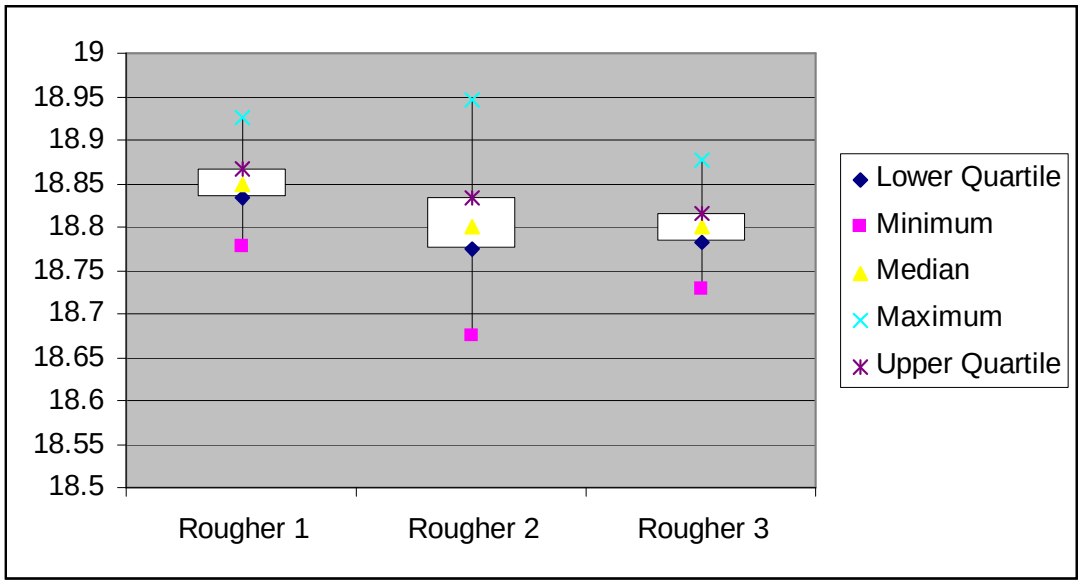
Managing Six Sigma: Understanding the Importance of Self Study

By Dean Christolear

Chapter Three - Analyze

The Specification for the shaft is 18.85 +/- 0.10 mm. Rougher 1 appears to be making good parts. Rougher 2 appears to have a large amount of variation and is making a lot of undersized parts. Rougher 3 is also making some undersize parts but does not appear to have the large amount of variation exhibited by Rougher 2.



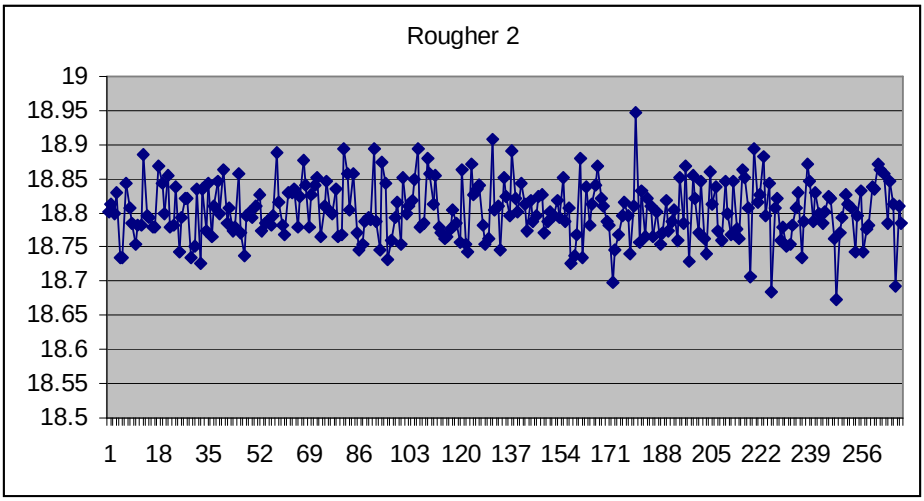
You share the information with the production supervisor, and he is suspicious of the gage on Roughers 2 and 3. He calls for the gages to be re-mastered. The gage man informs the supervisor that the gages were not mastered correctly and were under by about 0.05 to 0.06 mm. The gages are now back in service and Rougher 2 and 3 are retargeted.

Rougher 2 presents a different problem. The targeting issue has been corrected but the variation is so great that there will always be parts out of specification on the high and low ends of the tolerance.

Return to the file `Rougher check sheets.xls` and go to Sheet 1 where you previously generated the box plot. Highlight the entire column for Rougher 2 (including the header) beginning in Cell B25. NOTE: Do not paint any data in the first 24 rows where the Box plot calculations and charting were performed. This will cause errors in your charting.

Insert a Run chart as you did before. You can find an excellent reference on Run charts at http://quality.disa.mil/pdf/runchart.pdf. You are expected to have a thorough understanding of this tool.

Once completed, your Run chart should look like this.



There do not appear to be any cycles, trends or shifts that might point to issues with the machine or with differences between shifts. In order to perform a more thorough analysis, you decide to do a Capability Study. A Capability Study is a formal analysis that will fully demonstrate the ability (or lack of ability) of Rougher 2 to manufacture parts within specification.

You can find an excellent reference on Process Capability at http://www.itl.nist.gov/div898/handbook/ppc/section4/ppc46.htm. You are expected to have a thorough understanding of this tool.

In order to begin the analysis you will need to calculate the following values:

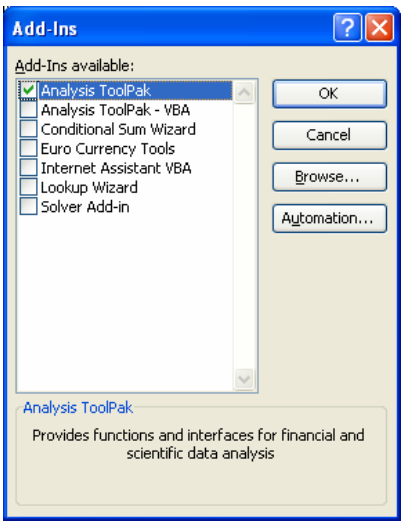
The average of the data set, also called the "mean";

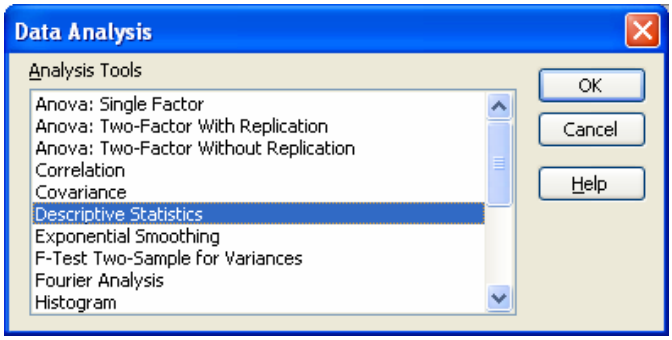
The standard deviation of the data set, and

The tolerance range of the part, sometimes called "engineering tolerance."

The tolerance range is easily calculated by subtracting the minimum allowable shaft size from the maximum allowable shaft size. The average and standard deviation can be calculated using the functions AVERAGE and STDEV; however, we will use the Data Analysis ToolPak in Excel®.

From the Tools menu select Add-Ins, and check the box for Analysis ToolPak and Analysis ToolPak -VBA. Click OK.

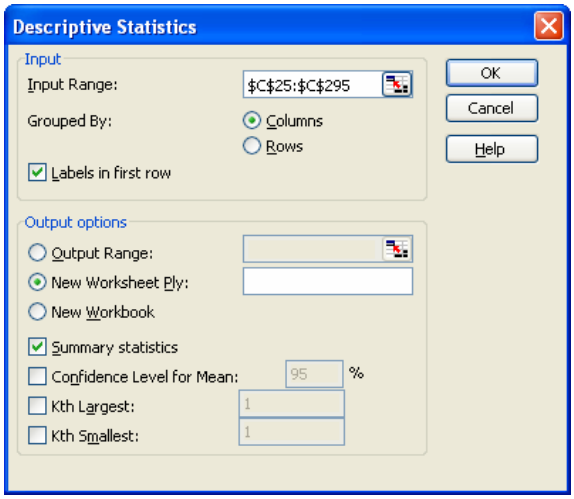




Again, from the Tools menu select the new menu item Data Analysis, at the bottom of the menu. Select Descriptive Statistics and click OK. In the Input section, paint the range of data for Rougher 2, including the heading, beginning in Cell B25.

NOTE: Do not paint any data in the first 24 rows where the box plot calculations and charting were performed. This will cause errors in your charting.

Make sure Columns is selected. Check the Labels in First Row box. In the Output Options section, make sure New Worksheet Ply is selected and check Summary Statistics. The dialogue box should appear as shown. Click OK.



A new worksheet ply will be added to your spreadsheet--most likely labeled Sheet 2--with a number of descriptive statistics. You may need to widen Column A. Select it by clicking on the "A" column heading. Select Format, Column, Width. A value of 20 should allow you to view the entries in Column A completely.

	A	B
	Rougher 2	
2		
3	Mean	18.80273
4	Standard Error	0.002609
5	Median	18.799
6	Mode	18.831
7	Standard Deviation	0.042878
8	Sample Variance	0.001839
9	Kurtosis	0.176644
10	Skewness	0.089197
11	Range	0.272
12	Minimum	18.674
13	Maximum	18.946
14	Sum	5076.737
15	Count	270
16		

The resultant values for average and standard deviation are seen to be included among the descriptive statistics. In the open cells below the descriptive statistics, enter the following labels in column A:

USL

LSL

Tolerance Range

Cp

Cpk Upper

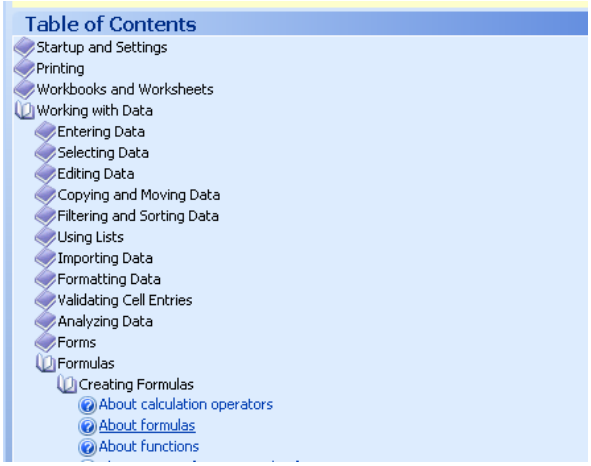
Cpk Lower

Cpk

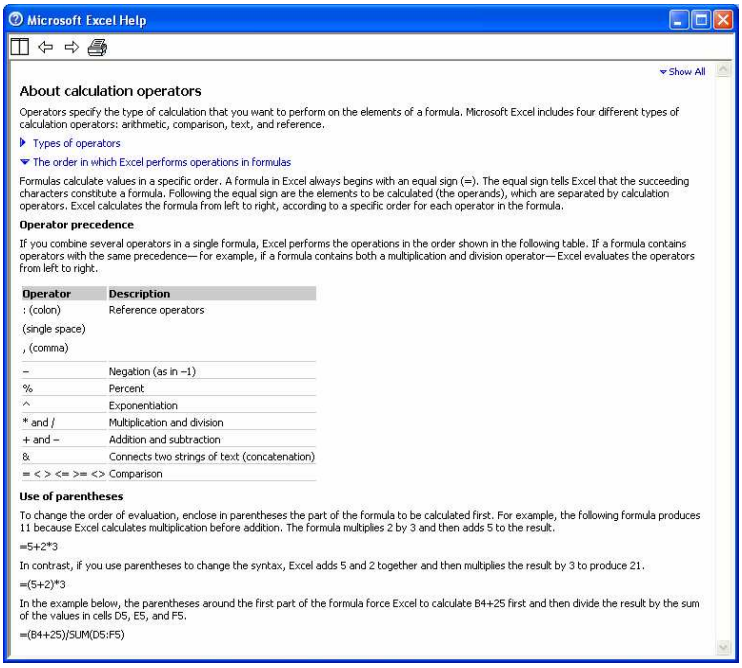
You will be calculating many of these values in Excel® by using formulas. In an Excel® formula, the following operations are performed using the keys shown:

Addition	Plus Sign	+
Subtraction	Minus Sign, Hyphen	-
Multiplication	Asterisk	*
Division	Forward Slash	/
Start the formula	Equal Sign	=

If you are not already familiar with Excel® formulas, you should review them by opening Help, Microsoft Excel Help, and clicking on Table of Contents. Navigate to Working with Data, Formulas, About Formulas.



You should also review About Calculation Operators, which explains the order in which Excel® performs operations in formulas.



Microsoft Excel Help

Show All

About calculation operators

Operators specify the type of calculation that you want to perform on the elements of a formula. Microsoft Excel includes four different types of calculation operators: arithmetic, comparison, text, and reference.

Types of operators

The order in which Excel performs operations in formulas

Formulas calculate values in a specific order. A formula in Excel always begins with an equal sign (=). The equal sign tells Excel that the succeeding characters constitute a formula. Following the equal sign are the elements to be calculated (the operands), which are separated by calculation operators. Excel calculates the formula from left to right, according to a specific order for each operator in the formula.

Operator precedence

If you combine several operators in a single formula, Excel performs the operations in the order shown in the following table. If a formula contains operators with the same precedence— for example, if a formula contains both a multiplication and division operator— Excel evaluates the operators from left to right.

Operator	Description
: (colon)	Reference operators
(single space)	
, (comma)	
–	Negation (as in –1)
%	Percent
^	Exponentiation
* and /	Multiplication and division
+ and –	Addition and subtraction
&	Connects two strings of text (concatenation)
= < > <= >= <>	Comparison

Use of parentheses

To change the order of evaluation, enclose in parentheses the part of the formula to be calculated first. For example, the following formula produces 11 because Excel calculates multiplication before addition. The formula multiplies 2 by 3 and then adds 5 to the result.

=5+2*3

In contrast, if you use parentheses to change the syntax, Excel adds 5 and 2 together and then multiplies the result by 3 to produce 21.

=(5+2)*3

In the example below, the parentheses around the first part of the formula force Excel to calculate B4+25 first and then divide the result by the sum of the values in cells D5, E5, and F5.

=(B4+25)/SUM(D5:F5)

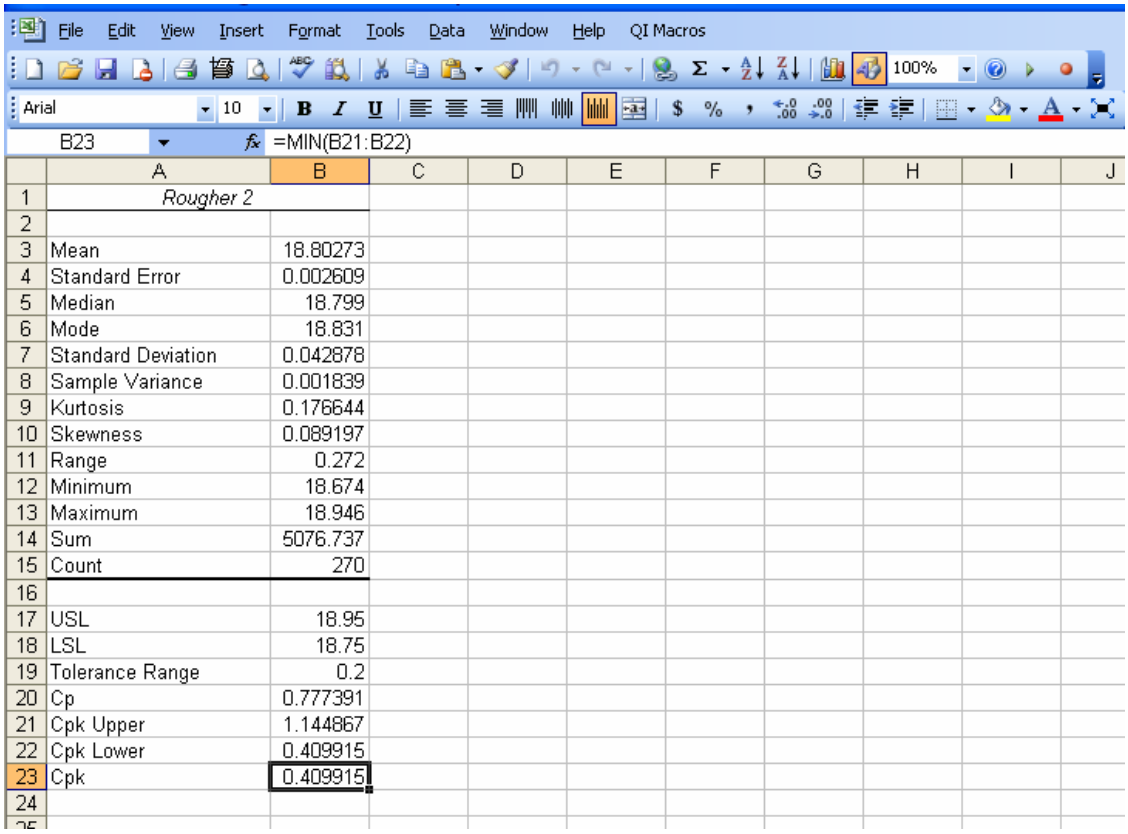
A thorough understanding of Excel® formulas is required for the remaining portions of this study program.

In Column B enter the values for the Upper Specification Limit ("USL") and the Lower Specification Limit ("LSL"). The tolerance range will need to be calculated. In the cell next to the label "Tolerance Range", enter the formula =B17-B18, where B17 and B18 correspond to the cells containing the USL and LSL values, respectively.

From your reading, you know that Cp is calculated as the tolerance range divided by six standard deviations. Enter the formula =B19/(6*B7). Notice that parentheses are used to maintain the proper precedence of calculation. The formula =B19/6*B7 will yield an incorrect result. Continue entering the formulas for Cpk Upper and Cpk Lower.

Cpk is the lesser of Cpk Upper and Cpk Lower and is easily found using the Excel® function MIN. Go to Insert, Function, All, MIN and select the range of cells containing Cpk Upper and Cpk Lower.

Your spreadsheet should now look like this:



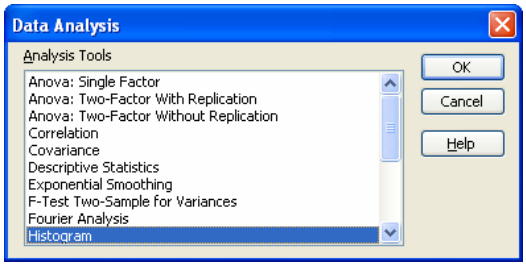
B23 =MIN(B21:B22)

	A	B
1	*Rougher 2*	
2		
3	Mean	18.80273
4	Standard Error	0.002609
5	Median	18.799
6	Mode	18.831
7	Standard Deviation	0.042878
8	Sample Variance	0.001839
9	Kurtosis	0.176644
10	Skewness	0.089197
11	Range	0.272
12	Minimum	18.674
13	Maximum	18.946
14	Sum	5076.737
15	Count	270
16		
17	USL	18.95
18	LSL	18.75
19	Tolerance Range	0.2
20	Cp	0.777391
21	Cpk Upper	1.144867
22	Cpk Lower	0.409915
23	Cpk	0.409915
24		

The generally-accepted value for an acceptable process is Cpk $\geq$ 1.67. Clearly, Rougher 2 does not meet this requirement. Anticipating questions from your management, you decide to include a histogram with your analysis.

A histogram is a bar chart that groups the data into categories, or "bins", and displays the number of data points in the data set that fall within a particular bin. You can find an excellent reference on Histograms at http://quality.disa.mil/pdf/histgram.pdf. You are expected to have a thorough understanding of this tool.

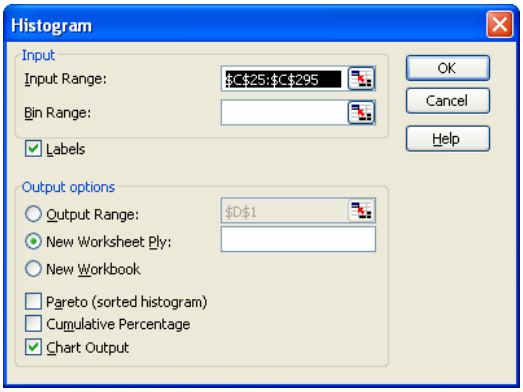
The easiest way to display a histogram in Excel® is by using the Data Analysis ToolPak. Click on Sheet 1 where your data for Rougher 2 is located. Select Tools and Data Analysis, then select Histogram. Click OK.



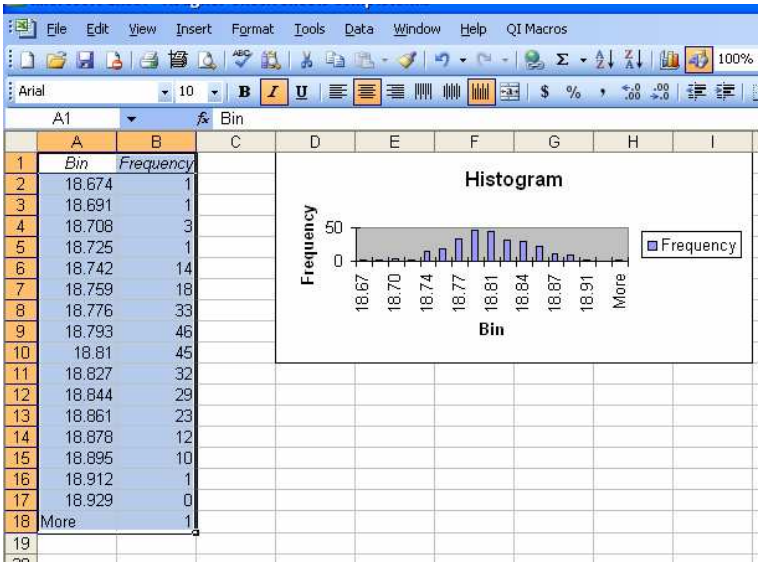
In the Input section of the dialogue box paint the range of data for Rougher 2 including the header beginning in Cell B25.

NOTE: Do not paint any data in the first 24 rows where the box plot calculations and charting were performed. This will cause errors in your charting.

Leave Bin Range blank and check the Labels box. In the Output Options section make sure New Worksheet Ply is selected and check the Chart Output box. Click OK.

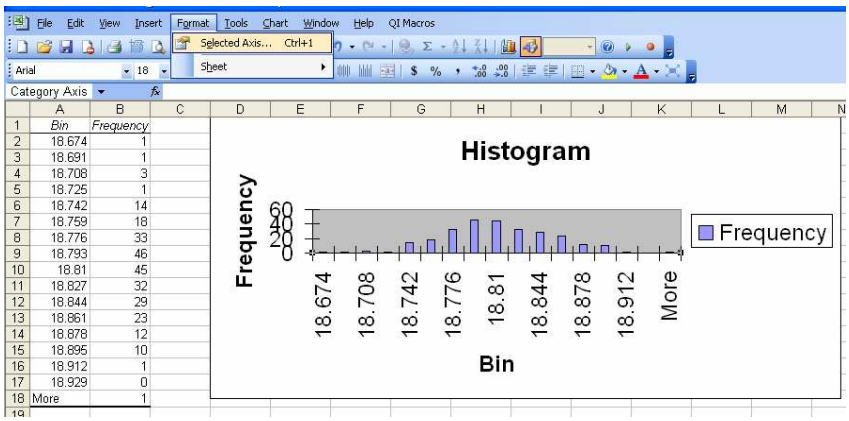


Your spreadsheet should look as shown.

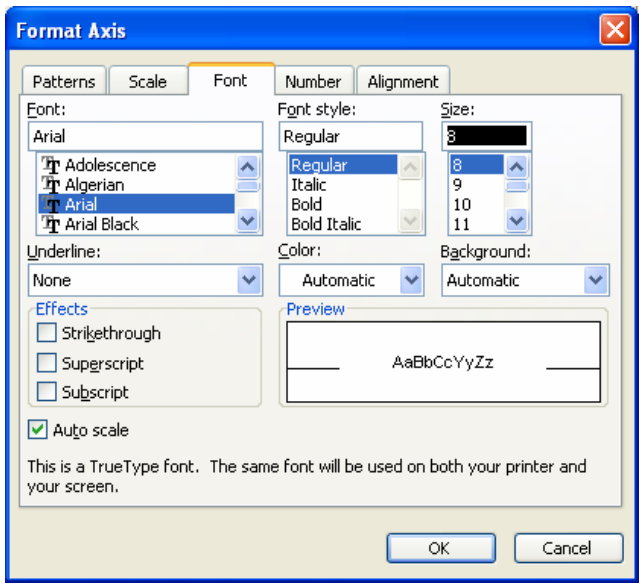


Bin	Frequency
18.674	1
18.691	1
18.708	3
18.725	1
18.742	14
18.759	18
18.776	33
18.793	46
18.81	45
18.827	32
18.844	29
18.861	23
18.878	12
18.895	10
18.912	1
18.929	0
More	1

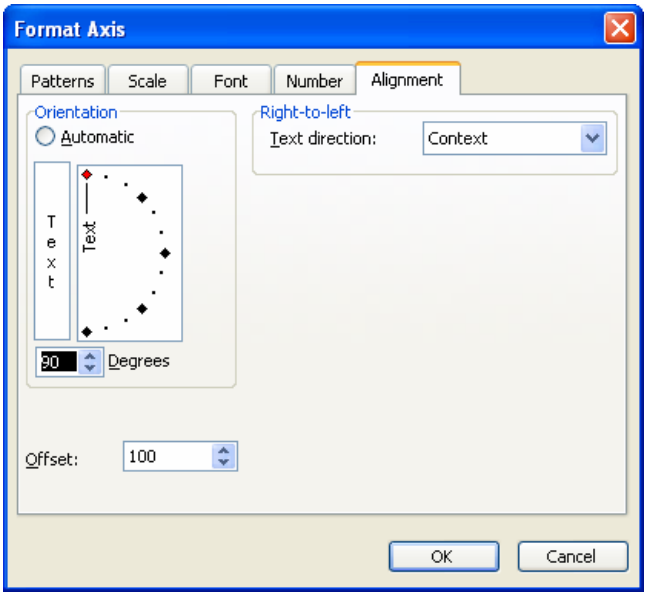
The chart is small and difficult to read. Click on the chart to activate it and drag the bottom-right corner outward to make the chart larger. Drag the corner to the general area of Cell N18. Click once on any of the bin labels to activate the X-axis. Select Format, Selected Axis.



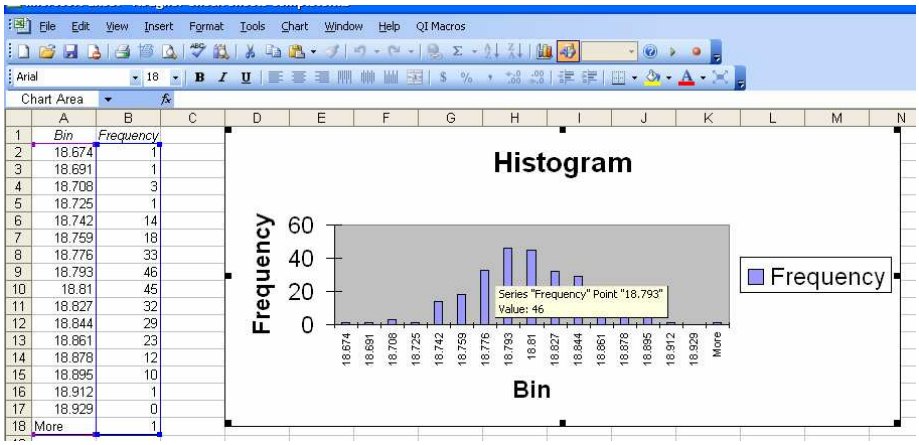
Select the Font tab and change the font size to 8.



Select the Alignment tab and change the alignment to 90 degrees. Click OK.



Your histogram should now look as shown. If you move the mouse arrow over any bar on the chart, a text box will appear showing the bin label and size of the bar.



For example, moving the arrow over the largest bar shows that 46 data points fall within the bin range of 18.793 – 18.81.

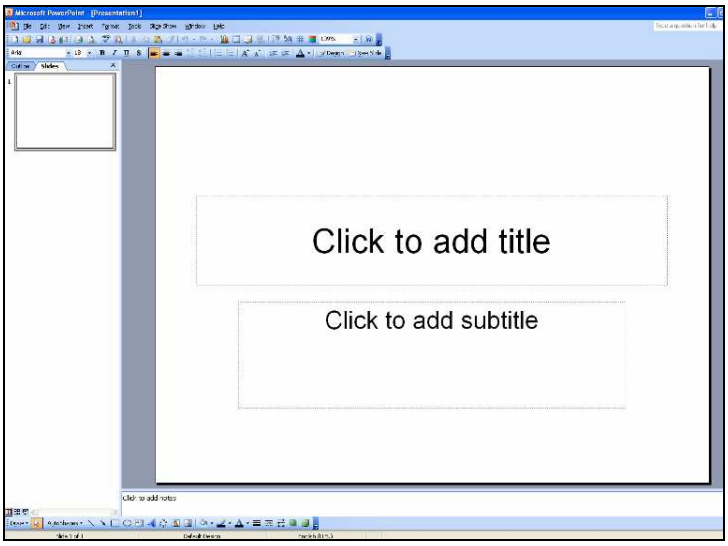
Histograms are useful in determining if the data is normally distributed. The normal distribution is easily identifiable by the bell shape of the histogram. You will learn more about how to identify a normal distribution but for this application, a histogram does an adequate job of assuring us that the data is normally distributed. Many Quality tools require that the data be normally distributed in order to be correctly applied.

Save the file to your computer. Ensure that the file is kept in a safe place—backup copies are encouraged.

You have now completed your initial analysis of the available historical data for Part No. 922. You contacted your supervisor to schedule a meeting to review the findings, and you were able to show him that the high levels of scrap in the department are most likely attributable to Rougher 2. He is very pleased with your analysis and quite happy that you shared the results with the area supervisor who re-targeted Rougher 2 and Rougher 3. Knowing that you have already impacted the scrap in the department, he is anxious to support you in taking your investigation further.

He has asked you to put together a slide for the next Operations meeting where he can share your findings with the plant. He doesn't want a lot of information, just one page that shows the capability.

Open Microsoft PowerPoint® and select File, New and Blank Document. Your screen should look as shown.

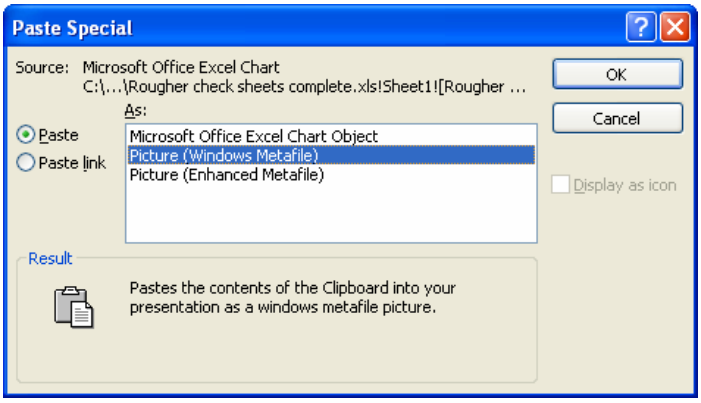


In the first text box, type “Capability Study.” In the second text box, type “Rougher 2” and “Part Number 922.” Reduce the font sizes to around 28 and 18 for the first and second boxes, respectively.

Open the Excel® file `Rougher check sheets.xls` and return to Sheet 1 where the Run chart is located. Click once on the chart to activate it then select Edit, Copy.

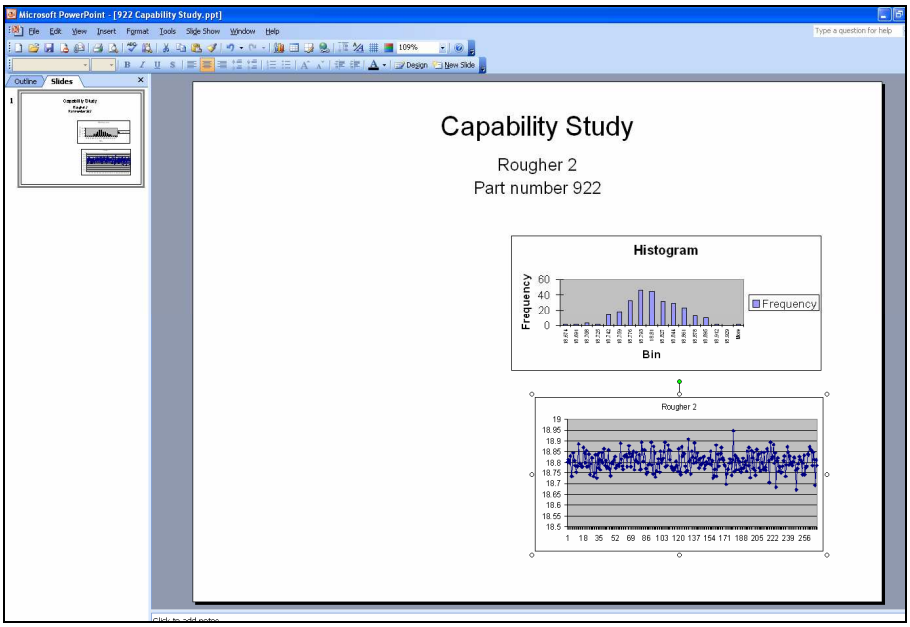
Return to PowerPoint® by clicking the mouse on the PowerPoint® icon at the bottom of your screen.

In PowerPoint® select Edit, Paste Special and then select Picture (Windows Metafile). Click OK.



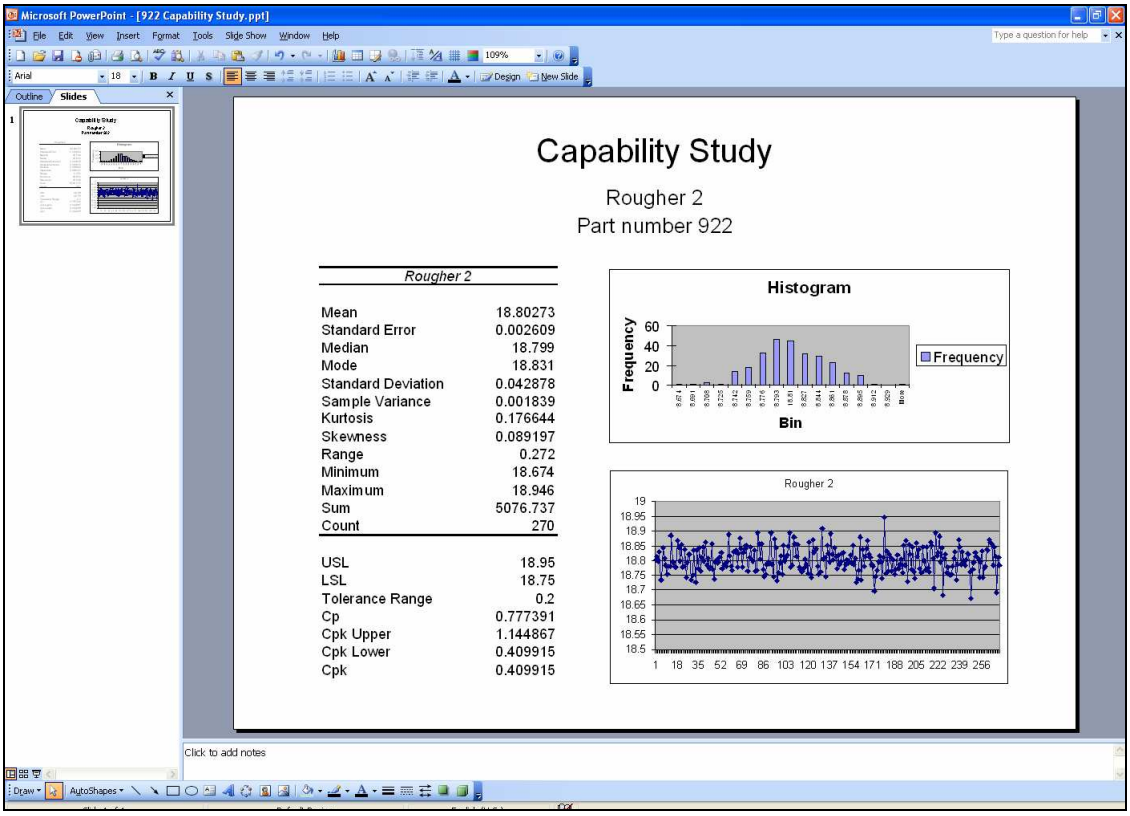
A picture of your Run chart will appear. Repeat this process with the histogram. Reduce the size of the charts and move them off to the right.

Your PowerPoint® file should look generally as shown.



Return to `Rougher check sheets.xls`, sheet 2, where you generated the descriptive statistics and calculated the process capability. Paint the range of data that contains information and select Edit, Copy. Return to PowerPoint® and select Edit, Paste Special and select Picture (Windows Metafile).

Arrange and size the information so that the slide appears generally as shown.



Save the file as `922 Capability Study.ppt` on your computer. Ensure that the file is kept in a safe place—backup copies are encouraged.