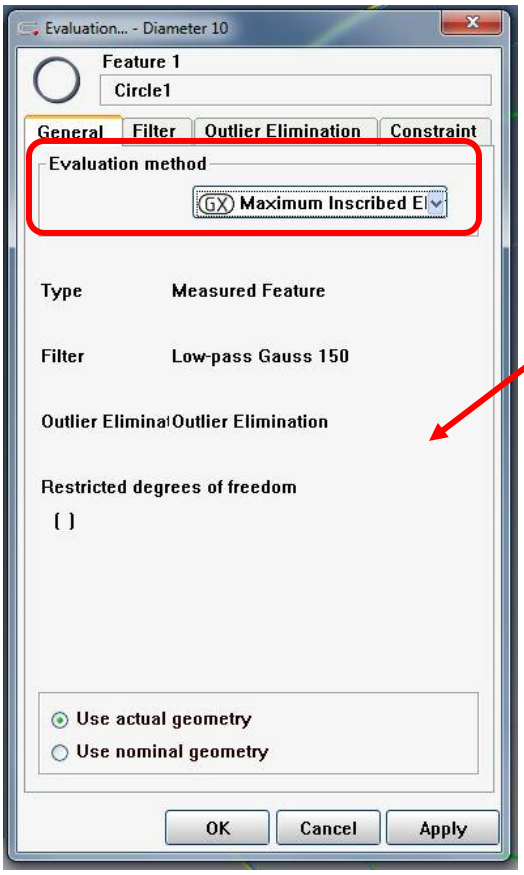
Lets look at how to set up the charcateristic for Diameter 10 to meet the requirement from the list above.



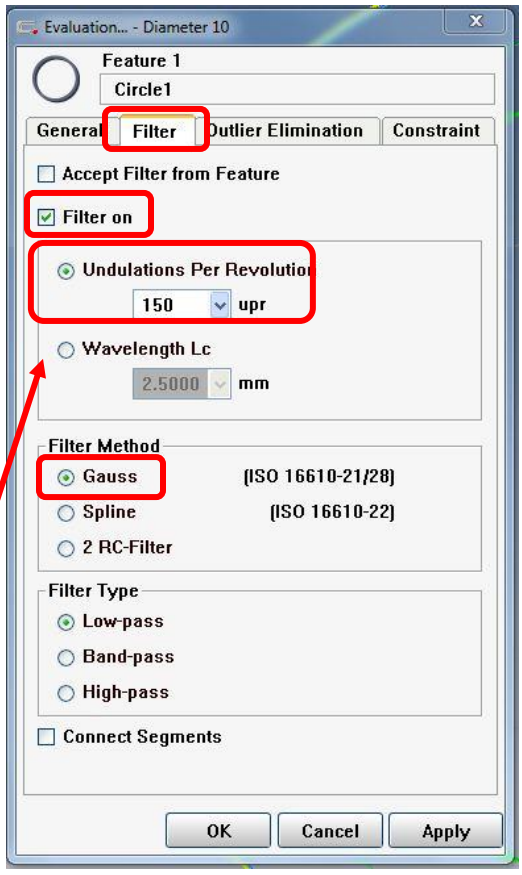
To start select the charcateristic you want to modify, in this case Diamater 10, double click to open or select the edit button.



Right or Left click on the feature button to open up the Evaluation window.



With the Evaluation window open change the Evaluation Method to Maximum Inscribed Element by selecting the drop down box.



Then Select the Filter tab. Check the Filter on box and set UPR to 150, Filter Method to Gauss.

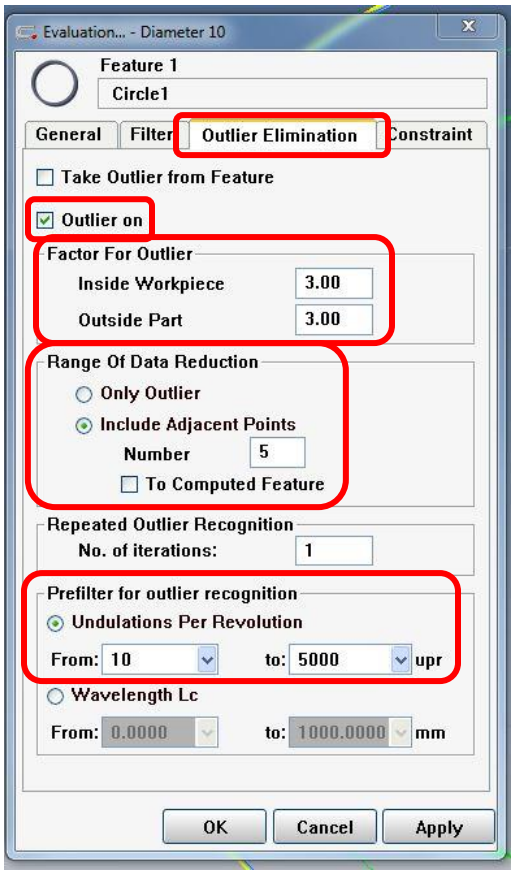
Next select the Oulier Elimination tab.

Check the Outlier on box.

Factor for Outlier by default is at ±3.

In Range of Data Reduction: Select Include Adjacent Points and type in 5 for the Number.

In Pre-Filter for Outlier Recognition: Select the Undulations Per Revolution, select the OK button for the warning that pops up. Then type in 10 in the From box (must type in, if you select the drop down, 10 is not available).



Open up PiWeb and talk about the data sets.