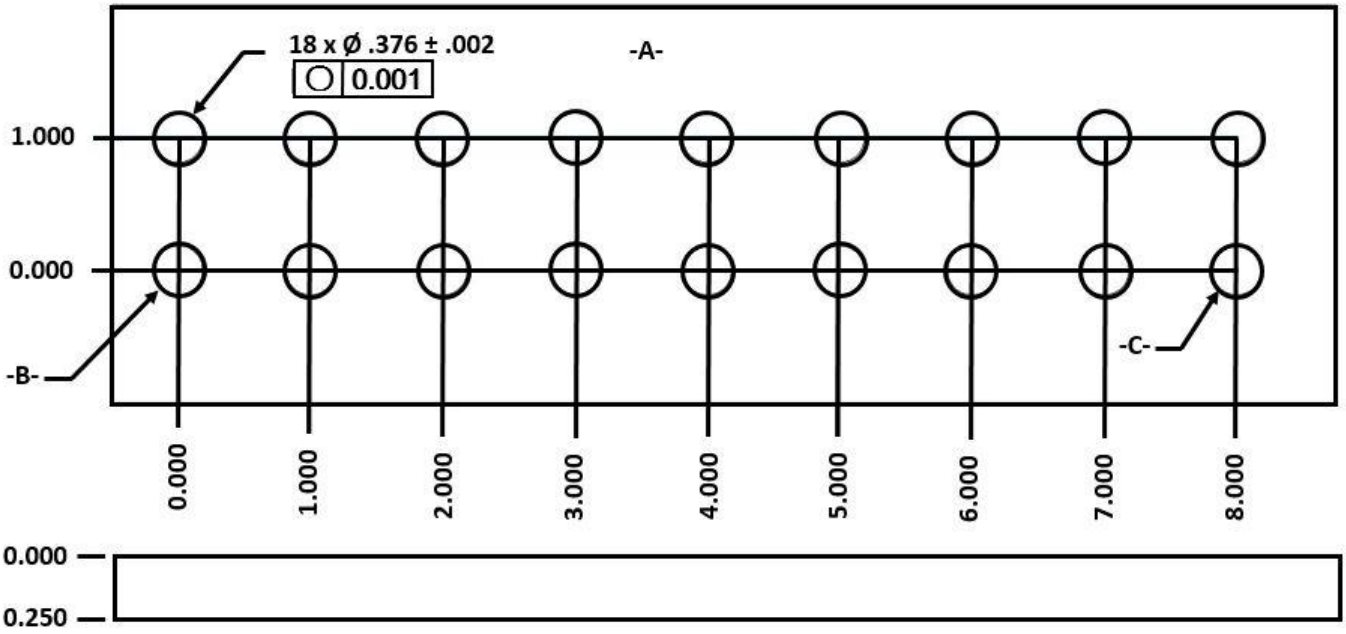
Task Oriented Measurement

For this presentation the Base Alignment and Clearance Planes are already created (page 49 thru 61 Calypso Basic – Level 1).

What does the drawing tell us, and how do we get Calypso to give us the correct answers?



For this print Diameters, Roundness and X and Y Locations are required

To start we need some Features and Characteristics

Next step is choosing the correct Evaluation Method and Measurement Strategy for our features and Characteristics.

To help choose the correct methods for evaluation and strategy we need to know if the results we want are for a <u>FUNCTIONAL TEST</u> or for <u>PROCESS CONTROL</u>.

What is Functional Testing?
What is Process Control?
Does it really matter?

<u>Functional Testing</u>: Giving results that simulate the function of the part, for example will a shaft fit into a bore. Most of the time this type of result is used to validate the assembly of mating parts.

<u>Process Control</u>: Giving results that are used to correct the machining process, for example are my diameters in the correct location. If not how much do I have to move them to get them correct?

DOES IT REALLY MATTER IF IT IS FOR FUNCTIONAL OR PROCESS CONTROL RESULTS????

YES ABSOLUTELY!!!!!

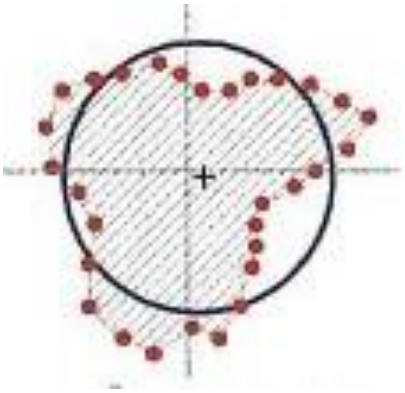
BUT WHY????

The why, has to do with how we evaluate the data for any given result.

For this discussion we are going to be dealing with Circles.

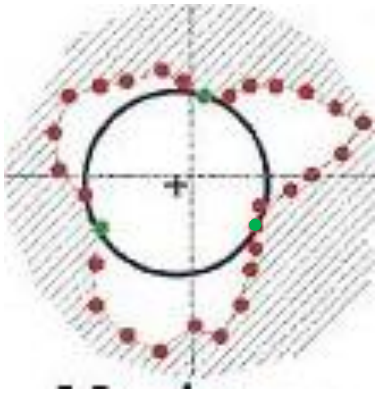
Circles have four common evaluations:

LSQ - Least Squares (Gaussian)
MIE - Maximum Inscribed Element
MCE - Minimum Circumscribed Element
MZ - Minimum Zone (Chebyshev)



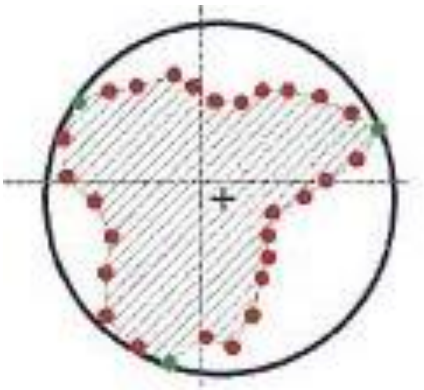
Least Squares

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.



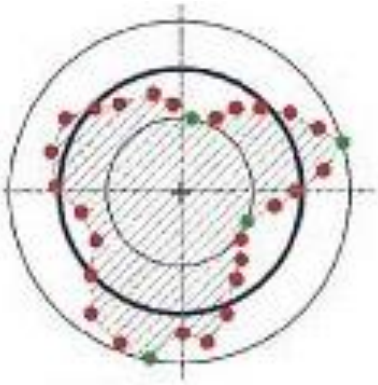
Maximum Inscribed Element

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.



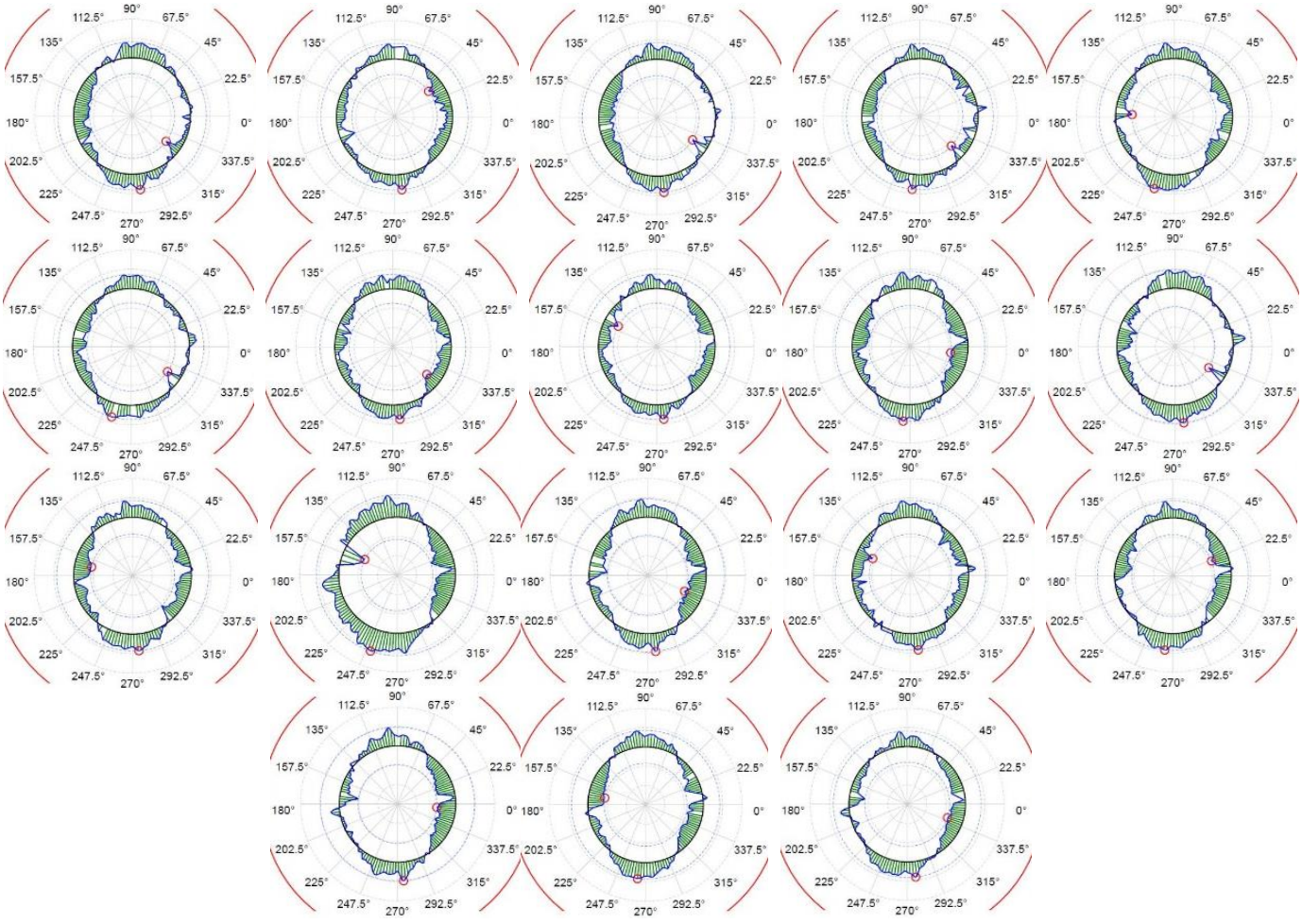
Minimum Zone

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.).

Now that we understand the evaluation methods we are going to be using, why is it important to decide between Functional and Process Control?

Trying to make process adjustments in X, Y, or Z axes to features like holes and

bosses (shafts) based on the Maximum Inscribed Element and Minimum Circumscribed Element may cause the chasing of one's tail. The reason is that form error is random. Here is the roundness values of the 18 holes in our part. These holes were created using the same cutter. Notice that all have similar looks to the data (the roundness is about the same) but locations of the high and low values as well as the shape are random.



One of the most common misconceptions about Maximum Inscribed and Minimum Circumscribed Element is that they only effect the size of the diameter. While it is true they change the result of the diameter. It is also true that they move the center of the circle to where the best fit Pin Gage or Smallest Ring Gage pass through or over the data.

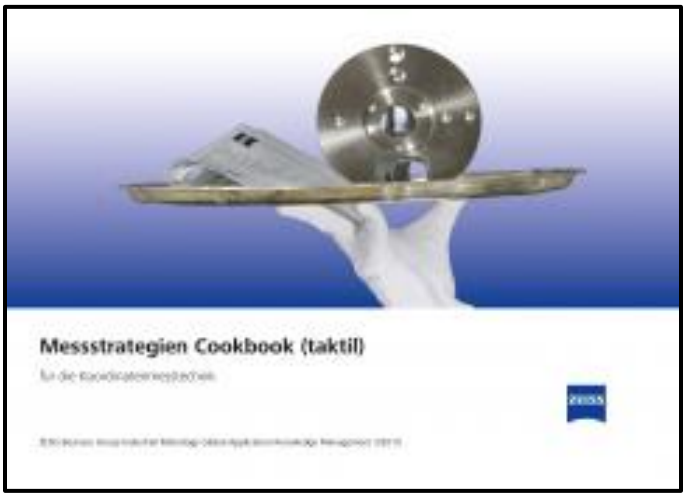
The reason we use Least Squares for Process Control is that the data is more stable and repeatable because it is using the average of all data points and is less influenced by the form of the feature (remember form is random). In the data below the characteristic is being evaluated with LSQ and MIE.

X Value .376 3	0.99998	1.00000	0.00200	-0.00200	-0.00002
X Value .376 MIE 3	0.99996	1.00000	0.00200	-0.00200	-0.00004
Y Value .376 3	-0.00002	0.00000	0.00200	-0.00200	-0.00002
Y Value .376 MIE 3	0.00003	0.00000	0.00200	-0.00200	0.00003
Diameter .376 3	0.37624	0.37600	0.00200	-0.00200	0.00024
Diameter .376 MIE 3	0.37604	0.37600	0.00200	-0.00200	0.00004
Roundness .376 3	0.00022	0.00000	0.00100	0.00000	0.00022

If we tried to make the adjustment to the Y value from the MIE data we would have moved the offset in the wrong direction. After the adjustment was made the next part might be better or way worse depending on the form error of the feature, because the form is random. The use of MIE in this situation will make for a very frustrated CNC operator!

By using the LSQ values for process changes, when the operator makes the adjustments the next part off the CNC will have moved in the correct direction making for a happy CNC operator.

Where does the Measurement Strategies and Evaluation Methods come from?



The Zeiss Measuring Strategies Cookbook

The print is asking for location, size, and roundness so I am going to start my search for correct measurement strategy and evaluation with the roundness value because it is the tightest tolerance for the features I need to measure.

So in the Cookbook table of contents I look up Roundness for bore which is on page 20.

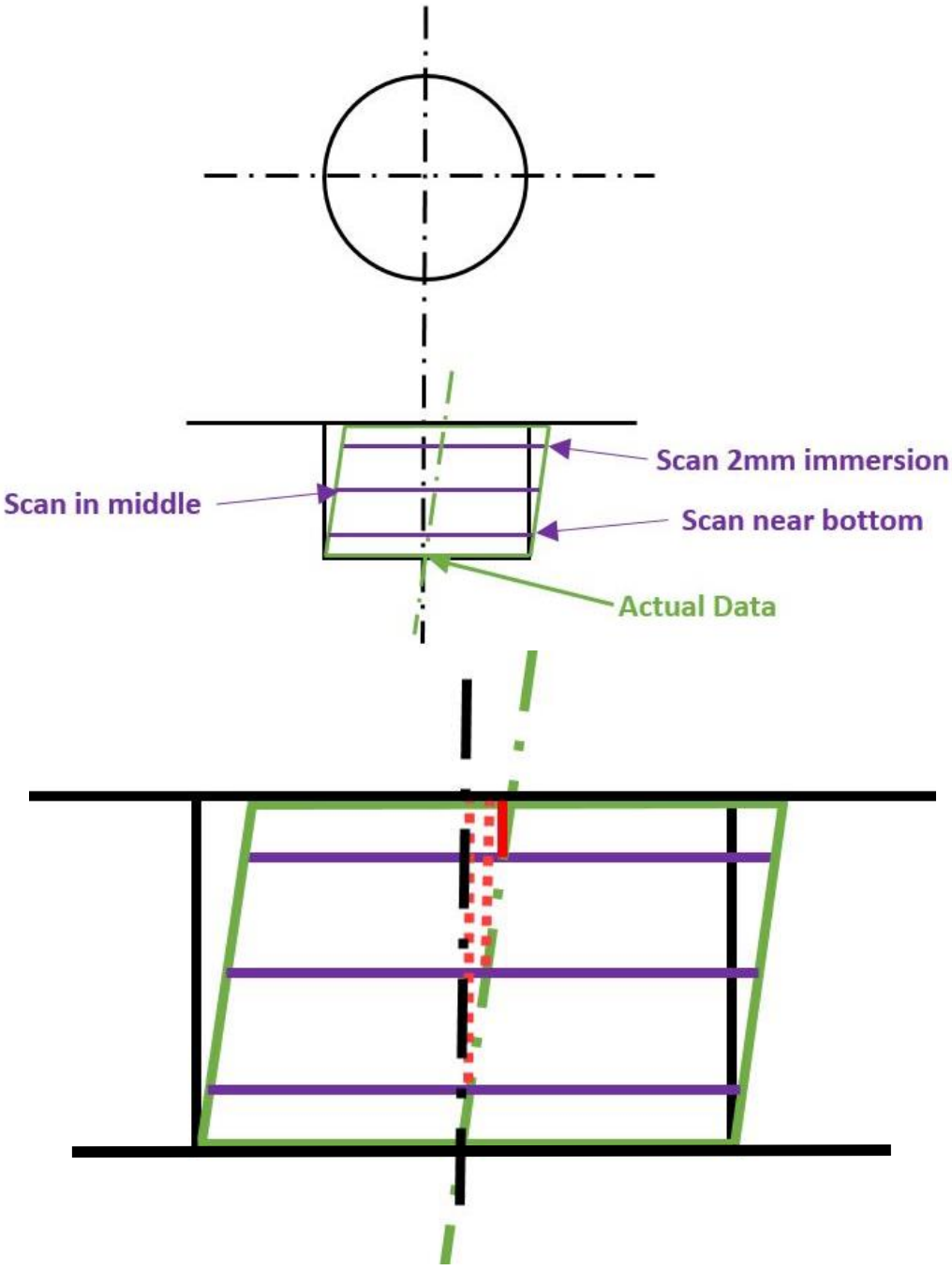
Page 20 suggest I use Z100G-F on page 16.

Page 16 under Z100G-F states that I should measure the feature as a circle because the diameter is bigger than the bore depth, at an immersion depth of 2mm. The scan should be counterclockwise, with speed of 10 mm/sec (active sensor) for 380° with a minimum of 425 points and recommends a Stylus of 3mm MAX. The standard setting for the Feature should be LSQ with an outlier of ± 3s, pre filter of 10-5000 UPR (undulations per revolution), 5 adjacent points and using a Gauss 50 UPR filter.

Page 20 tells me that my Roundness Characteristic should be evaluated as Minimum Zone

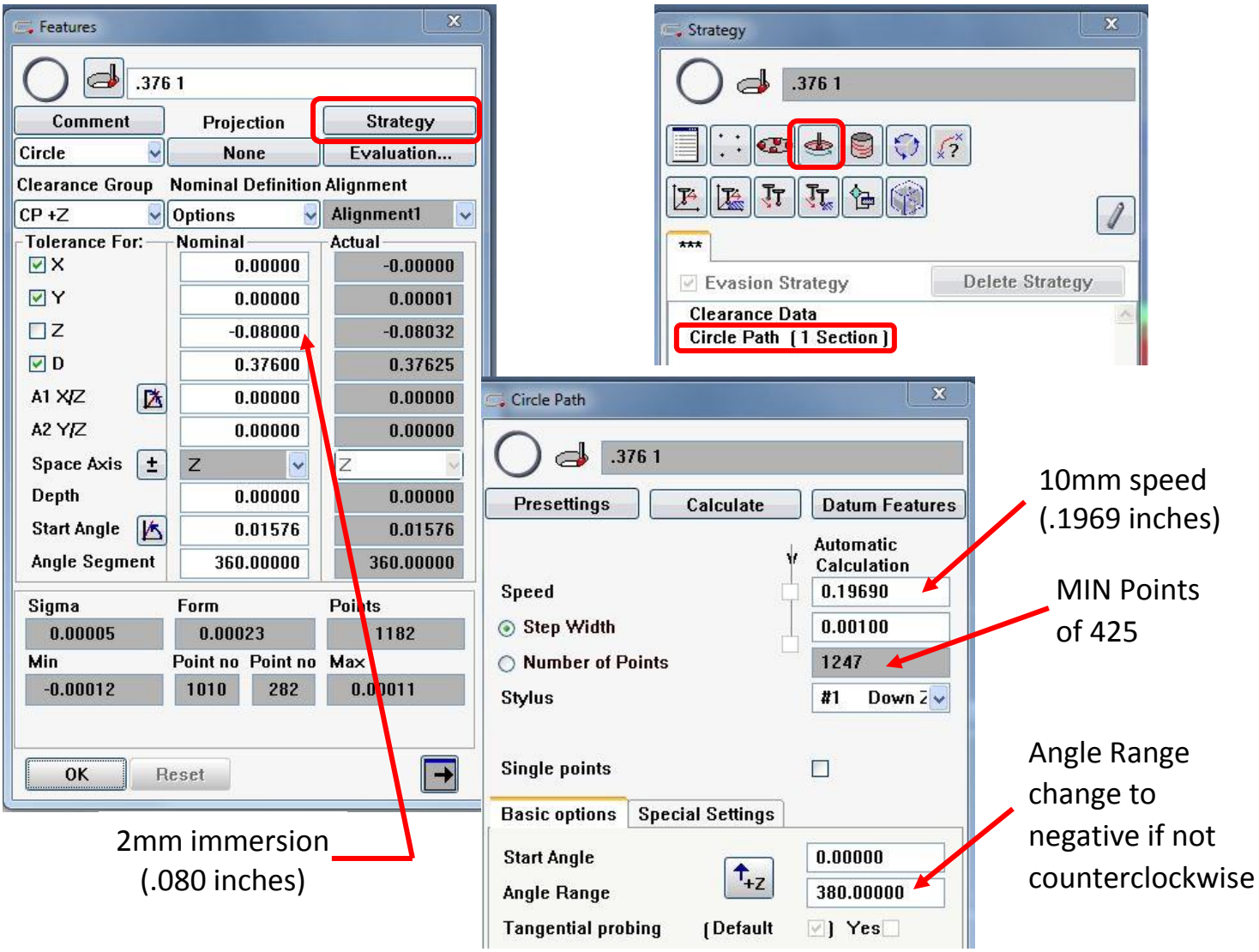
The one question that always comes up during class is why the 2mm immersion depth? Why don't we take the scan in the middle of the bore?

The 2 mm immersion depth gives us the correct value for location because it most closely represents the actual center of the bore. The Center of a Cylinder is an axis line and center of a circle is a point. So the deeper we take the scan into the bore the more potential error may occur (Circles are projected normal to the surface). In the example to the right notice the actual data is not quite perpendicular so the values of the centers change depending on where the scan is taken. The 2mm immersion scan is the closest to the actual intersection of the cylinders center line.

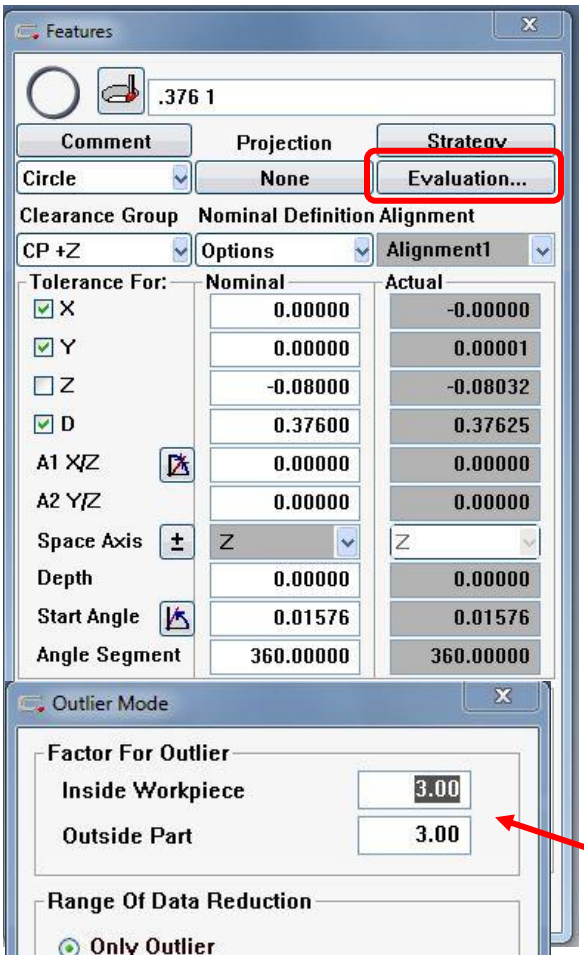


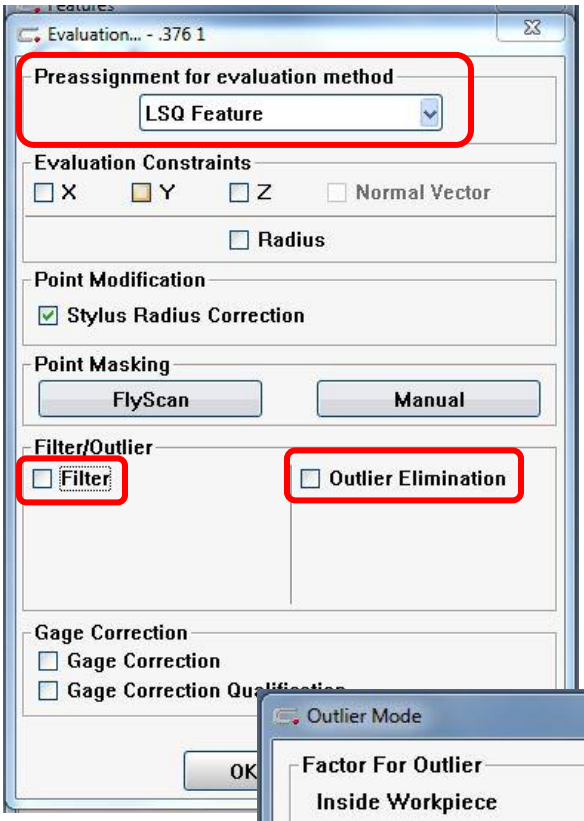
That seems like a lot of work and how do I get that into my feature.

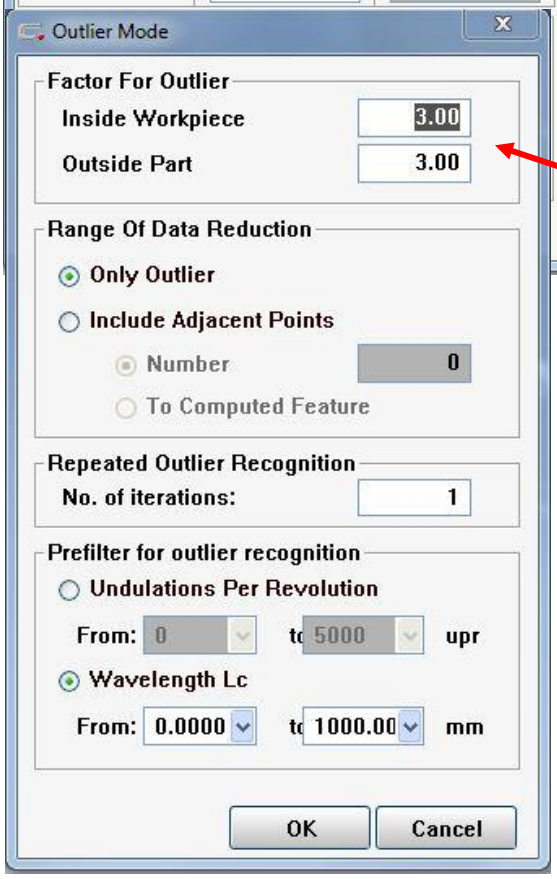
Open the Circle Feature and select Strategy, insert a circle path or double click to modify the existing circle path set speed, make sure min points are acquired, set angle range and counterclockwise scanning. Select ok until you are back to the main window.



After setting the strategy we are going to select Evaluation. Leave the Pre assignment for evaluation method at LSQ. Select the boxes for Filter and Outlier Elimination. Starting with the Outlier Elimination select the  **.**



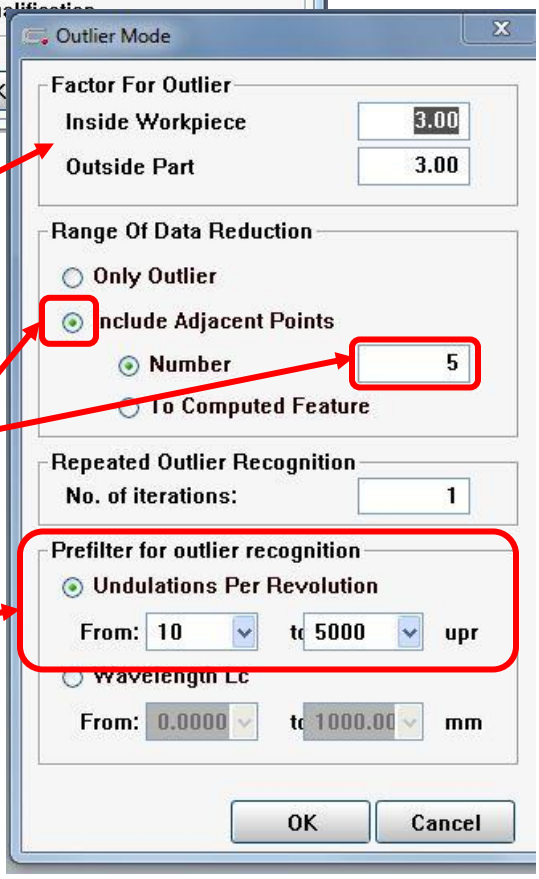




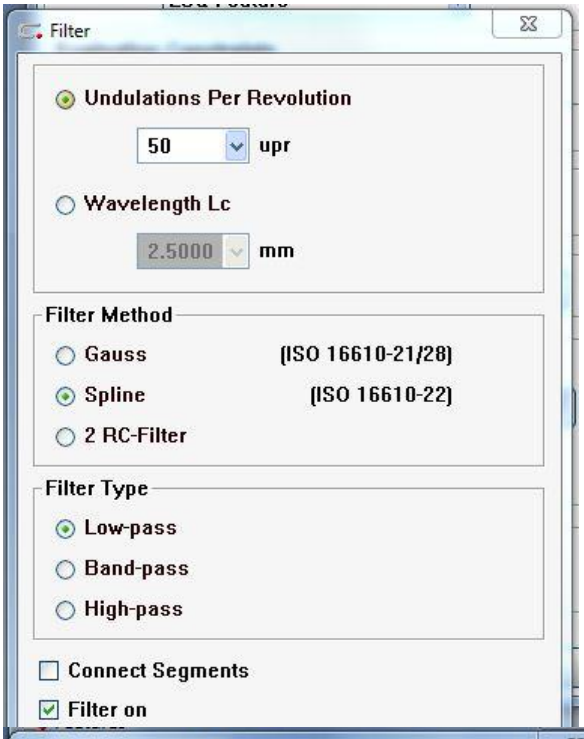
± 3s (default)

5 adjacent points

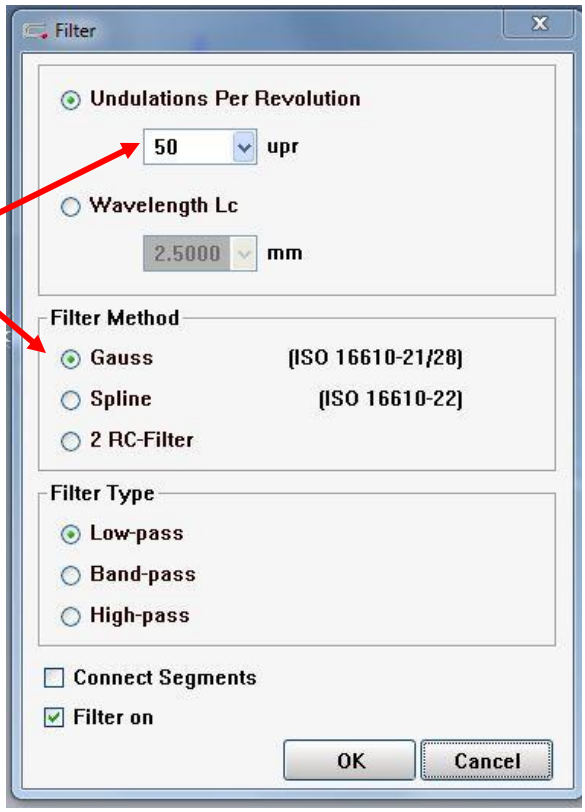
Pre Filter
10 to 5000 UPR

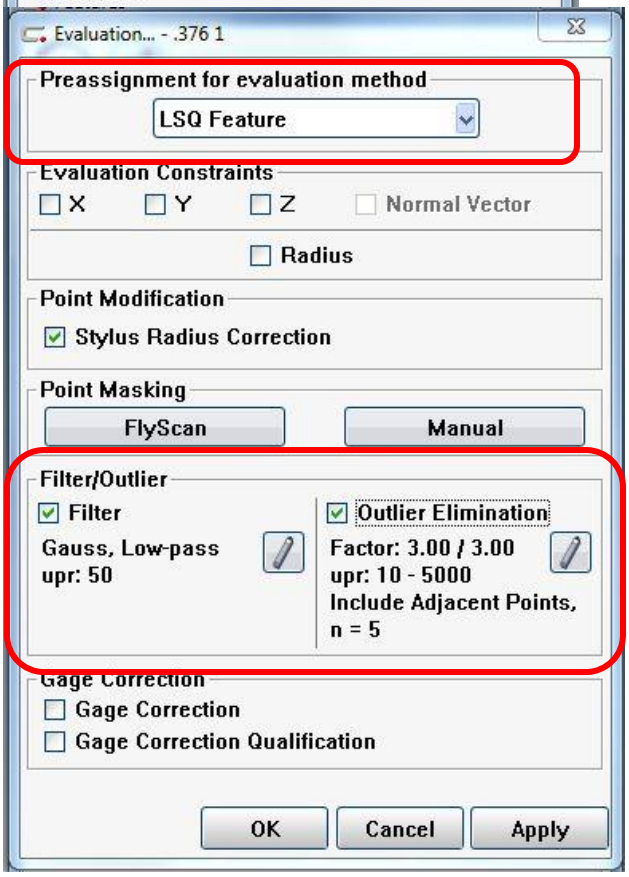


Next select the  **in the Filter section.**



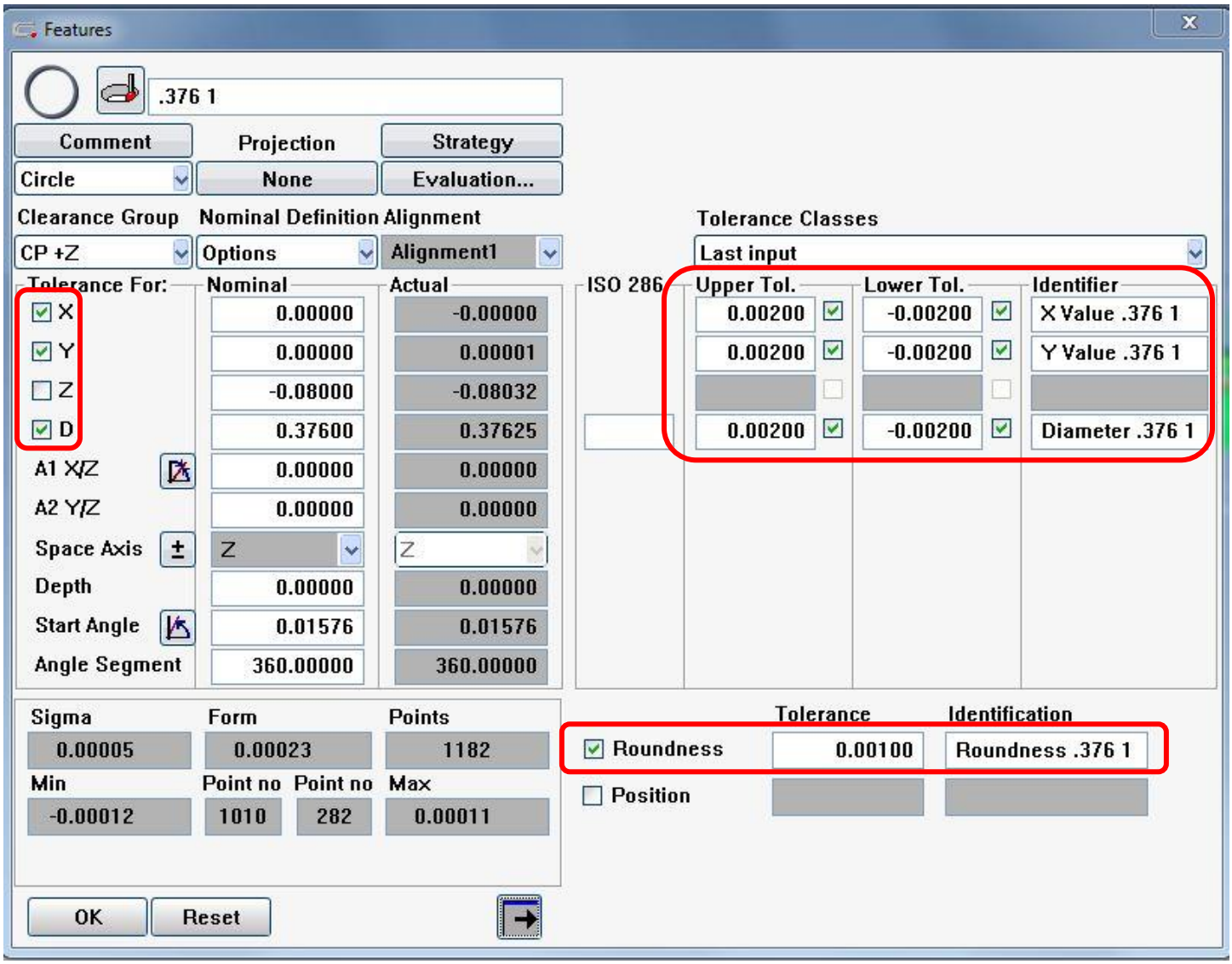
Gauss Filter at 50 UPR



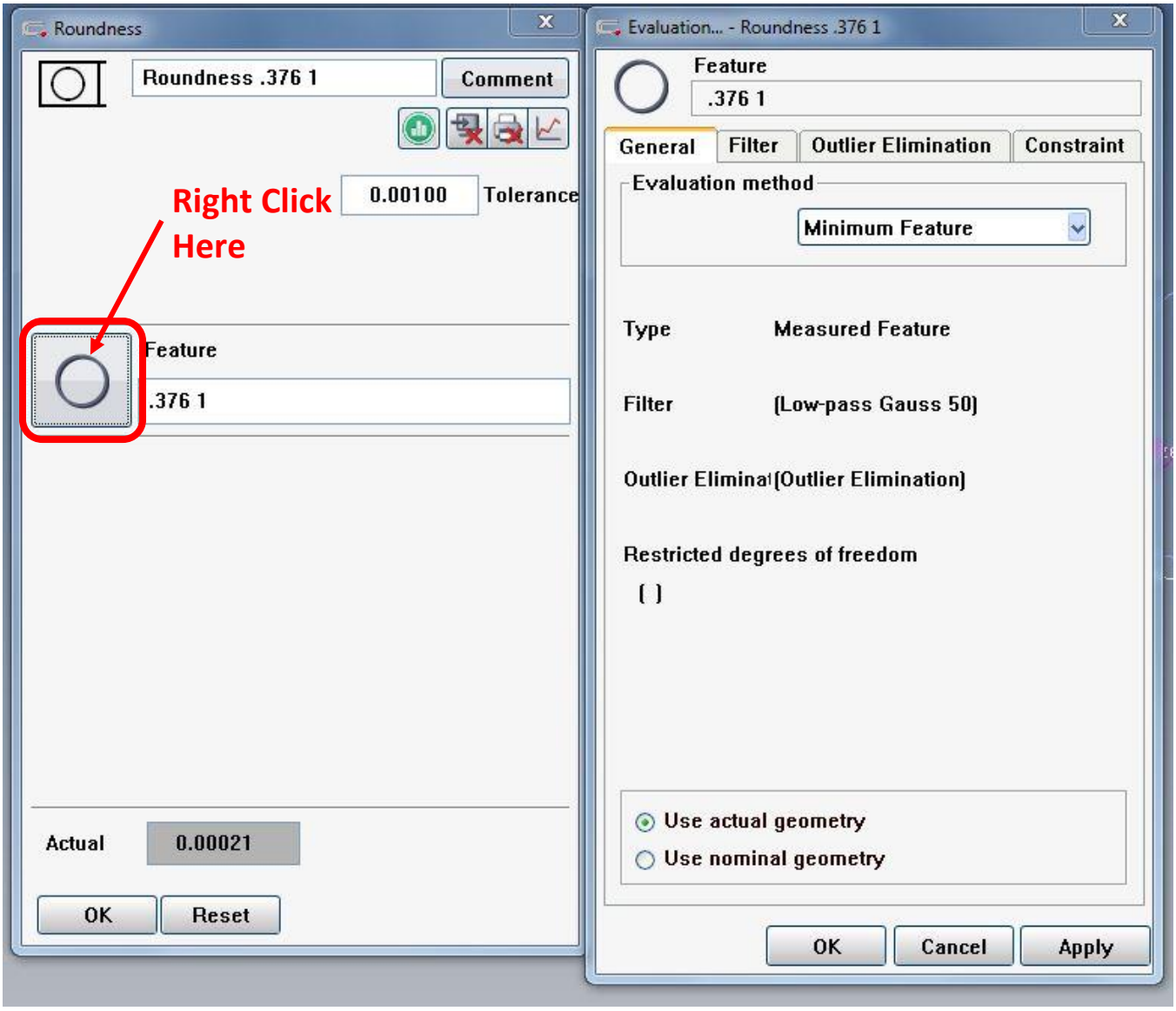


Finished Evaluation tab should look like this and match the cookbook.

Report X, Y, Diameter, and Roundness by checking the correct boxes and adding the print tolerances to the circle Features.



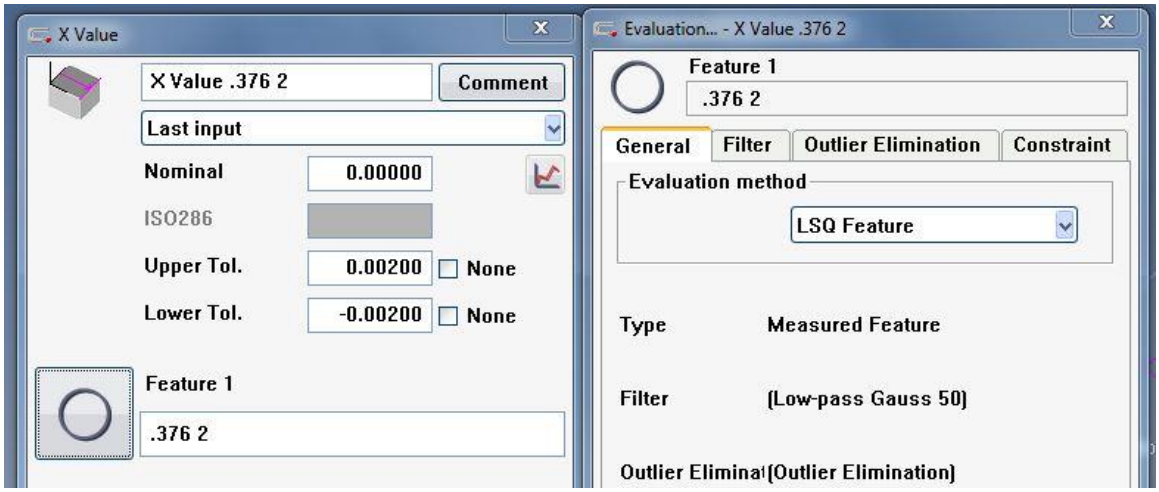
The Cookbook suggested a Minimum Zone for the Roundness. Let's double check that the Roundness Characteristic is being evaluated using Minimum Zone. After opening the Roundness Characteristic, Right Click on the Feature button this opens the Evaluation section of the characteristic. You can see that Calypso's default for Roundness is Minimum Feature, which is the same as Minimum Zone.

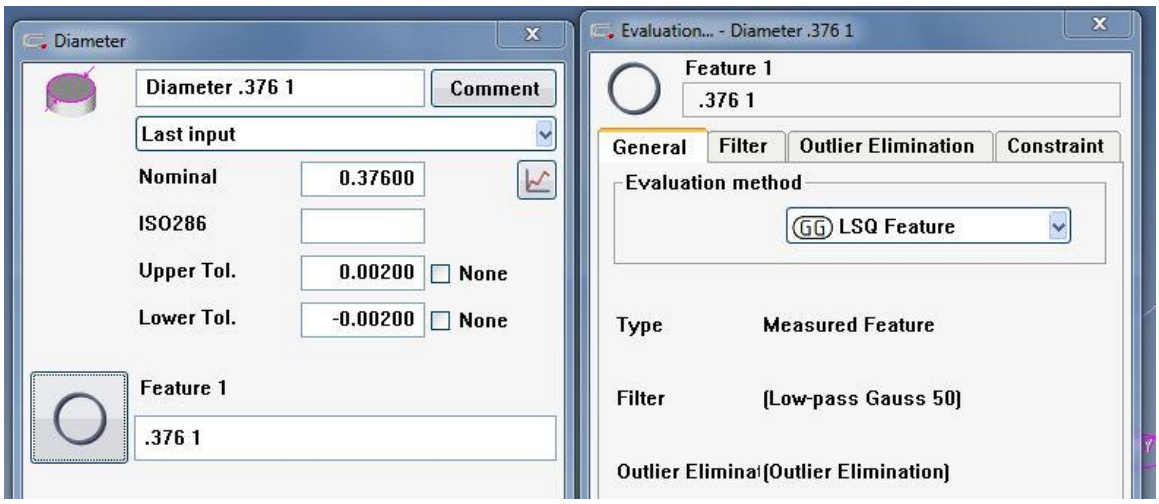


Now we need to deal with the Location and Diameter Characteristics. For this project we are go to assume that the data needs to be reported for both process control and functional testing.

PROCESS CONTROL

Starting with page 24 of the cookbook for process control, the circles need to be evaluated as LSQ for location (coordinates) and on page 17 of the cookbook for process control, the circles need to be evaluated LSQ for the diameter as well. If we open the X characteristic and right click on the feature, you will see that the evaluation method is LSQ and the same goes for the Y (not shown) and diameter characteristics. The LSQ came across from the Feature side. The reason we leave the feature side to LSQ is that it gives us the most stable feature possible, not as affected by outliers or form error. Change the evaluation method on the characteristic side to meet the requirement (functional or process control).





FUNCTIONAL TESTING

Starting with page 24 of the cookbook for functional checks, the circles need to be evaluated as MIE for location (coordinates) and on page 17 of the cookbook for functional checks, the circles need to be evaluated MIE for the diameter as well. To change the evaluation method, open the characteristic and right click on the feature like before. This time go to the drop down menu and select Maximum Inscribed Element. Repeat this for the Y and diameter characteristics.