Examples

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Preface

We would like to thank our customers for their continued trust and support in our products and services. It is the aim of this manual to serve as a quick and easy guide to the use of qs-STAT® millennium, with the help of several self-contained worked examples showing actual tasks and detailed procedures. More details and support may be found in the manual „1x1 for qs-STAT® millennium“, the program features summary as well as the online help.

Please consider that because of the flexibility of the software and the multiple configuration possibilities only standard settings can be given as examples here. Input screen masks, graphical displays, and reports must not necessarily have the same layout shown in this manual. Especially in case of company specific configurations, significant differences are possible. However, the main procedures will be the same. All the path descriptions for test data, catalogs, databases, etc. refer to the standard installation path in the C:\Q-DAS\QSSTAT_ME directory.

In a standard qs-STAT® installation, the data sets referred to in the worked examples are located in the directory C:\Q-DAS\QSSTAT_ME\EXAMPLES.
You also have the possibility to download these data sets as well as further worked examples from our internet website www.q-das.de.

We wish you success working with Q-DAS® QM tools.

Note:
Our offer includes seminars and courses in connection with our products. We would be pleased to mail you a detailed description of the course contents as well as a questionnaire to help you decide on the course that is right for you. Furthermore, we would gladly submit to you an individual offer for custom-tailored on-site training programs. For self-education, we recommend the purchase of our statistical reference books.

Legal Rights and Warranty

Limitation of Warranty
No warranty for the correctness of the contents of this manual is assumed. Since, despite every effort, errors can never be fully precluded, we are grateful for the notification of such errors. You may contact us under one of the following addresses:

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Table of Contents

Objective:

The goal of this task is to demonstrate the recording data capabilities within qs-STAT. The user will learn how to create a file from start to finish, entering critical tolerance information and manually recording measured values using the 'linear transformation' option.

Highlights:

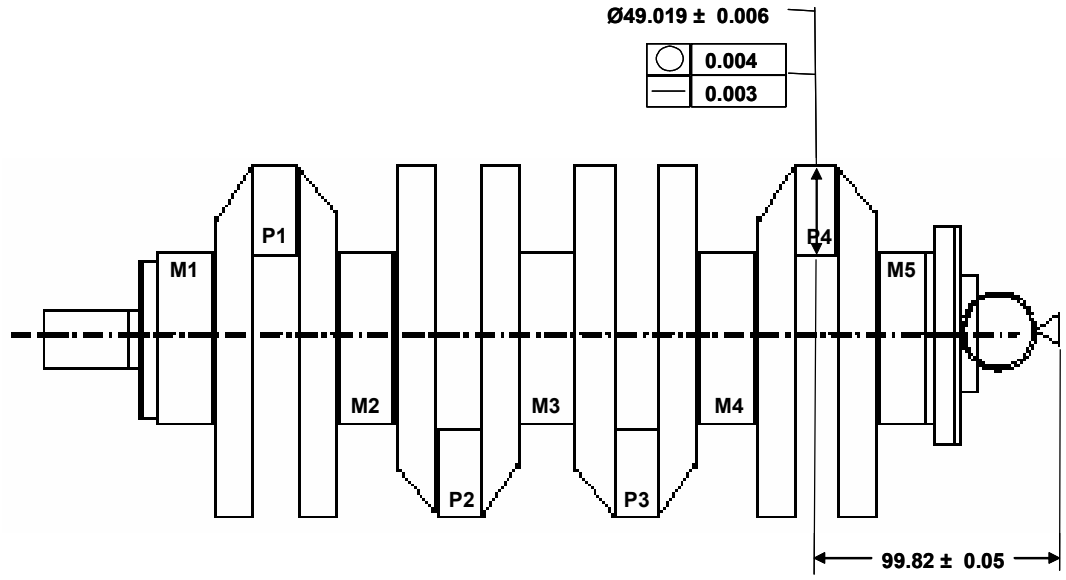
☑ Parts, Characteristics, Values Masks

☑ Data Handling

☑ Linear transformation

Background Information:

When creating a file, it is important that the correct tolerance information is entered for each characteristic as this will directly affect the capability results. Any additional data that can be entered is most beneficial when using qs-STAT to drill down on a process to determine any special causes.



Task:

Create a qs-STAT file for the four crankshaft features on Pin 4 (P4), as outlined in the part drawing above. Reference the information on the following page for descriptions and measurement values.

Additional Information:

Part No.	1
Part Descr.	Crankshaft

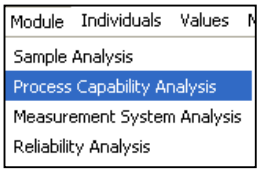
Char. No.	1	2	3	4
Char. Descr.	Posn. Jrnl P4	Diam. P4	Round. P4	Straight P4
Nominal	99.82	49.019	---	---
USL	99.87	49.025	0.004	0.003
LSL	99.77	49.013	---	---

Measured Values:

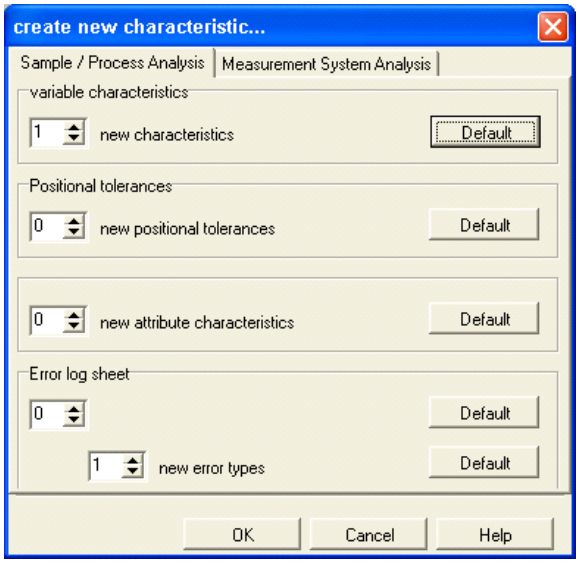
Crankshaft	Posn Jrnl P4	Diam P4	Round P4	Straight P4
1	99.83	49.014	0.0005	0.0009
2	99.82	49.018	0.0004	0.002
3	99.82	49.015	0.0009	0.0002
4	99.84	49.014	0.0004	0.0012
5	99.84	49.015	0.0007	0.0009
6	99.81	49.015	0.0007	0.0018
7	99.83	49.014	0.0013	0.0011
8	99.83	49.014	0.0007	0.0006
9	99.84	49.016	0.0001	0.0011
10	99.82	49.016	0.0006	0.0009
11	99.86	49.015	0.0013	0.0007
12	99.85	49.015	0.0017	0.0014
13	99.83	49.016	0.0027	0.0009
14	99.83	49.015	0.0007	0.0012
15	99.84	49.014	0.0028	0.0011

Procedure:

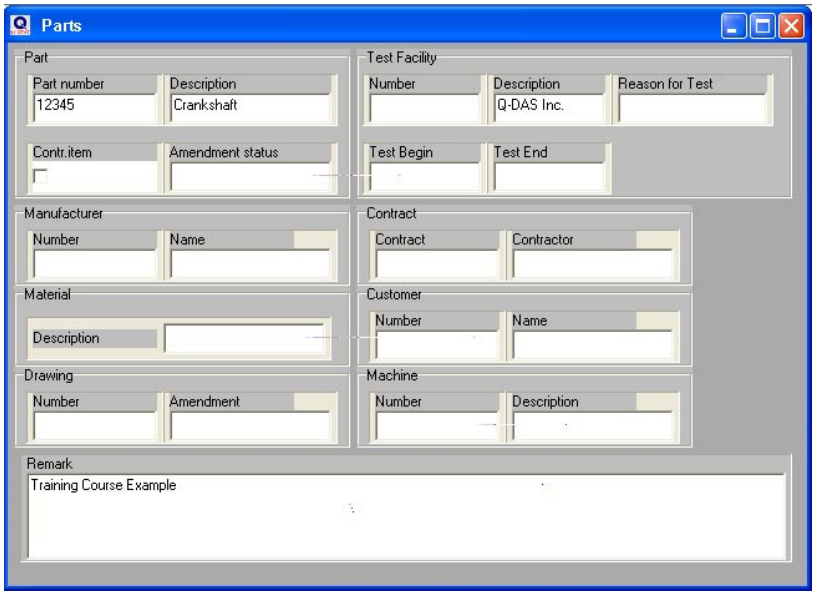
1. In qs-STAT Process Capability Module, go to the File pull-down menu and select File new or click the icon seen to the right. The 'create new characteristic …' window will appear as seen below. Under variable characteristics change the number to 4 and click ok.



File new

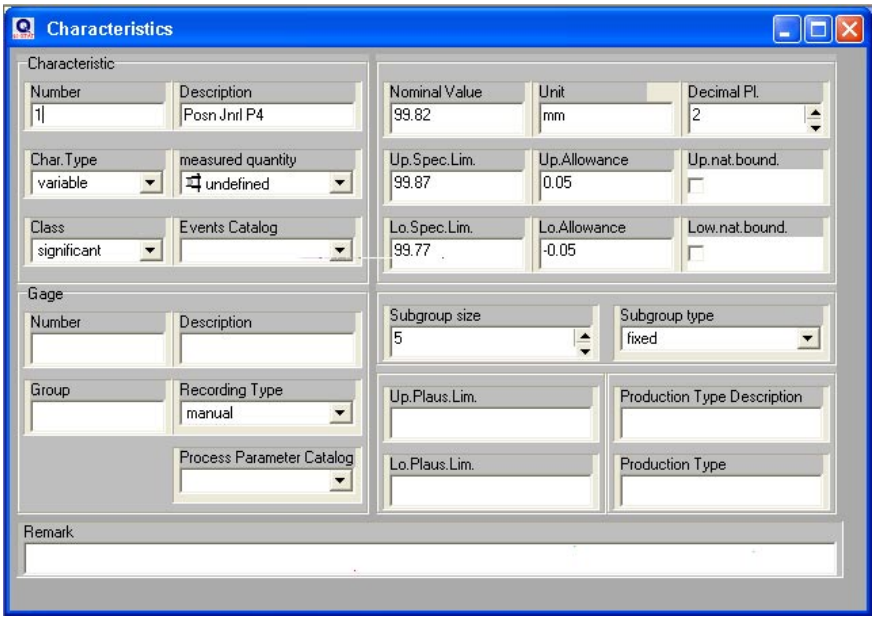


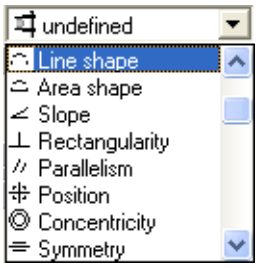
2. For the Parts Mask, the essential information is the part number and part description. These should be unique identifiers. Fill in the Part number as 12345 and the part description as crankshaft.



The three icons below navigate between the Parts, Characteristic and Value Masks, respectively.

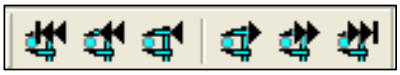
3. Switch from the Parts Mask to the Characteristics Mask. Fill in the characteristic number and description. These should be different than the part number and part description, but should also be unique identifiers.





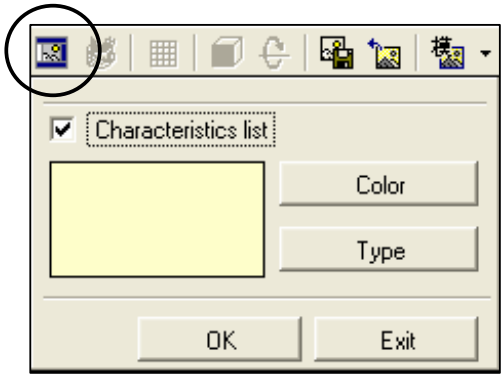
4. Enter the tolerance information from the part drawing on page 1 and select a measured quantity from the list that relates to the characteristic.

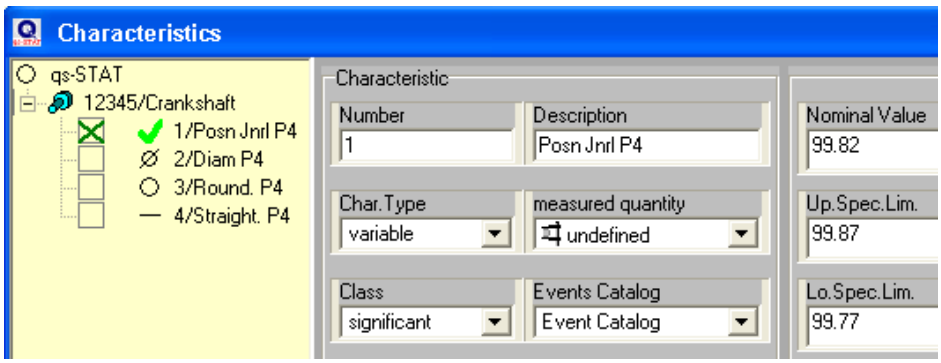
Use the icons below to move forwards and backwards through the characteristics.



Alternatively you can display the characteristic list and move through the characteristics by checking the appropriate one. See the steps below.

☞ Info icon



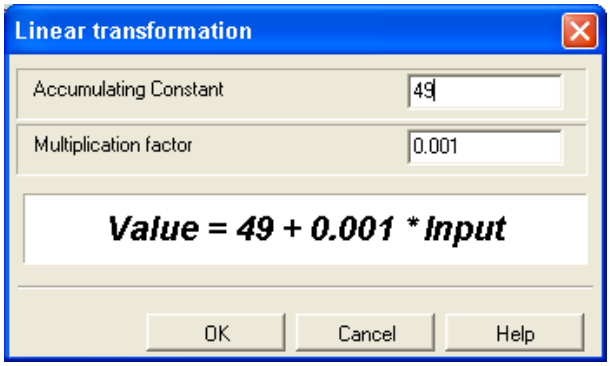


5. Complete the characteristic information for the other three characteristics.

6. Switch over to the Value Mask and enter in the data set for the first characteristics, Posn Jnrl P4.

7. For the second characteristic, Diam. P4, use the *linear transformation* when manually typing in the data.
   Set the linear transformation up as seen in the screen below. By doing this you '*input*' 14 and the '*value*' that is displayed in qs-STAT will be 49.014.

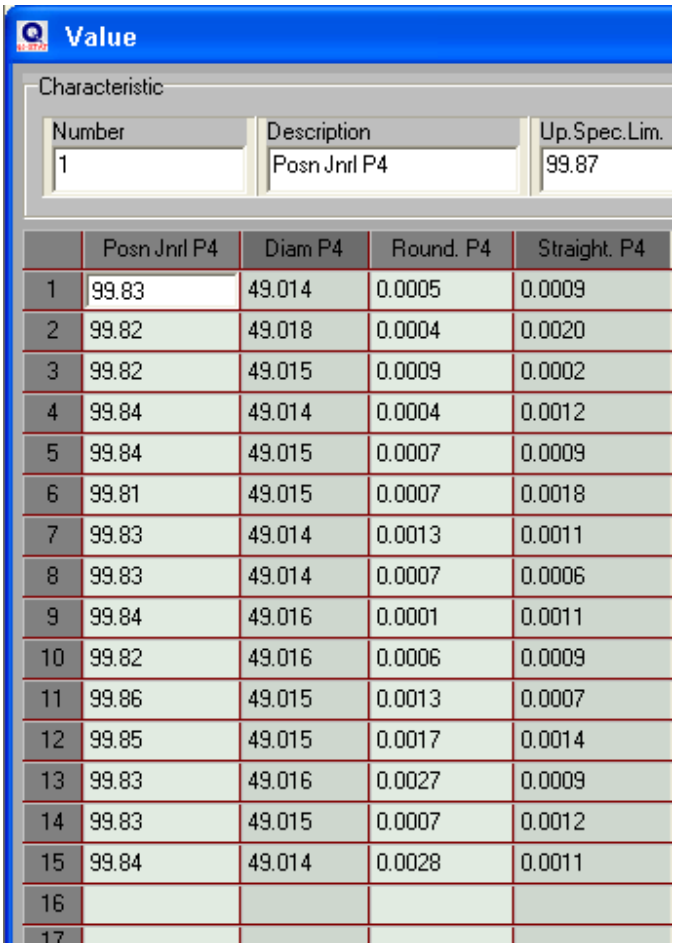
Linear Transformation



8. Complete the data entry for the last two characteristics. Practice using the linear transformation; re-set it before typing in the data for each characteristic.

9. Be sure to Save the file under File – Save as …

The completed Value mask should look like the one seen below, with 4 characteristics and 15 values each.



Value

Characteristic

Number	Description	Up.Spec.Lim.
1	Posn Jnrl P4	99.87

	Posn Jnrl P4	Diam P4	Round. P4	Straight. P4
1	99.83	49.014	0.0005	0.0009
2	99.82	49.018	0.0004	0.0020
3	99.82	49.015	0.0009	0.0002
4	99.84	49.014	0.0004	0.0012
5	99.84	49.015	0.0007	0.0009
6	99.81	49.015	0.0007	0.0018
7	99.83	49.014	0.0013	0.0011
8	99.83	49.014	0.0007	0.0006
9	99.84	49.016	0.0001	0.0011
10	99.82	49.016	0.0006	0.0009
11	99.86	49.015	0.0013	0.0007
12	99.85	49.015	0.0017	0.0014
13	99.83	49.016	0.0027	0.0009
14	99.83	49.015	0.0007	0.0012
15	99.84	49.014	0.0028	0.0011
16				

Objective:

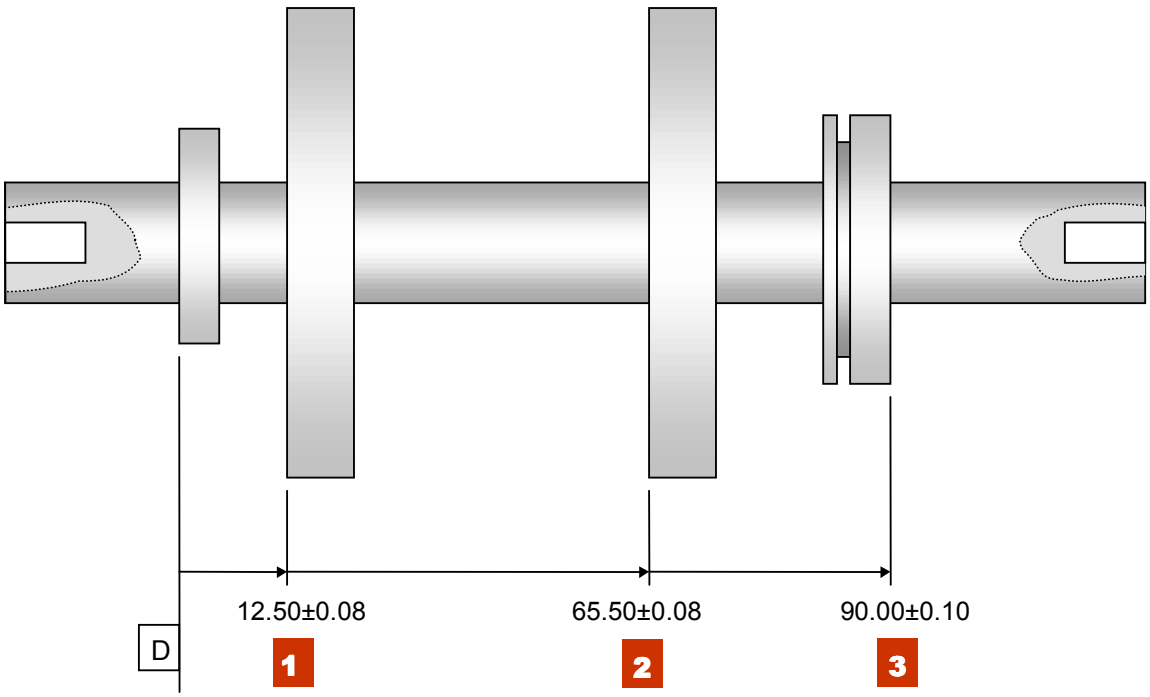
This task is designed to expand on the user's basic knowledge of the recording data setup in qs-STAT and to introduce additional, advanced recording data options. These will include the "logical operator" and "Common Additional Data Fields" such as date, time, operator, machine, etc.

Highlights:

- ☑ Recording Data
- ☑ Additional Data Fields
- ☑ Logical Operator

Background Information:

Within qs-STAT, it may be necessary to link or connect certain related characteristics; for example to determine the calculated true position value of X and Y coordinates or to find the sum of two sets of data measured from two length characteristics. These types of functions can be done using the 'logical operator' feature. As for additional data fields, this information can be used to assist in the traceability of a part or to drill down on a process in order to determine the exact location of the problem, i.e. Machine and Cavity number.



Task:

Create a new file and the recording data environment for the three characteristics highlighted on the part sketch. Record the measured values and the additional data fields for each characteristic as outlined below. (Hint: Use the Common Additional Data Fields option when entering the machine and cavity information.)

Create the special characteristic for the distance between Journals 2 and 3. Using the logical operator complete the data values.

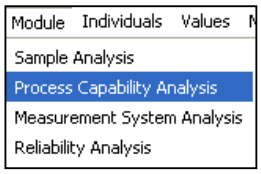
Measured Values & Additional Data:

Spindle	Jrnl 1	Cavity	M/C #	Jrnl 2	Cavity	M/C #
1	12.479	2	1	65.436	2	1
2	12.489	2	1	65.422	2	1
3	12.498	2	1	65.46	2	1
4	12.546	2	1	65.433	2	1
5	12.485	3	1	65.454	3	1
6	12.513	3	1	65.461	3	1
7	12.55	3	1	65.439	3	1
8	12.547	3	1	65.463	3	1
9	12.491	4	2	65.45	4	2
10	12.521	4	2	65.463	4	2
11	12.524	4	2	65.446	4	2
12	12.485	4	2	65.467	4	2
13	12.542	5	2	65.43	5	2
14	12.508	5	2	65.423	5	2
15	12.493	5	2	65.429	5	2
16	12.446	5	2	65.439	5	2

Spindle	Jrnl 3	Cavity	M/C #
1	90.051	2	1
2	90.05	2	1
3	90.039	2	1
4	90.036	2	1
5	90.035	3	1
6	90.071	3	1
7	90.058	3	1
8	90.062	3	1
9	90.062	4	2
10	90.053	4	2
11	90.049	4	2
12	90.039	4	2
13	90.054	5	2
14	90.075	5	2
15	90.045	5	2
16	90.041	5	2

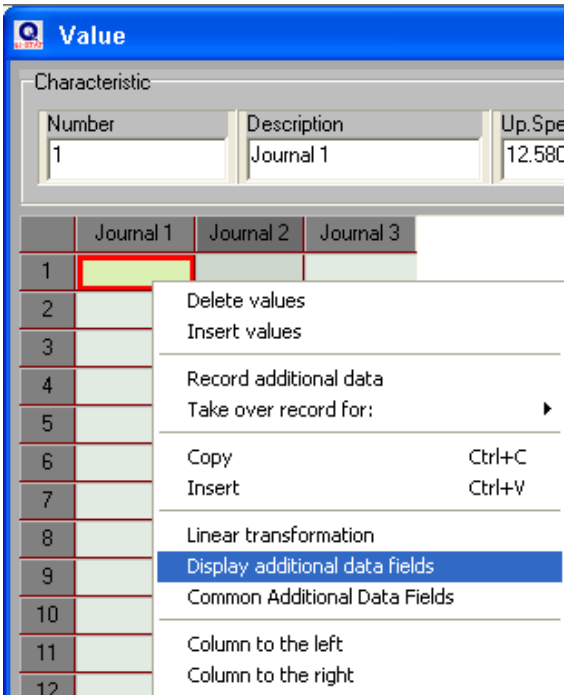
Procedure:

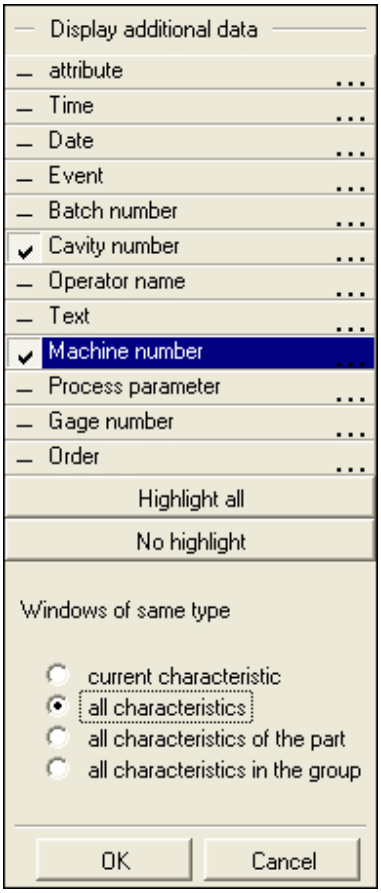
1. Starting with a new file in the Process Capability Module, fill in the appropriate parts and characteristic information for each of the three Journals.



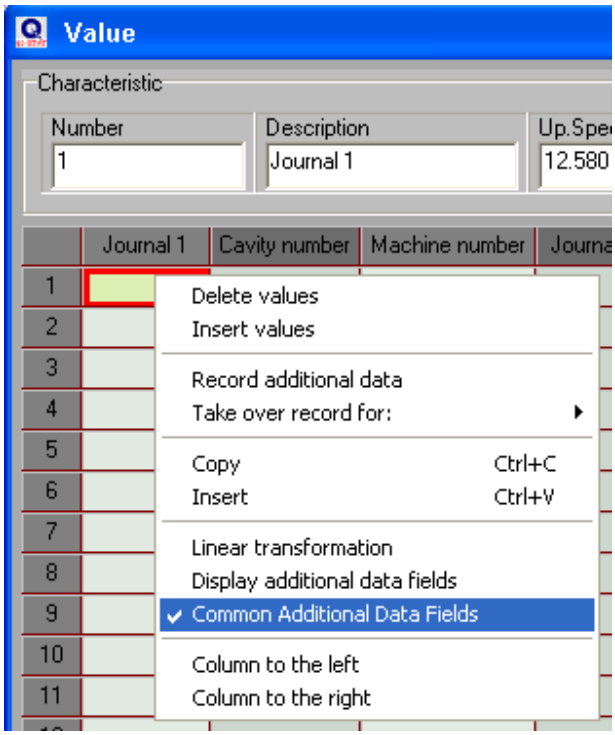
File new

2. In the Value Mask, prior to entering data turn on the additional data fields for machine and cavity. This can be done by right mouse clicking on the highlighted cell and selecting “Display additional data fields.” In the pop up window, check Cavity number and Machine number; select “all characteristics” and click OK.





3. Again right mouse click in the highlighted cell and select “Common Additional Data Fields.”

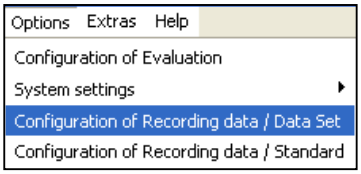


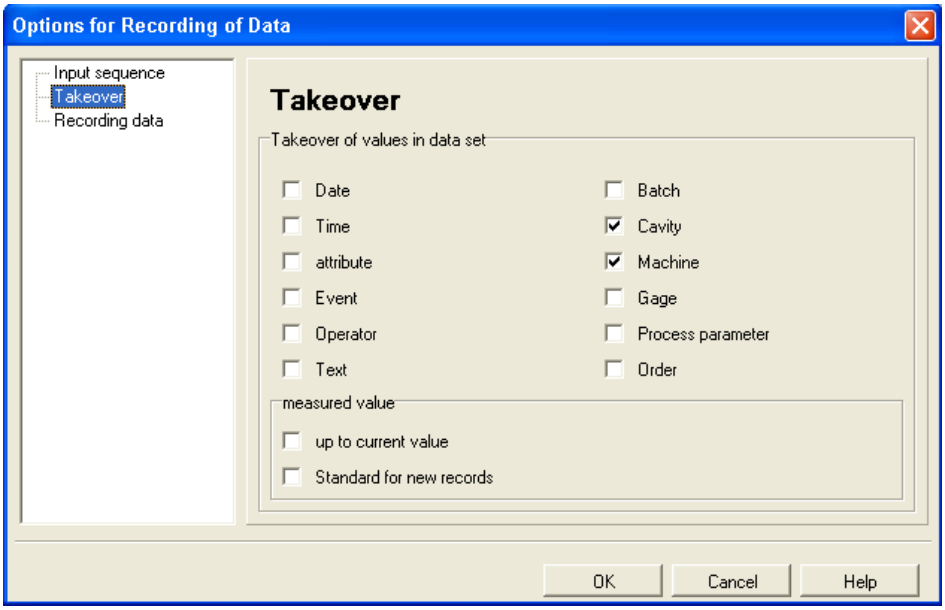
Common Additional Data Fields means that the additional information, such as machine # and cavity # are carried over for each part - all characteristics (across the row).

	Journal 1	Cavity numbe	Machine numb	Journal 2	Cavity numbe	Machine numb	Journal 3	Cavity numbe	Machine nu
1	12.479	2	1	65.436	2	1	90.051	2	1
2									
3									

For this example, we want the additional data to carry over for each characteristic (across the row) and for each part (down the column). The “Takeover” function works for the second half.

4. Go to “Options” pull down menu, “Configuration of Recording data / Data Set” – “Takeover.” Check the boxes for Cavity and Machine. Click OK.

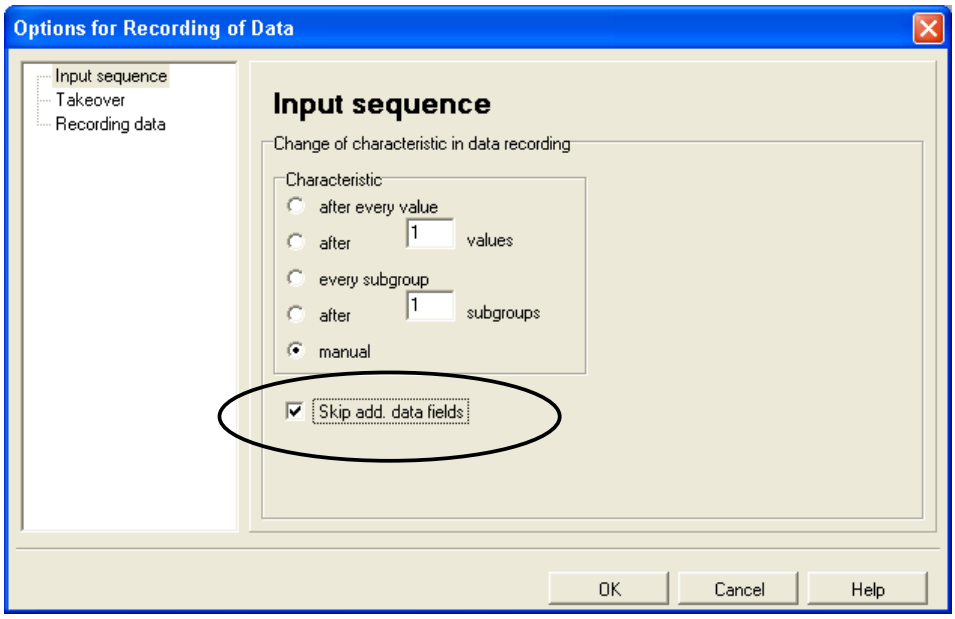




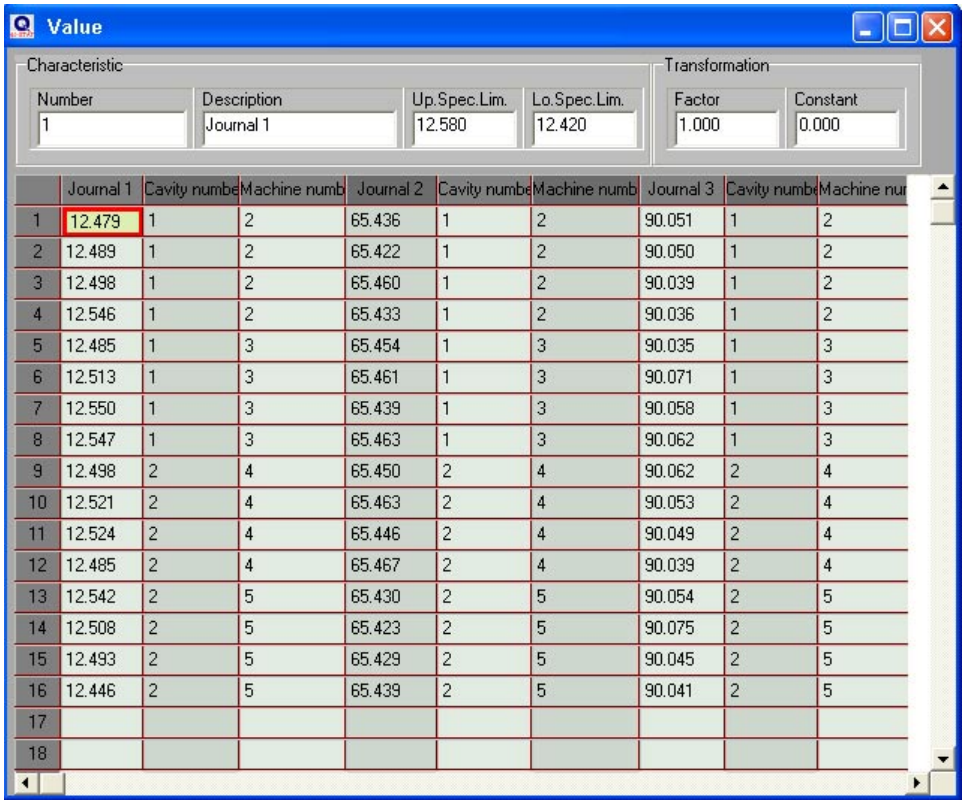
Prior to typing in the data, change the “Input sequence” such that the additional data fields are skipped. This will allow the values to be typed in one after another down the column.

5. Go to the “Options” pull down menu, “Configuration of Recording data / Data Set” – “Input sequence.” Check the box for “Skip add. data fields.” Click OK. Refer to the graphic on the following page.

6. Now type in all of the data for the three characteristics including the machine and cavity numbers.

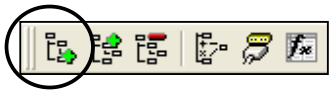


The completed Values Mask is seen below for the three Journals, including the additional data.



	Journal 1	Cavity numbe	Machine numb	Journal 2	Cavity numbe	Machine numb	Journal 3	Cavity numbe	Machine nur
1	12.479	1	2	65.436	1	2	90.051	1	2
2	12.489	1	2	65.422	1	2	90.050	1	2
3	12.498	1	2	65.460	1	2	90.039	1	2
4	12.546	1	2	65.433	1	2	90.036	1	2
5	12.485	1	3	65.454	1	3	90.035	1	3
6	12.513	1	3	65.461	1	3	90.071	1	3
7	12.550	1	3	65.439	1	3	90.058	1	3
8	12.547	1	3	65.463	1	3	90.062	1	3
9	12.498	2	4	65.450	2	4	90.062	2	4
10	12.521	2	4	65.463	2	4	90.053	2	4
11	12.524	2	4	65.446	2	4	90.049	2	4
12	12.485	2	4	65.467	2	4	90.039	2	4
13	12.542	2	5	65.430	2	5	90.054	2	5
14	12.508	2	5	65.423	2	5	90.075	2	5
15	12.493	2	5	65.429	2	5	90.045	2	5
16	12.446	2	5	65.439	2	5	90.041	2	5
17									
18									

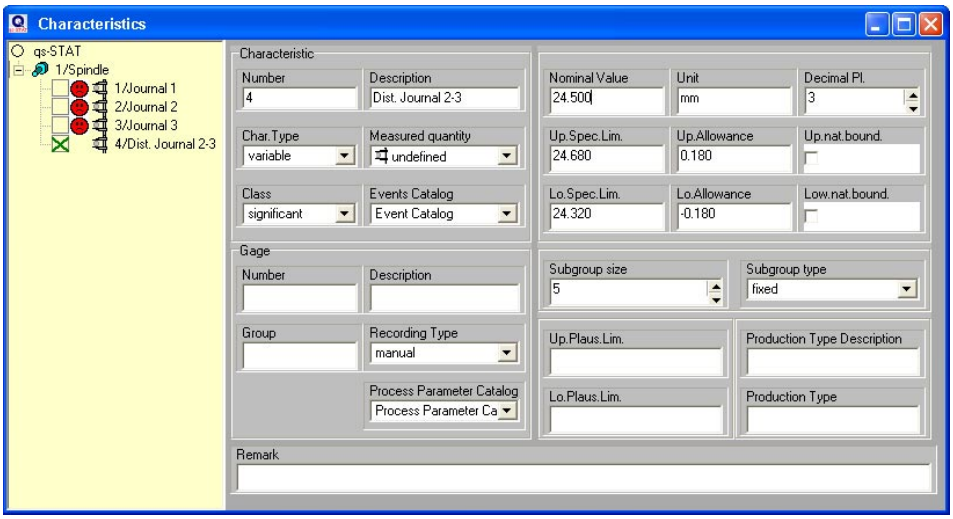
7. Add a fourth characteristic for the distance between Journals 2 and 3.



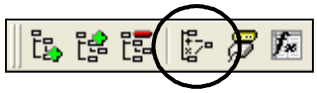
Append element

In the Characteristics Mask on the third characteristic, click the “Append element” icon. This will add a fourth element to the end of the list.

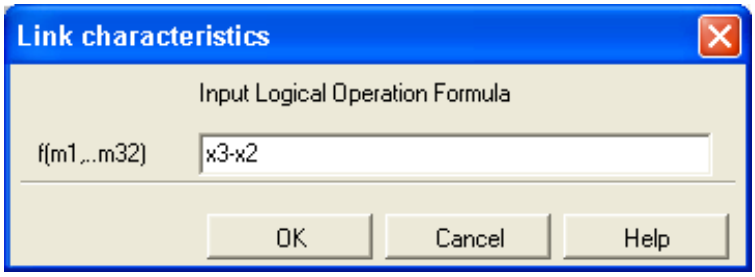
8. Fill in the appropriate tolerance information calculated from Journals 2 and 3, as seen below.



9. Using the “Link characteristics” icon a Logical Operation Formula can be input so the distance between Journals 2 and 3 is automatically calculated.



Link characteristics

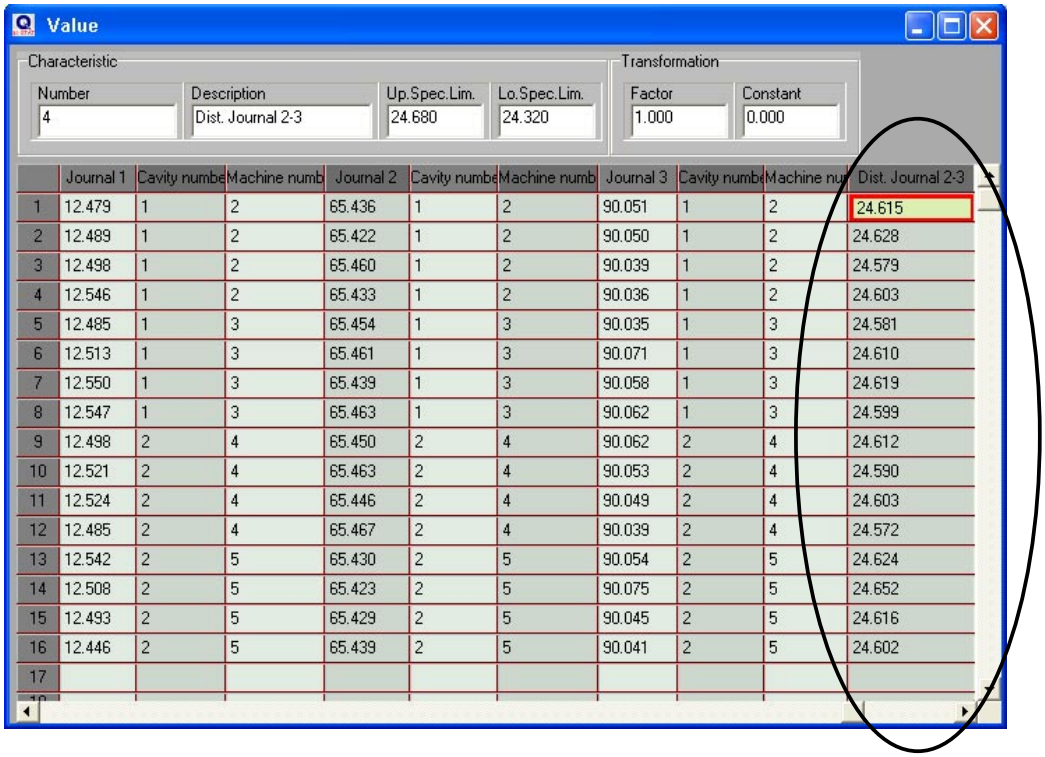


10. For the distance between the two Journals, type in the Logical Operation Formula: **x3 - x2**.
    The "x" represents characteristic, and this formula calculates characteristic #3 minus characteristic #2.

Other examples of Logical Operator Formulas include:

- average value of characteristics **avg(x1; x2; x4)**
- maximum value of characteristics **max(x1 .. x4)**
  (i.e. max of characteristic 1 thru characteristic 4)

The Value Mask is now filled in for the Distance between Journals 2 and 3.



	Journal 1	Cavity numbe	Machine numb	Journal 2	Cavity numbe	Machine numb	Journal 3	Cavity numb	Machine nu	Dist. Journal 2-3
1	12.479	1	2	65.436	1	2	90.051	1	2	24.615
2	12.489	1	2	65.422	1	2	90.050	1	2	24.628
3	12.498	1	2	65.460	1	2	90.039	1	2	24.579
4	12.546	1	2	65.433	1	2	90.036	1	2	24.603
5	12.485	1	3	65.454	1	3	90.035	1	3	24.581
6	12.513	1	3	65.461	1	3	90.071	1	3	24.610
7	12.550	1	3	65.439	1	3	90.058	1	3	24.619
8	12.547	1	3	65.463	1	3	90.062	1	3	24.599
9	12.498	2	4	65.450	2	4	90.062	2	4	24.612
10	12.521	2	4	65.463	2	4	90.053	2	4	24.590
11	12.524	2	4	65.446	2	4	90.049	2	4	24.603
12	12.485	2	4	65.467	2	4	90.039	2	4	24.572
13	12.542	2	5	65.430	2	5	90.054	2	5	24.624
14	12.508	2	5	65.423	2	5	90.075	2	5	24.652
15	12.493	2	5	65.429	2	5	90.045	2	5	24.616
16	12.446	2	5	65.439	2	5	90.041	2	5	24.602
17										

Objective:
The goal of this task is to introduce the user to the graphical analysis aspect of qs-STAT. Several of the investigative tools that are available for the Individual Value chart will be demonstrated using example data containing measurements from multiple machine, gages, operators, etc.

Highlights:

☑ Data Handling

☑ Graphical Analysis

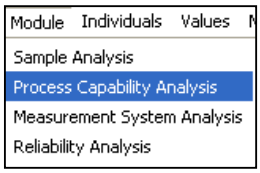
☑ Value chart

Background Information:
Process data may contain a multitude of elements of variation, and it can be difficult to find the root of the problem in the JUNGLE of variation. qs-STAT can assist the user in deciphering where the primary cause is located, by seperating out the data by machine number or by indicating whether an assignable cause has been recorded at the value.

Task:

Analyze an existing set of data from the file, Multifixture.dfq and investigate for any causes of variation that may be able to be removed from the analysis.

Procedure:

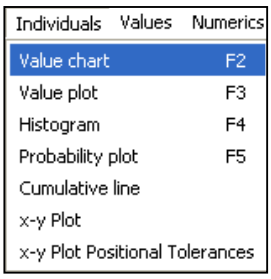


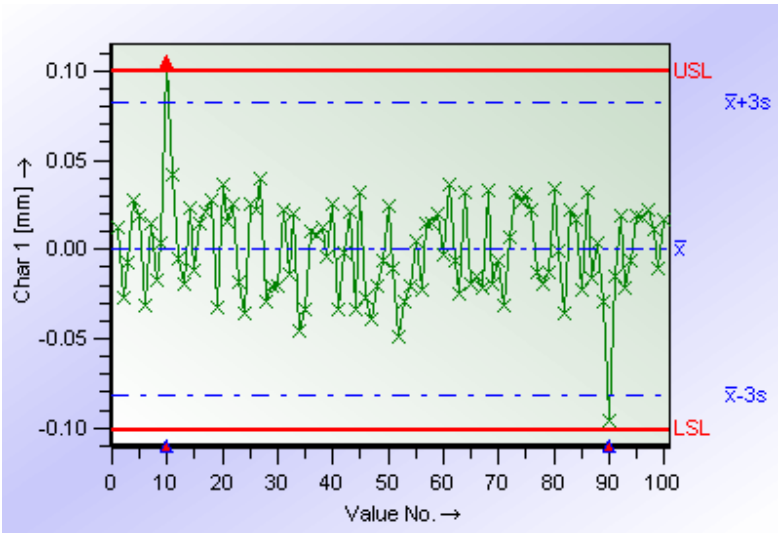
1. In the Module Process Capability Analysis, open the file Multifixture.dfq. This file is located in the qs-STAT installation directory, Q-DAS\QSSTAT_ME\Examples.

Value chart Individuals:

File – Open

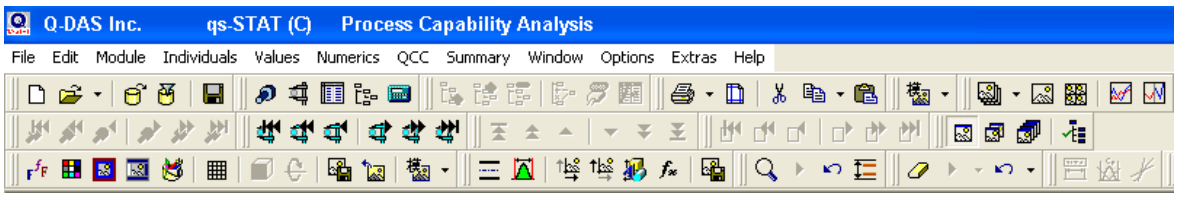
Upon opening the file, a Value chart individuals will automatically open as the default screen setup. This chart can be found under the Individuals pull-down menu.



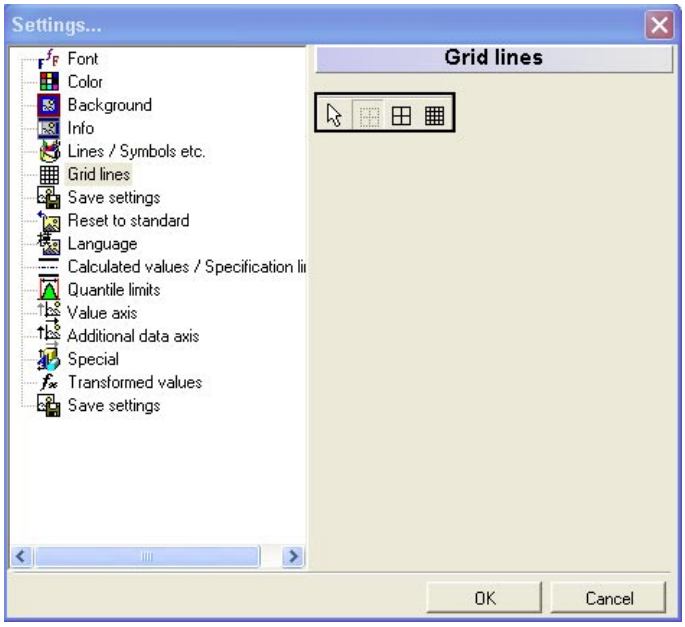


All of the options for the charts can be accessed in one of two ways:

a) Use the icons/buttons on the toolbar



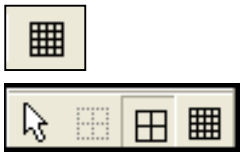
b) Right mouse click on the graphic, and select the appropriate item.

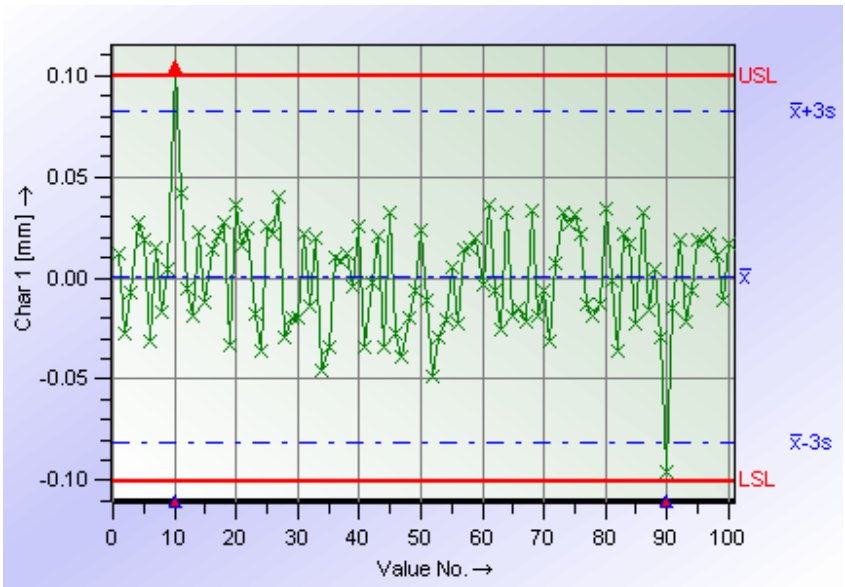


Grid lines:

2. Select the “Grid lines” icon and turn on grid lines.

Grid lines





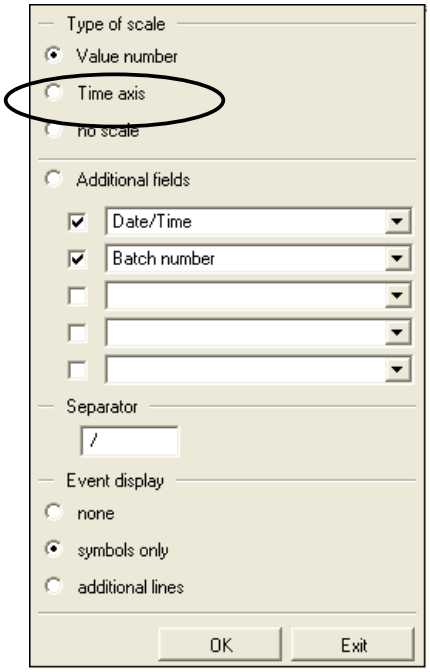
Save settings

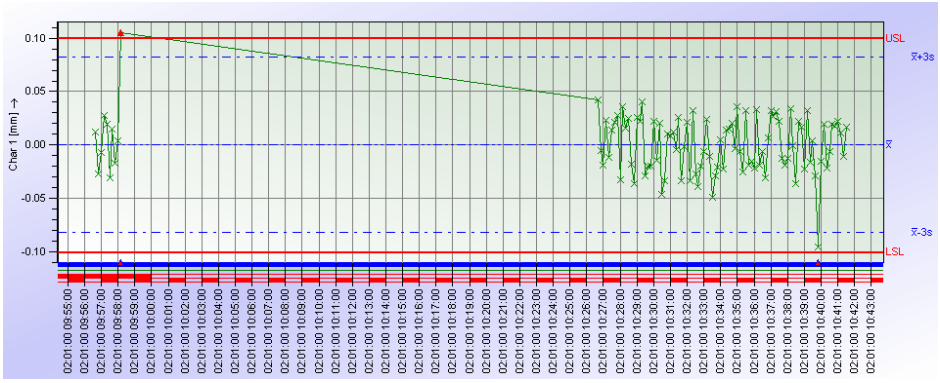
Any changes that are made to the appearance of the graphics, such as grid lines, can be saved as the new default by clicking the “Save settings” icon.

X-axis display:

3. Along the x-axis of a Value chart, the Value No. is displayed. This can be changed to show date & time, scaled time, machine #, etc. Click the “Value axis” icon and select Type of scale … Time axis.

Value axis

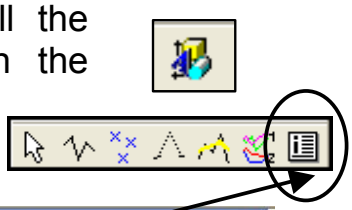


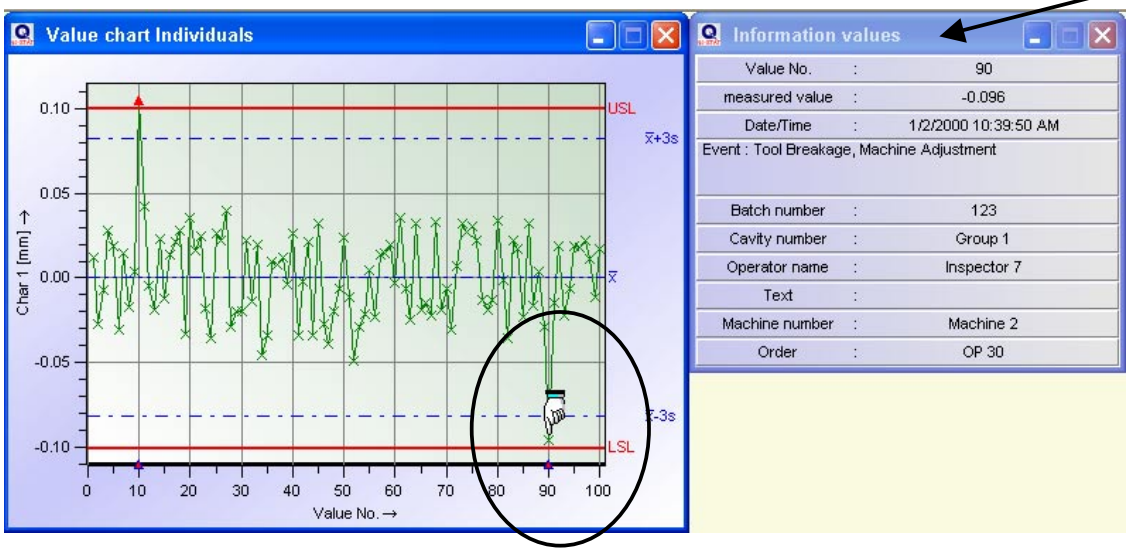


Time axis (scaled time) is displayed to show when the down time occurred.

Information values:

4. The “Information values” box is a very useful tool when it comes to analyzing your data. It gives all the specifics about a particular value. Click on the “Special” icon, then the “Information values” icon.





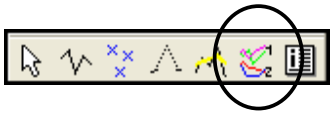
With the Information values turned on, put the mouse inside the Value chart. The mouse becomes a hand which points to a specific value. In the graphic above, the hand is on value # 90. The Info box to the right shows what events occurred, the batch #, cavity #, etc.

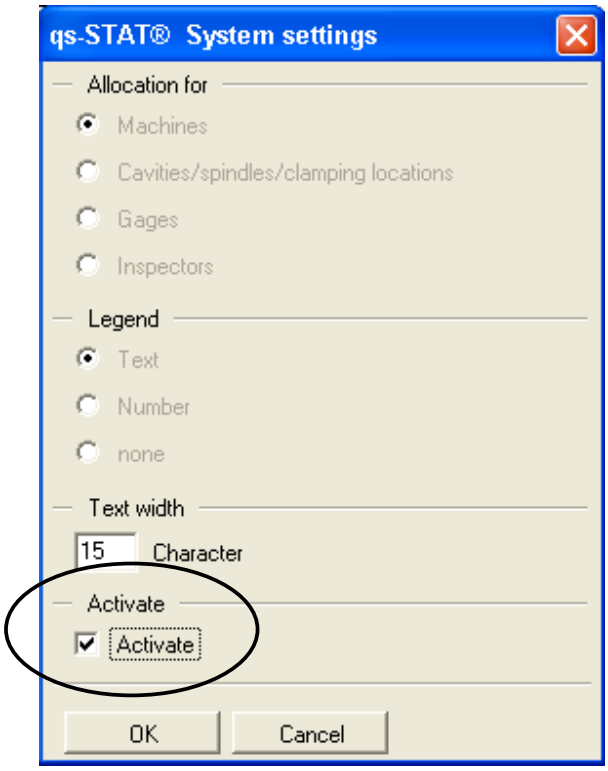
The blue and red triangles along the Value No. axis at #10 and #90 indicate that an event has occurred there.

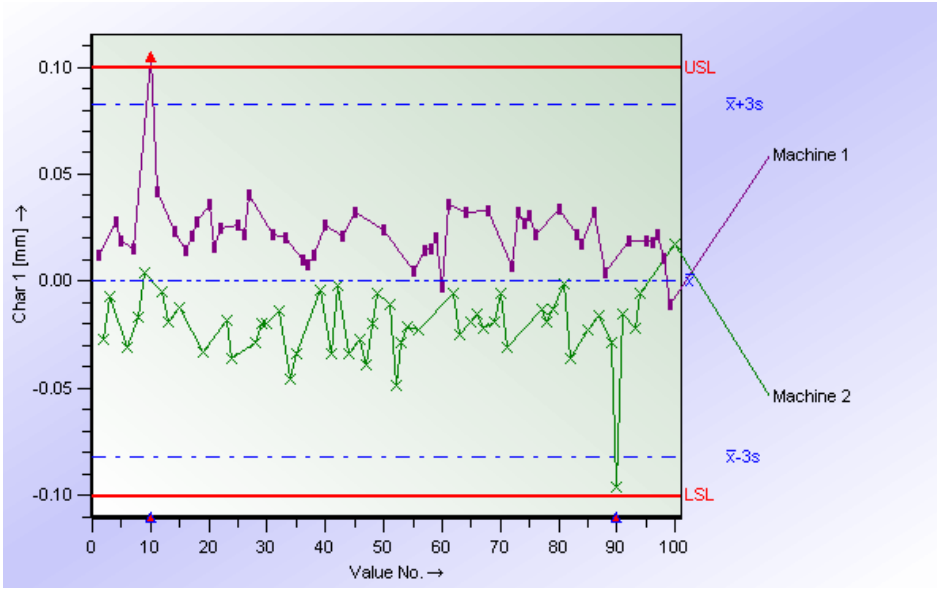
Separation of data:

When multiple machines are present, it may be useful to separate the data by machine in order to see where the machines are running with respect to each other and with respect to the tolerance.

5. Go to the “Special” icon and click on the “Separate” icon. In the window that appears, check the Activate box; select Allocation for … Machines.





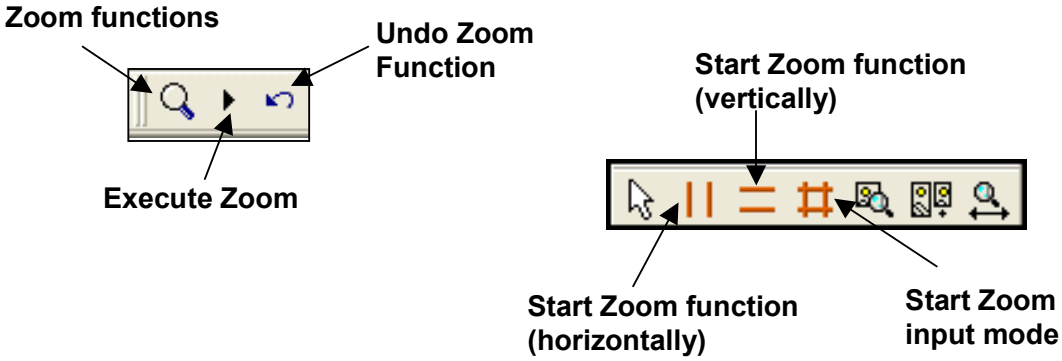


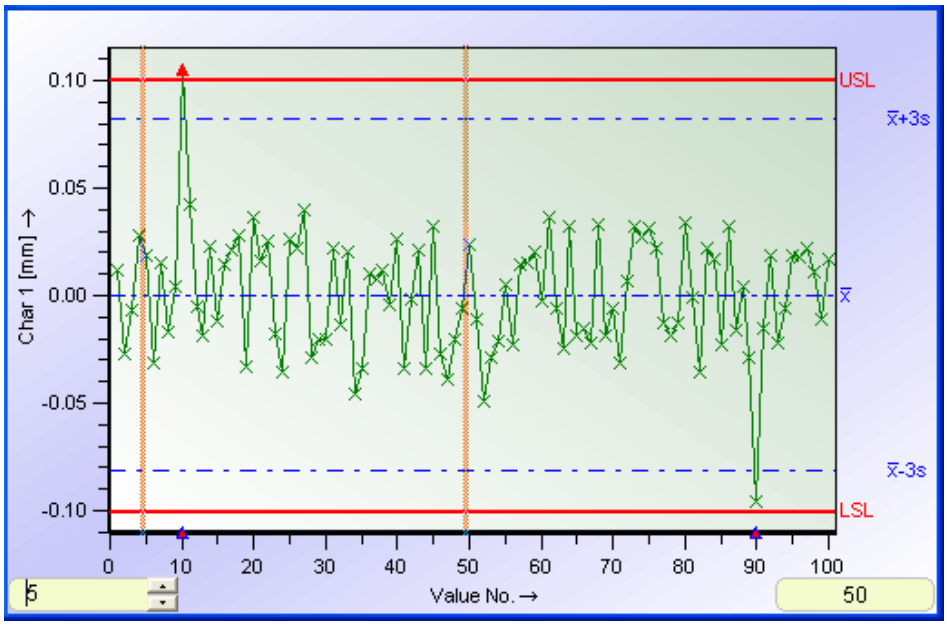
6. To change the coloring of the lines and symbols for each separate machine, go to the “Lines / Symbols etc.” icon. In the window that appears, click on the first or second line box and select a new color. For the symbols, the type of symbol can be changed in addition to the symbol color.

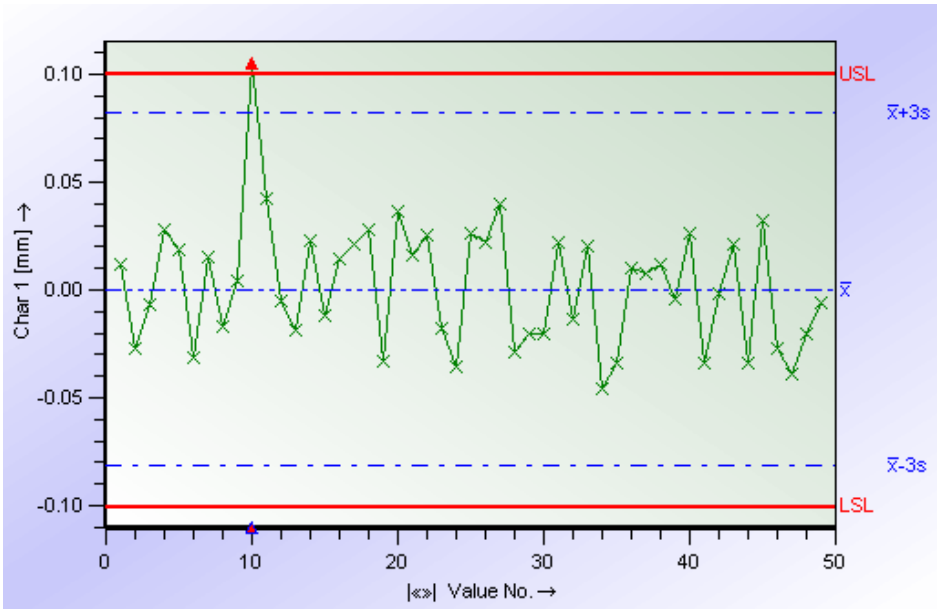
Lines / Symbols etc.

Zoom Function:

7. On the Value chart, there are several zoom functions available. Click the “Zoom functions” icon and select zoom horizontal. Set up the zoom lines, using the mouse or the numbers in the lower corners of the graphic. Then click “execute zoom.”



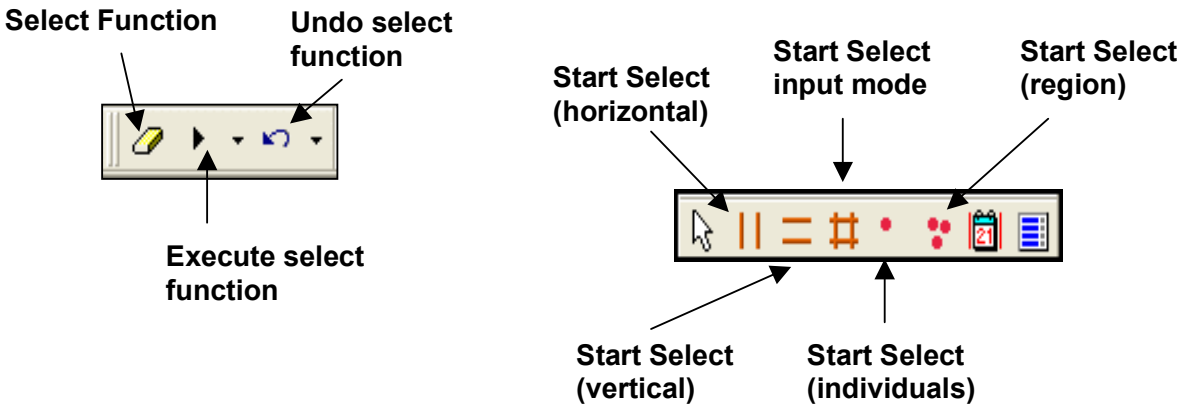




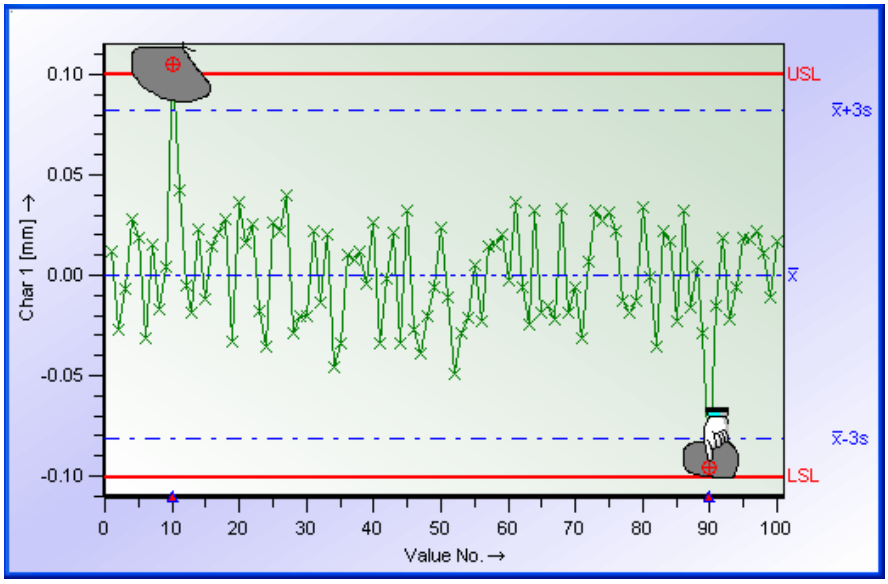
Notice the value chart is now only displaying values 1 -50.

Select Function:

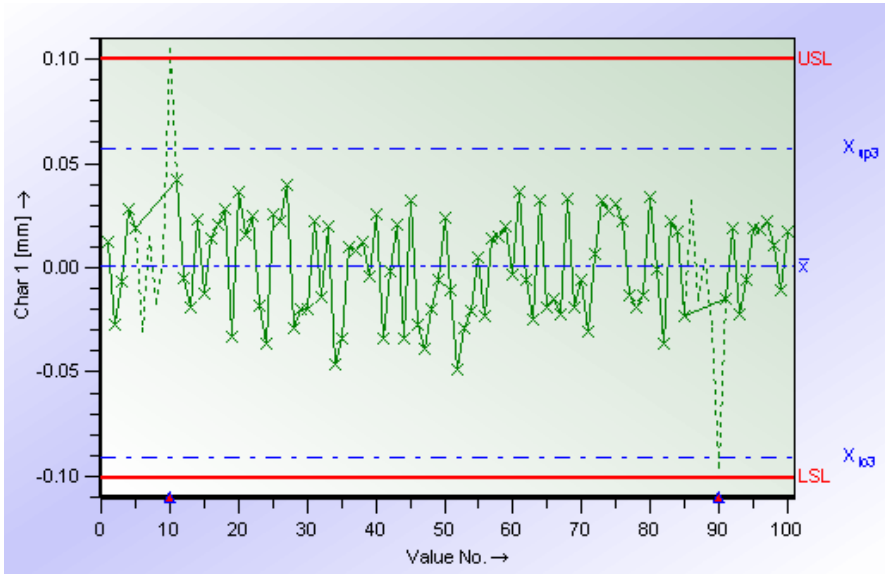
Under certain circumstances, a value or a group of values may need to be removed from the capability analysis. For example, if there is an obvious outlier that has an assignable cause, then by using the “select function” that value can be de-selected. The capability of the characteristic will then be recalculated without that value or rather without the whole subgroup. In Process Capability Module, the statistics are based on sub grouping or sample plans, therefore an individual value alone can not be removed.



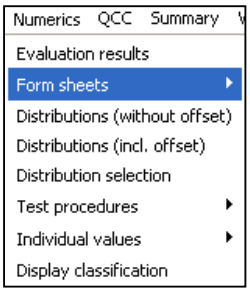
8. In the value chart below, there are outliers with assignable causes (events) at value #10 and #90. To de-select these, click the “Select Function” icon and the “Start Select (region)” icon. Using the mouse draw a circle around each value. Be sure to completely close the circle. Then right mouse click on the value inside the circle.



9. Now click the “Execute select function” icon.



The de-selected subgroups now appear as dashed lines.



10. Open up a Form Sheet 3 from the Numerics pull down menu to view the capability results after the de-selection.

Below is a comparison of the capability results before and after the de-selection. To undo the previous de-selection, click the "undo select function" icon.

Before de-selection:

Drawing Values			Collected Values			Statistics		
T_m	=	0.000				$\bar{x}$	=	0.00027
LSL	=	-0.100	x_{min}	=	-0.096	$\bar{x}$-3s	=	-0.08178
USL	=	0.100	x_{max}	=	0.105	$\bar{x}$+3s	=	0.08232
T	=	0.200	R	=	0.201	6s	=	0.16409
			$n_{<T>}$	=	99	$p_{<T>}$	=	99.97440 %
			$n_{>USL}$	=	1	$p_{>USL}$	=	0.01329%
			$n_{<LSL}$	=	0	$p_{<LSL}$	=	0.01231%
			n_{tot}	=	100	n_{eff}	=	100
Model distribution		=	Normal Distribution					
Calculation method		=	M4 - Percentile (0.135%-x-99.865%)					
Prospective performance index		=	T_p	=	1.00 ≤ **1.22** ≤ 1.44			
Critical performance index		=	T_{pk}	=	0.98 ≤ **1.22** ≤ 1.45			
The requirements were not met (T_p,T_{pk})								
Calculation method		=	Q-DAS 1					

The Capability Indices are

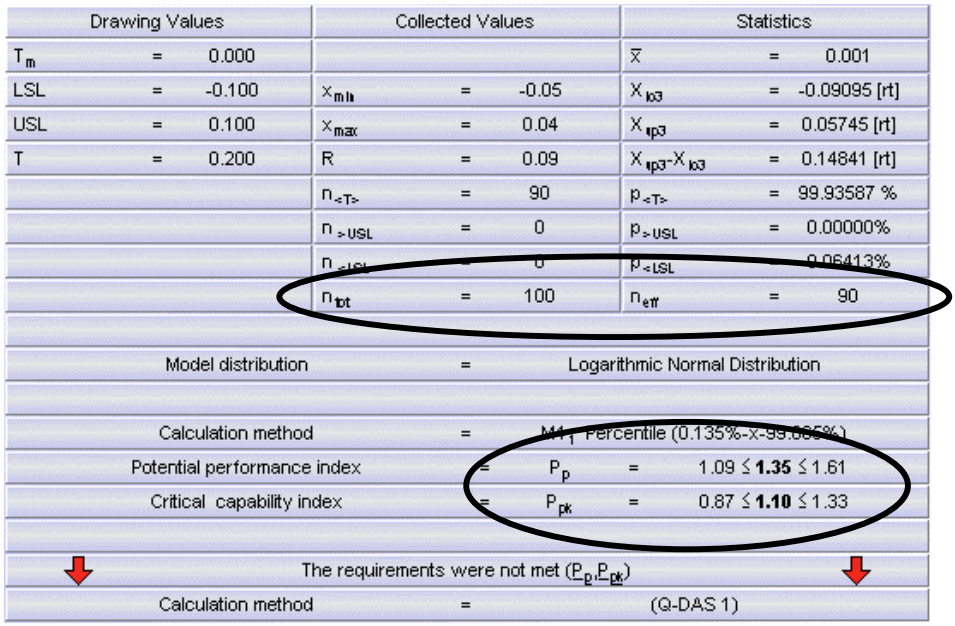
T_p /T_{pk} = 1.22 /1.22

The '**T**' indicates that the process is unstable.

At the same time, the capability number requirements were not met. Nowadays, the requirement is typically set at 1.67 as a minimum number. Of course the requirements you will work with depend on your company's standards.

By de-selecting the values, you can determine whether those assignable causes are the sole reason for the stability issue and the low capability numbers.

After de-selection:



Drawing Values			Collected Values			Statistics		
T_m	=	0.000				$\bar{x}$	=	0.001
LSL	=	-0.100	x_{min}	=	-0.05	X_{k3}	=	-0.09095 [rt]
USL	=	0.100	x_{max}	=	0.04	X_{tp3}	=	0.05745 [rt]
T	=	0.200	R	=	0.09	$X_{tp3}-X_{k3}$	=	0.14841 [rt]
			$n_{<T>}$	=	90	$p_{<T>}$	=	99.93587 %
			$n_{>USL}$	=	0	$p_{>USL}$	=	0.00000%
			$n_{<LSL}$	=	0	$p_{<LSL}$	=	0.06413%
			n_{tot}	=	100	n_{eff}	=	90
Model distribution			=		Logarithmic Normal Distribution			
Calculation method			=		M4 Percentile (0.135%-x-99.865%)			
Potential performance index			=	P_p	=	1.09 ≤ **1.35** ≤ 1.61		
Critical capability index			=	P_{pk}	=	0.87 ≤ **1.10** ≤ 1.33		
The requirements were not met (P_p,P_{pk})								
Calculation method			=		(Q-DAS 1)			

First, the 'n_{eff}' has changed to equal 90. 'n_{eff}' (effective values) indicates the number of values used in the calculations. To the left of that is 'n_{tot}' = 100, showing that there were originally 100 values for this characteristic.

Secondly, the Capability Indices have changed to

P_p /P_{pk} = 1.35 /1.10

The 'T' has changed to a 'P' indicating that the process is now stable.

The message "The requirements were not met (P_p P_{pk}) shows that the capability of the process still needs improvement.

Note: The Select Function is best used as an investigative tool to see whether a specific problem or cause is the sole reason for instability or low capability indices.

Objective:

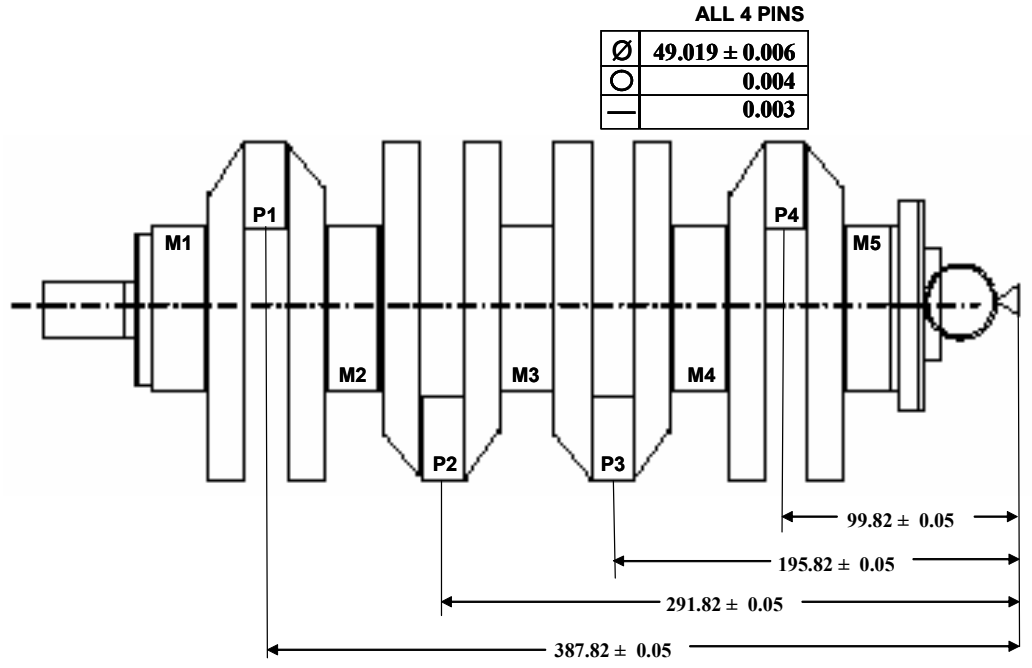
This task will demonstrate a broad range of qs-STAT graphics used in a general statistical analysis. It will provide the user with a standard default screen setup, emphasizing the four steps to system acceptance. Customization of form sheets and printout of standard reports will also be discussed.

Highlights:

- ☑ Data Handling
- ☑ Graphical Analysis
- ☑ Control Chart
- ☑ Histogram
- ☑ Multiple Charts

Background Information:

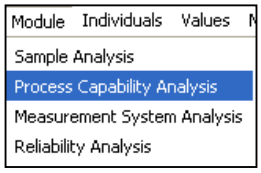
In a previous recording data example, four crankshaft features were created in order to demonstrate the setup of each qs-STAT Mask. Building upon the original example, a file has been created which includes a total of sixteen features on the crankshaft with 50 measurements each. The data is ready to be analyzed.



Task:
Evaluate the existing set of data from the file, Crankshaft.dfq, according to the recommended Four Steps to System Acceptance:

1) In Tolerance
2) In Control
3) Appropriate Distribution Model
4) Passing Capability Indices

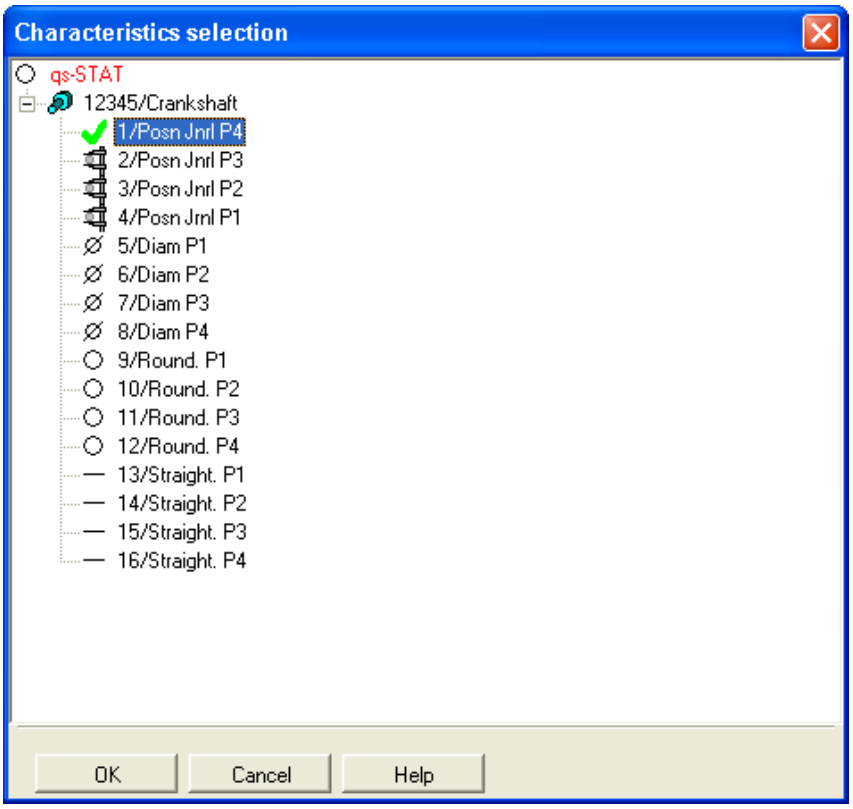
Procedure:



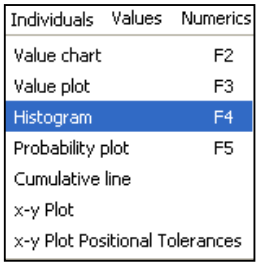
File – Open

1. In the Process Capability Analysis Module, open the file Crankshaft.dfq. This file is located in the qs-STAT installation directory, Q-DAS\QSSTAT_ME\Examples.

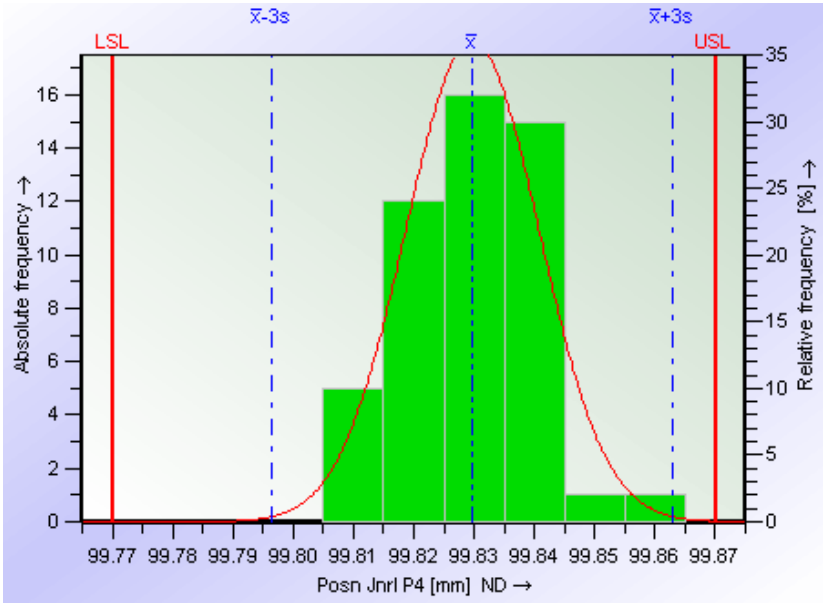
As the characteristics selection window appears, click OK.



Histogram:



2. Leave the default Value chart open on the desktop and from the "Individuals" pull down menu; open a "Histogram."



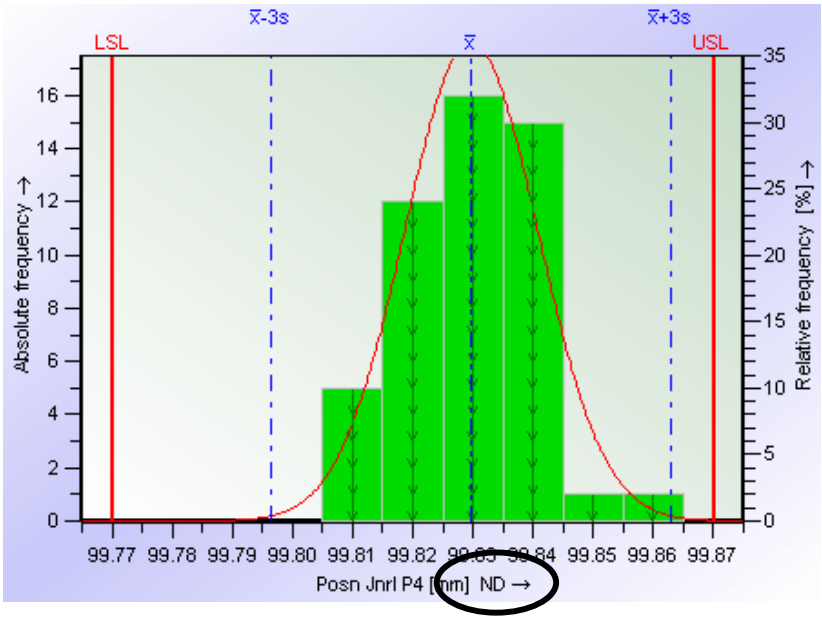
On a Histogram, the Characteristic description is found along the bottom, x-axis, of the chart.

The "Absolute frequency" scale is shown on the left side of the histogram. This scale is the actual number of values that fall within each column of the histogram.
The "Relative frequency" axis is displayed on the right side showing what percentage of the values fall in each column.
For example, according to the Absolute frequency scale, sixteen values fall in the topmost column, whereas approximately 32% of the values fall in that column according to the Relative frequency scale.

☞ *Absolute frequency vs. Relative frequency*

3. As long as the Absolute frequency scale is on, a value plot can be overlaid on the histogram. Click the "Special" icon and the "Actual value plot on/off" icon to turn the value plot on as seen on the following page.

Special



Histogram with Value plot overlaid

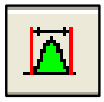
The histogram in the example above for Position Journal P4 is a Normal Distribution (ND). qs-STAT automatically selects the best fit distribution model for the data based on the statistical evaluation method selected by the customer or recommended by Q-DAS. This setup can be found in the “Configuration of Evaluation” which is under the “Options” pull down menu.

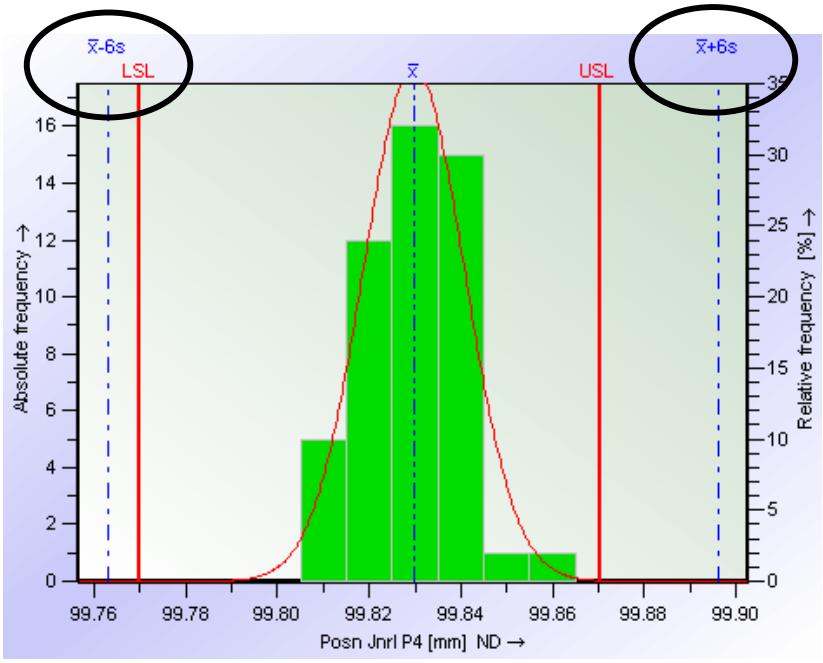
The following information regarding Quantile limits applies solely to data that is normally distributed.

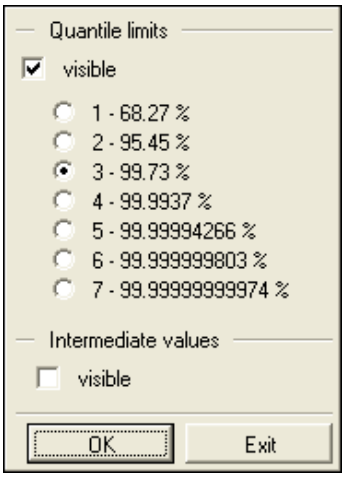
The default setting on the histogram shows blue dashed lines for the “average ± 3 sigma.” 99.73% of the data is predicted to fall within these lines, based on the process model. These lines can be changed from one sigma up to seven sigma, although three sigma is the standard.

4. Click on the “Quantile limits” icon to change the visible limits from 3-99.73% to 6-99.999…%

Quantile limits







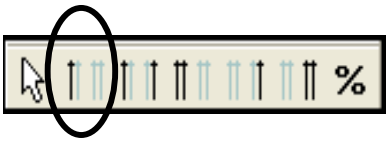
The table below refers to Process Capability, P_{pk}, for various quantile limits. The table can be interpreted as follows: for the above data set to reach a P_{pk} of 2.00, the specification limits would have to be opened up to the ± 6s lines or the variation would need to be reduced to comply with the current specification limits. With a capability of 2.00 ± 6s, the probability is that 0.001 parts per million would be out of specification.

Ppk	Probability
1.00 ± 3s	2700 ppm
1.33 ± 4s	63 ppm
1.67 ± 5s	0.6 ppm
2.00 ± 6s	0.001ppm

Another feature available on the histogram is the C-value function. This feature graphically interprets the capability of the process.

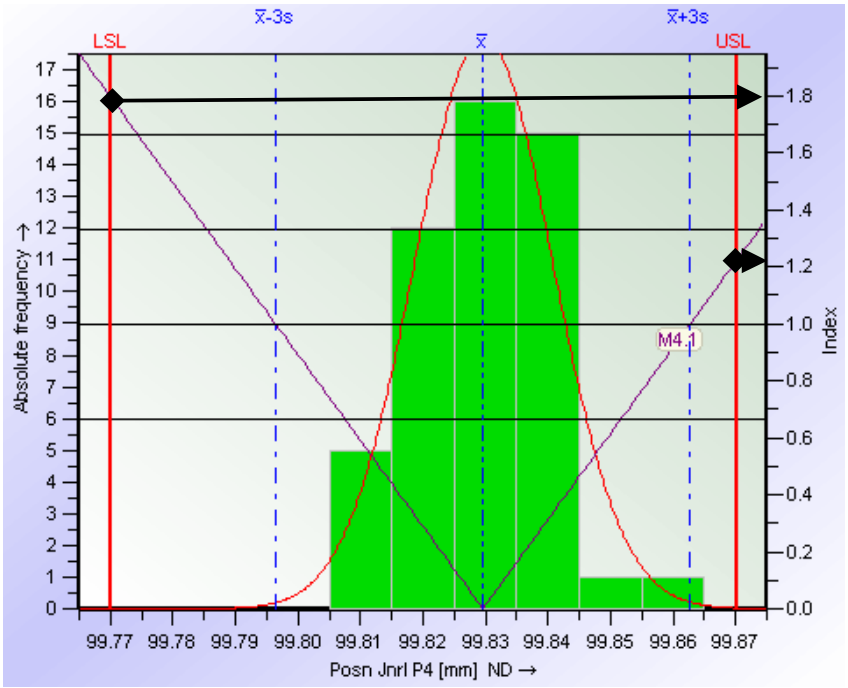
Additional data axis

5. First turn off the Relative value axis on the right side of the histogram. Click on the "Additional data axis" icon and select the first option.



C-value function

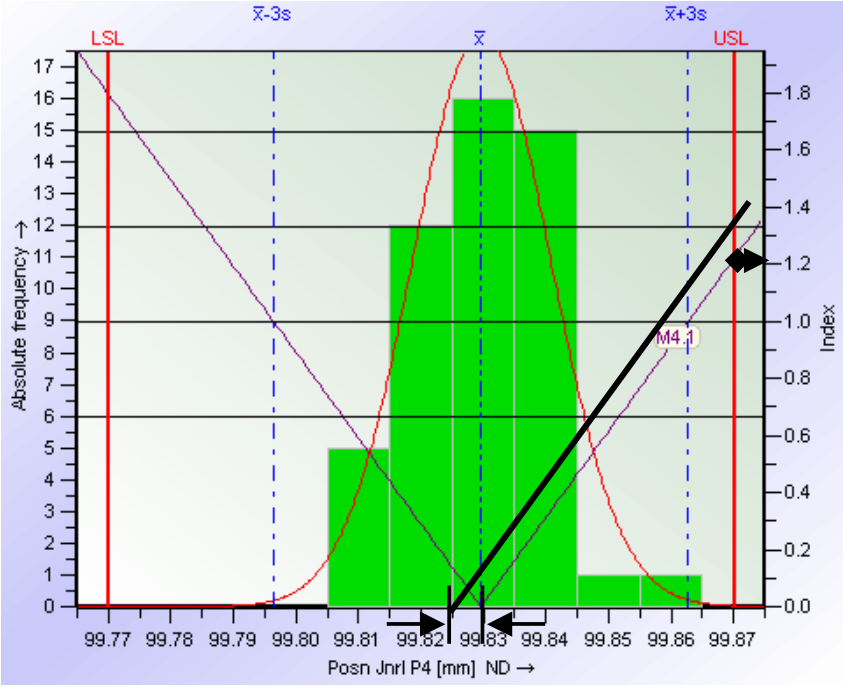
6. Now click the "C-value function" icon and select Calculation method: $M4_1$ Percentile



The C-value function uses the Percentile method to calculate the green V line seen above. Locate where this line intersects the USL and the LSL, using the Index scale to the right. The minimum of these two results is the capability of the process. In this case, the results are approximately 1.8 and 1.2, therefore the capability is 1.2

The C-value function can also be used to estimate what setting adjustment to make in order to reach a required capability.

For example, if the requirement is a minimum capability of 1.33, the graphic below shows that the process is just below the requirement with a capability of 1.22. To estimate the adjustment needed, imagine a line parallel to the interceptor at the 1.33 index and extended to the value axis. The difference between this point and the process average is the minimum setting adjustment, assuming the process variation gets no larger.



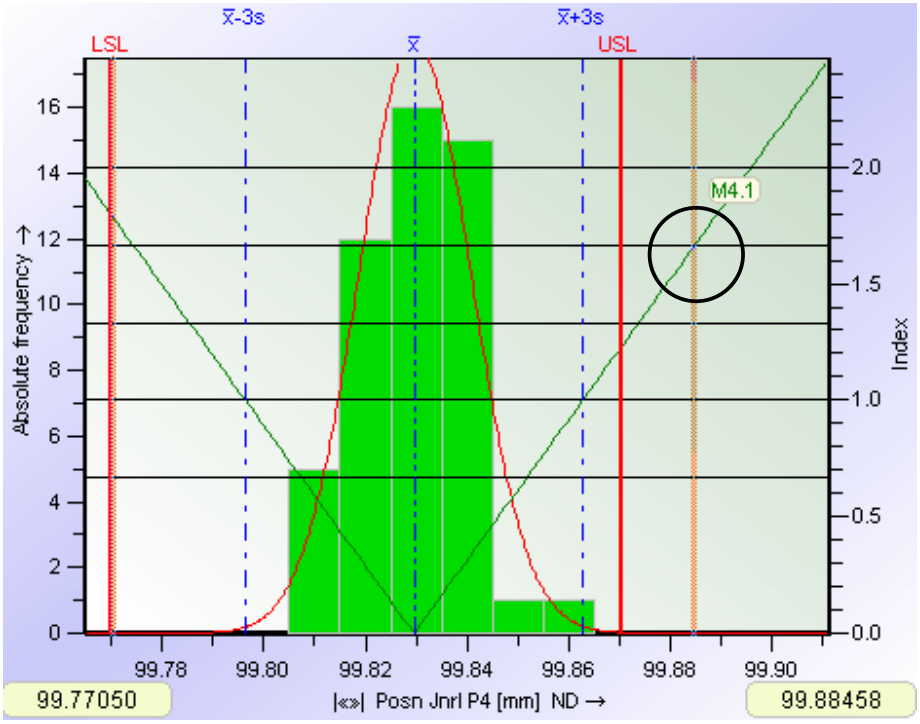
☞ *Estimating setting adjustments using the C-value function*

From another perspective, the C-value function can be used to estimate what the tolerance would need to be increased to in order to reach a required capability index.

In this example, set the capability requirement at 1.67. Use the zoom function (horizontally) to zoom out beyond the USL to the intercept of the green V line with the 1.67 index.

According to the graphic below, the tolerance would need to be moved from 99.87 to 99.885 in order to meet a capability requirement of 1.67.

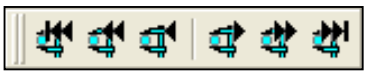
Turning on the 5th quartile will achieve the same results as using the zoom function, in this case.

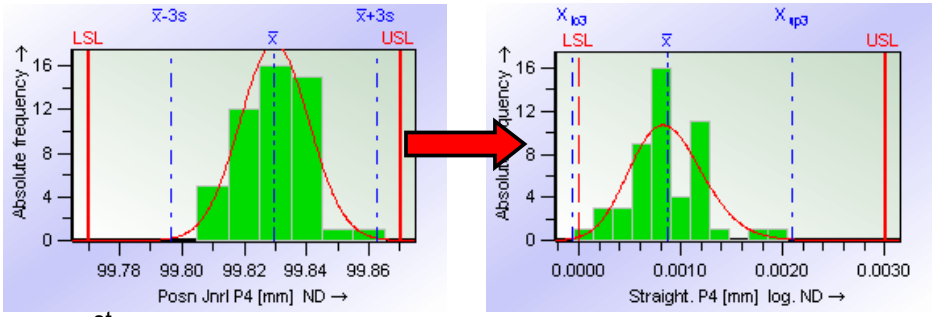


Turn off the C-value function by clicking on the icon again and selecting Exit.

Navigating Charts

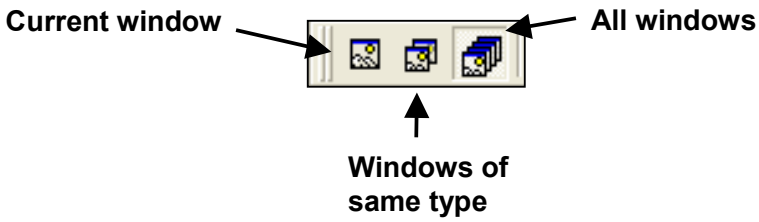
7. Use the arrow icons below to move forwards or backwards through the characteristics.





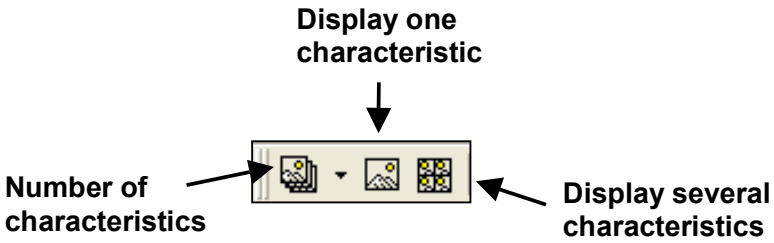
1st characteristic last characteristic

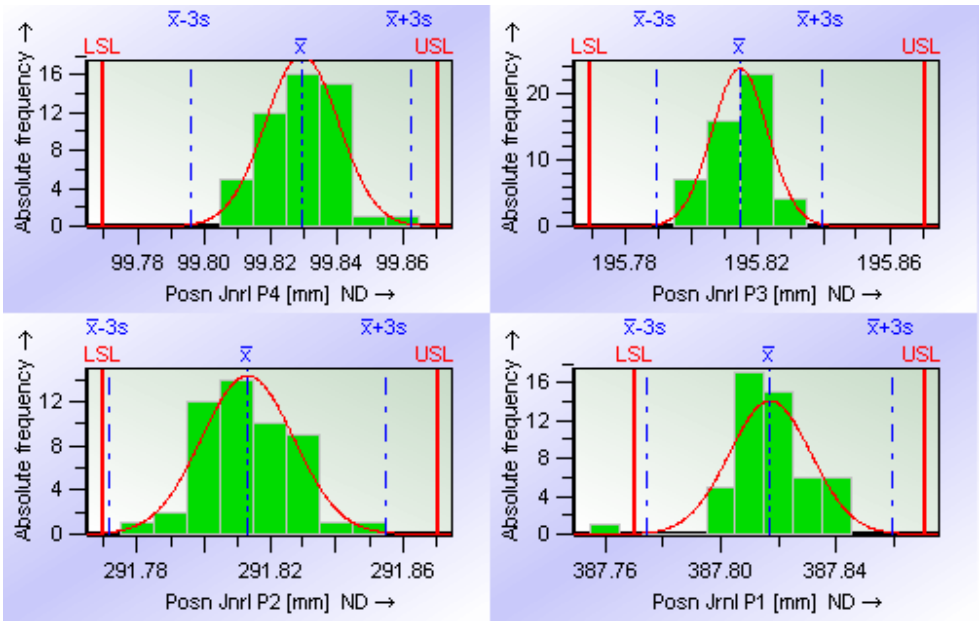
If several charts, such as a value chart and histogram, are both open be sure to click the “All windows” icon when scrolling through the characteristics so the charts move forwards/backwards together.

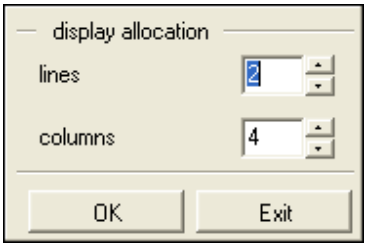


Multiple charts

8. Click the “Display several characteristics” icon to display multiple charts. Determine the number of charts to display by clicking the arrow on the “Number of characteristics” icon.

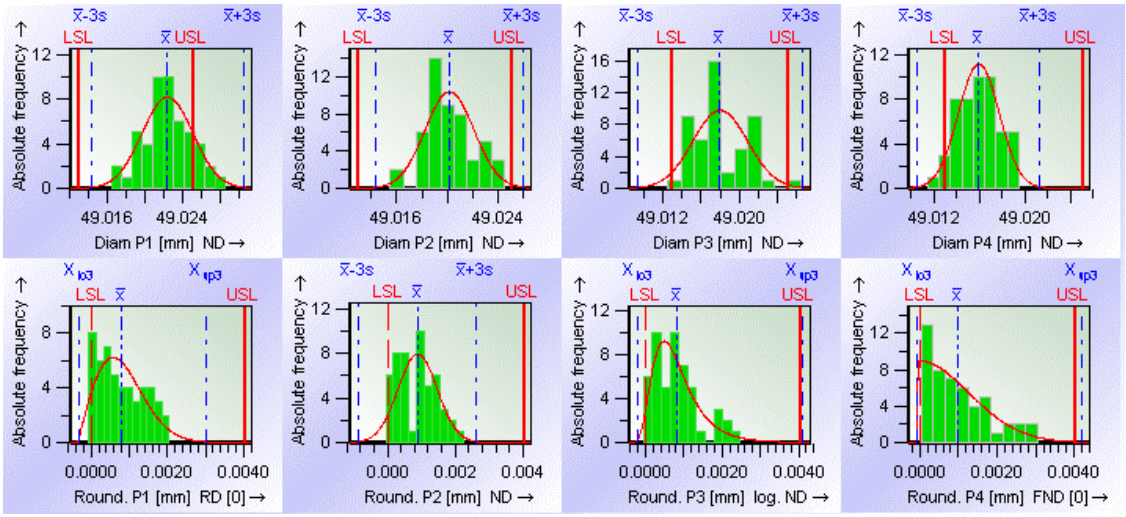




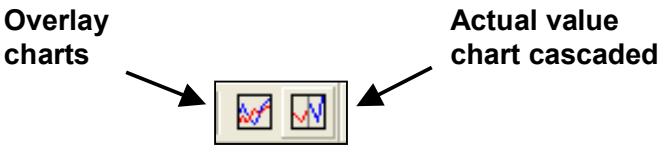


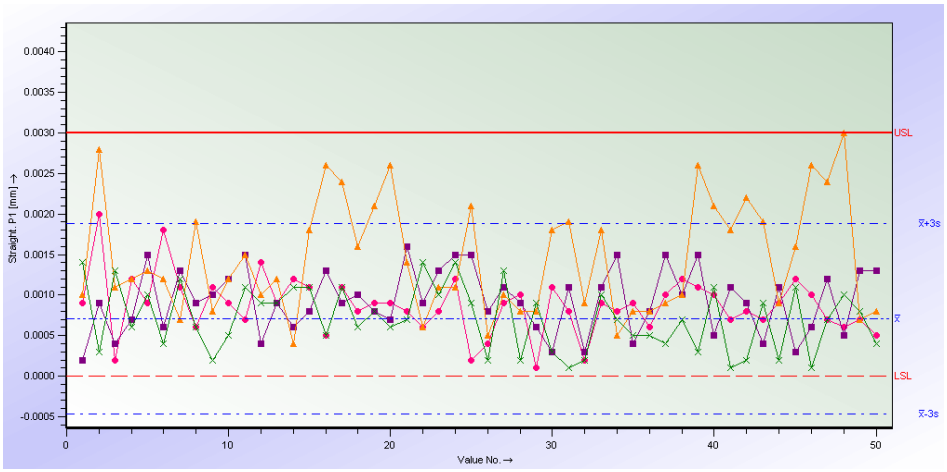
The multiple graphics can also be displayed by number of rows (lines) and number of columns.

9. Click the “Number of characteristics” icon and select 2 lines, 4 columns. Scroll through the characteristics so the four Pin Diameters are on the first line and the four Pin Roundness’ are on the second line.



10. On the Value chart, move to the Straightness characteristics and click the “overlay charts” icon. The resulting graphic is on the following page.

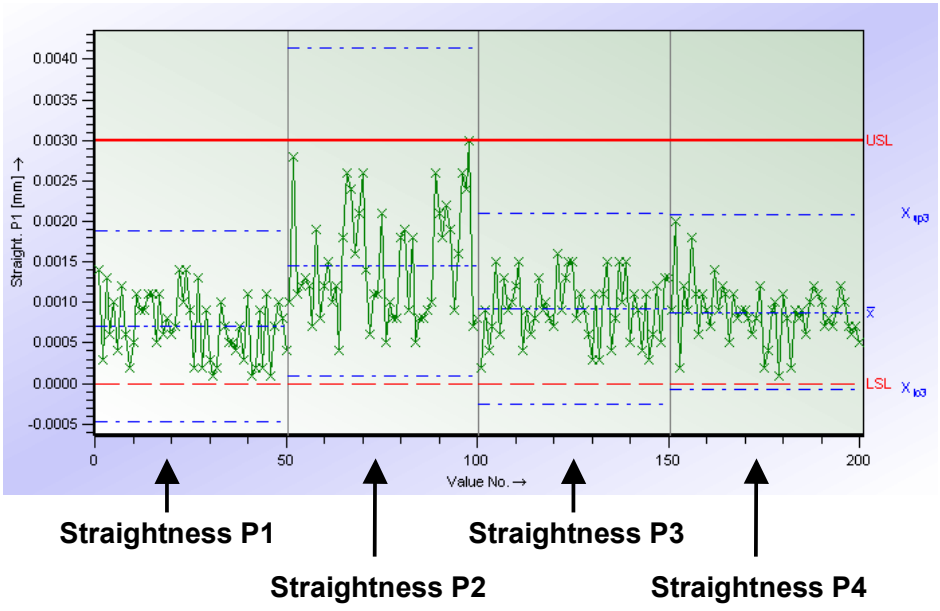




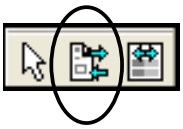
Value chart overlay (Straightness P1-P4)

Use the Lines / Symbols etc. icon to change the colors and symbols of the four lines.

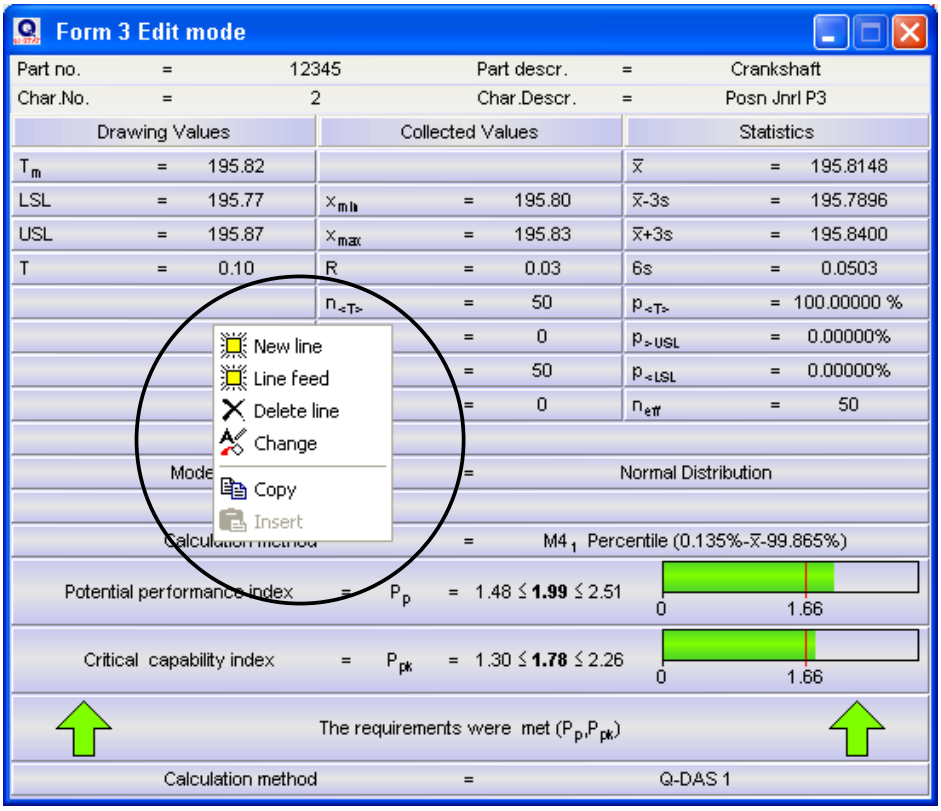
11. Similar to the overlay is the actual value chart cascaded, seen below. This displays the four Pin Straightness' one after another.



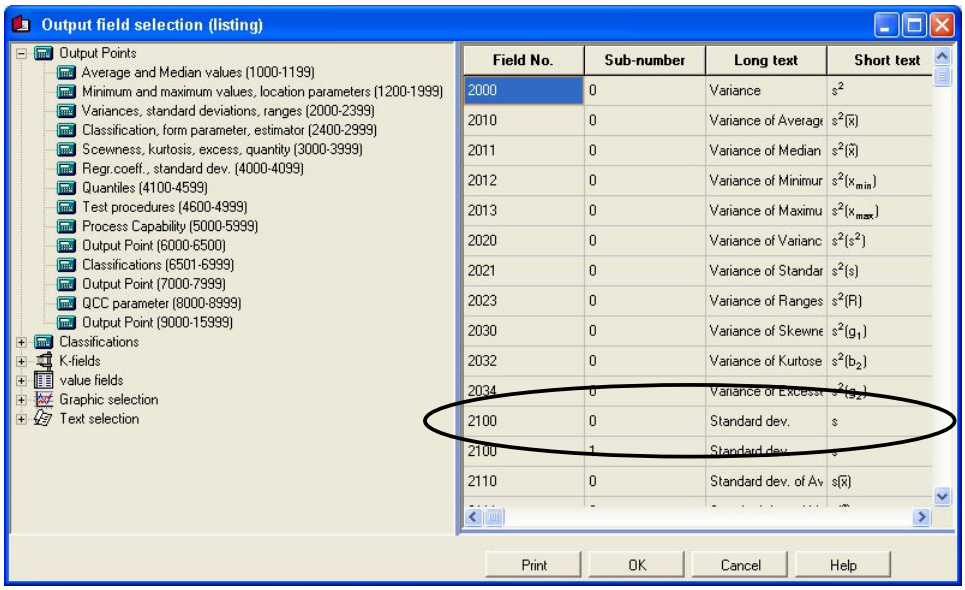
The available options for Value charts and Histograms have now been discussed. Next take a look at how to edit Form sheets.



12. Open up Form sheet 3 from “Numerics.” Click the “Special” icon and the “Edit mode on/off” icon. Right mouse click on a blank cell in the form sheet, and the options will appear as seen below; select “Change.”



In the ‘Configuration” window, click the “Selection” button for the “Output field selection (listing).” From here select an output point, such as standard deviation, and click OK. The standard deviation will now appear on the form sheet.



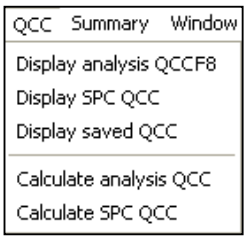
Available fields for the Form sheets

Part no.	=	12345		Part descr.	=	Crankshaft	
Char.No.	=	2		Char.Descr.	=	Posn Jnrl P3	
Drawing Values			Collected Values			Statistics	
T_m	=	195.82				$\bar{x}$	= 195.8148
LSL	=	195.77	x_{min}	=	195.80	$\bar{x}$-3s	= 195.7896
USL	=	195.87	x_{max}	=	195.83	$\bar{x}$+3s	= 195.8400
T	=	0.10	R	=	0.03	6s	= 0.0503
			$n_{<T>}$	=	50	$p_{<T>}$	= 100.00000 %
s	=	0.0083885	$n_{>USL}$	=	0	$p_{>USL}$	= 0.00000%
			n_{tot}	=	50	$p_{<LSL}$	= 0.00000%
			$n_{<LSL}$	=	0	n_{eff}	= 50
Model distribution			=		Normal Distribution		
Calculation method			=		M4 1 Percentile (0.135%-$\bar{x}$-99.865%)		
Potential performance index	=	P_p	=	1.48 ≤ **1.99** ≤ 2.51	0	1.66	
Critical capability index	=	P_{pk}	=	1.30 ≤ **1.78** ≤ 2.26	0	1.66	
The requirements were met (P_p,P_{pk})							
Calculation method			=		Q-DAS 1		

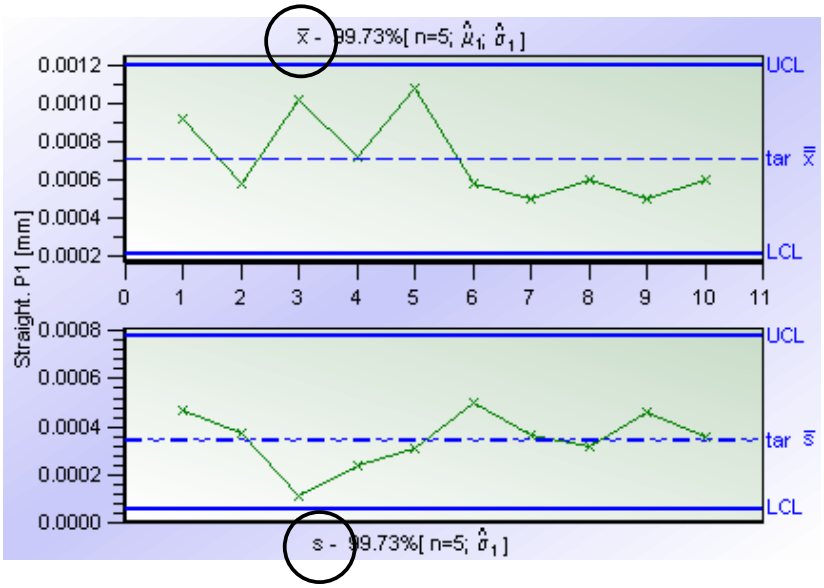
Edited Form sheet with changes

☞ *Click the Edit on/off icon again to exit the Edit mode.*

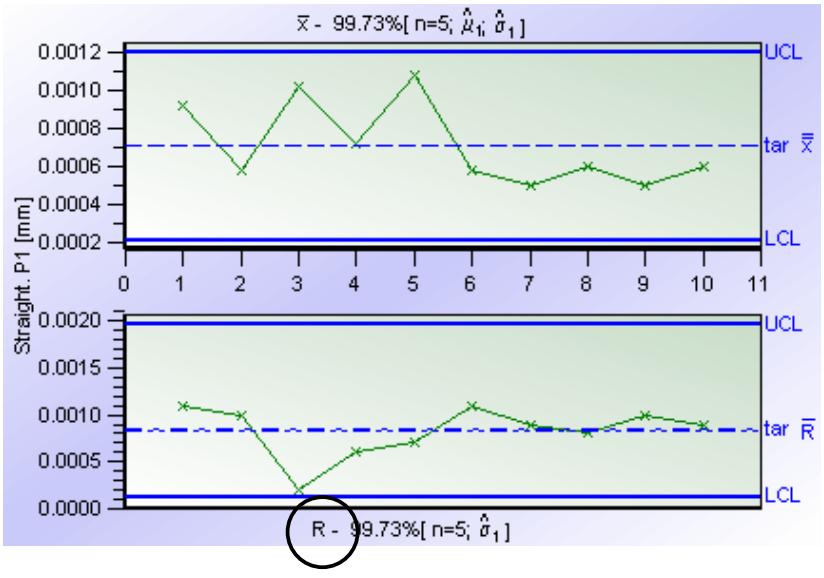
The last graphic necessary to fulfill the four steps to system acceptance is the Quality Control Chart.



12. Under the "QCC" pull down menu, select "Display analysis QCC."

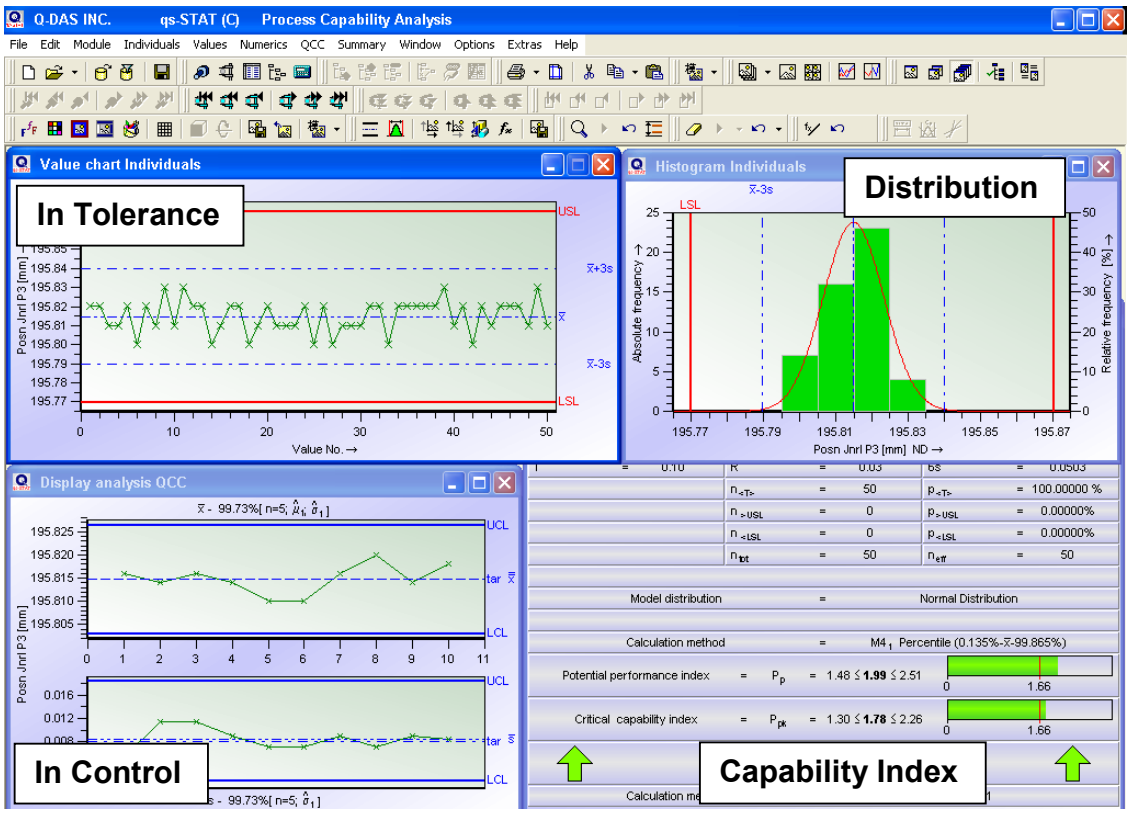


The default setting shows an x_{bar} and s chart for the average and standard deviation. This can be changed to an x_{bar} and R chart by going to the QCC – "Calculate analysis QCC." Under the variation charts folder, select "R chart (exact calculation)."

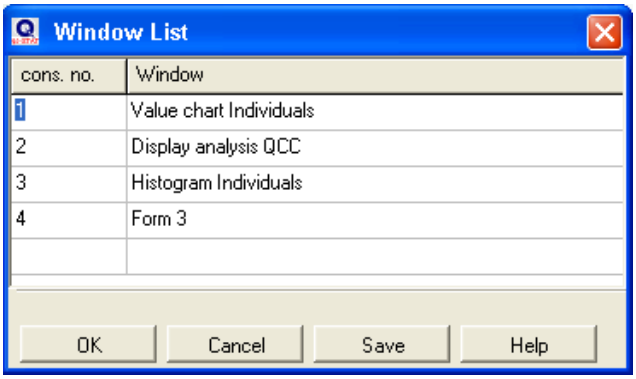


The Q-DAS Inc. suggested screen setup is seen below. It follows the Four Steps to System Acceptance:

1) In Tolerance
2) In Control
3) Appropriate Distribution Model
4) Passing Capability Indices



To save this screen setup as the default setting, go to the "Window" pull down menu and select "List." Click the Save button.



Objective:

To complete the Worked Examples for the Process Capability Module the summary graphics need to be discussed. These graphics are particularly useful for parts with multiple characteristics and allow for an overview display of information on a single graphic. The user should now feel comfortable navigating throughout qs-STAT Process capability Module.

Highlights:

☑ Box Plot

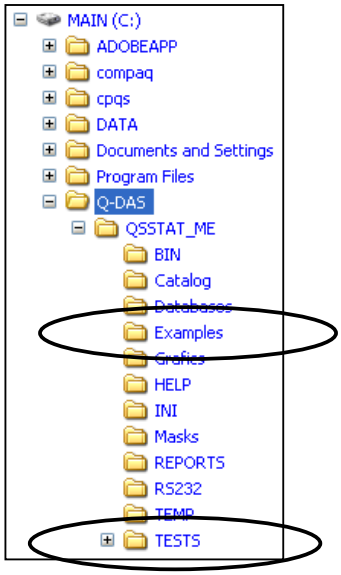
☑ C Values chart

☑ Characteristic Statistics

☑ Defects/No. of non-conforming units

Background Information:

Example test files have been created for the user in order to best demonstrate specific graphics under the Summary category. These example files can be found in one of two places; either the Q-DAS installation directory - Examples folder or the Q-DAS installation directory - Tests folder.

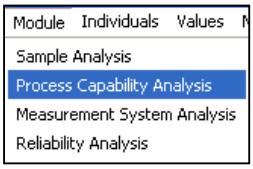


Task:

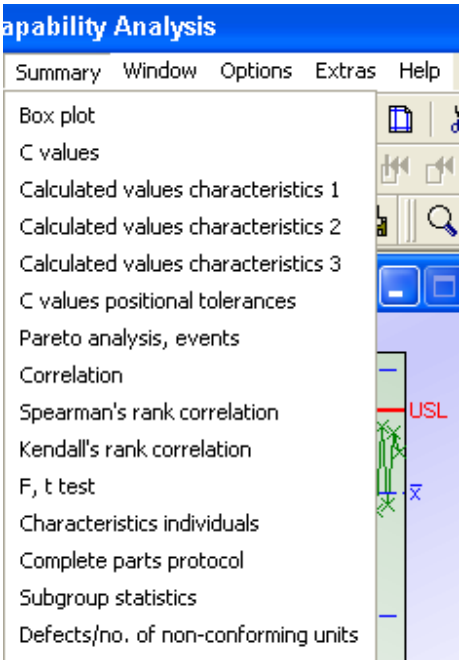
Use the following files to view the different options available for each specified Summary graphic:

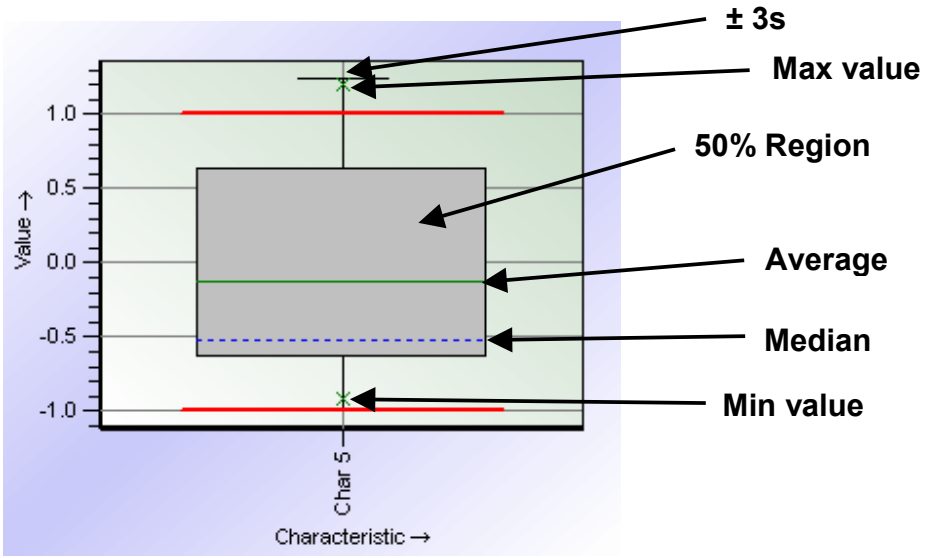
Nonconforming.dfq	Box Plot Defects/No.non-conforming units
Test_all.dfq	C Values chart Characteristic Statistics Standard Reports

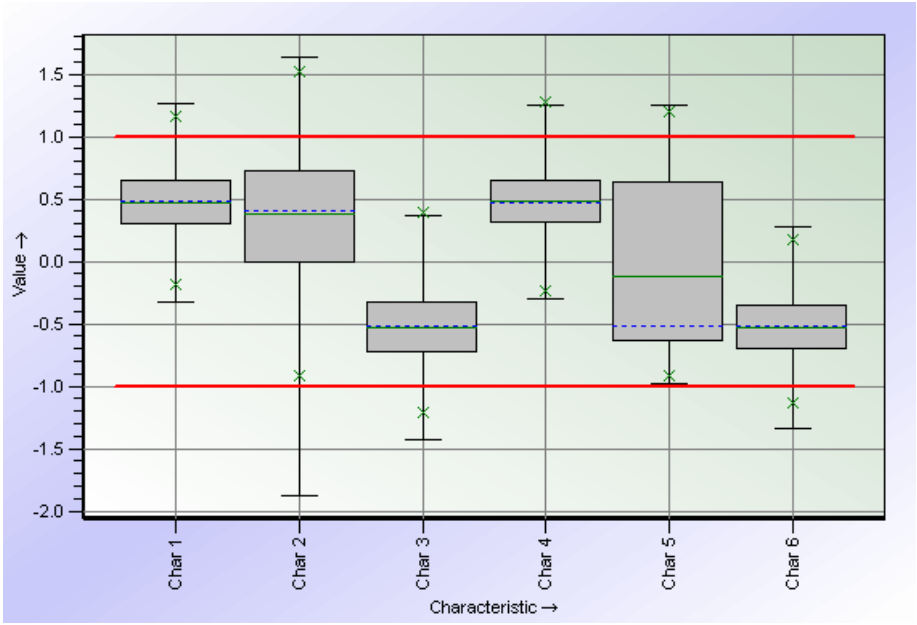
Procedure:



1. In the Module Process Capability Analysis using the file Nonconforming.dfq (Q-DAS\QSSTAT_ME\Examples), open a **Box Plot** from the Summary pull down menu.

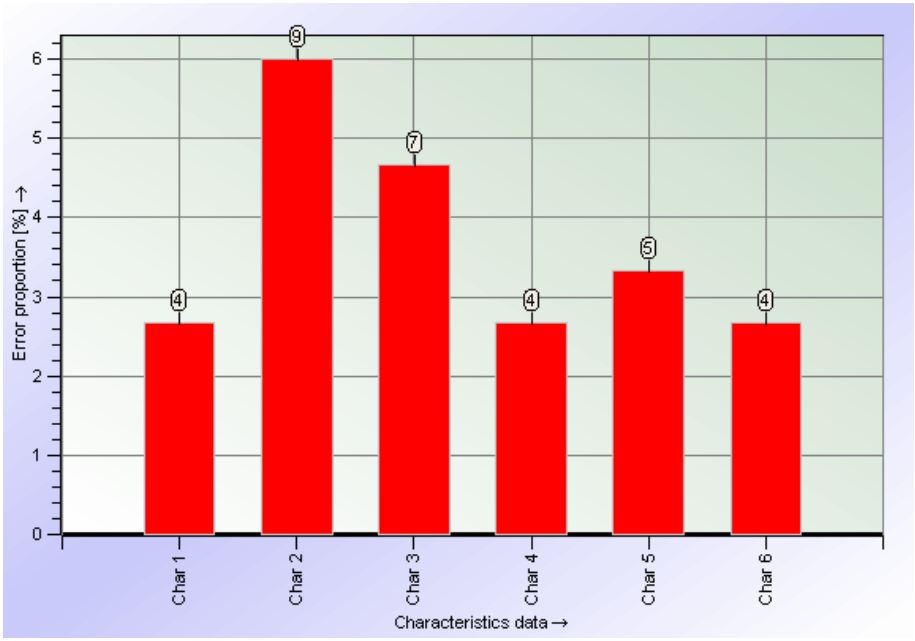






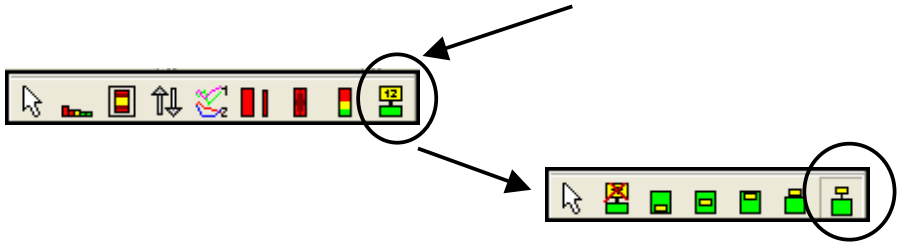
The Box Plot is shown with a Normalized tolerance for all characteristics. It portrays a good overall picture of the range and location of the data with respect to the tolerance.

2. Under Summary, open the **Defects/no. of non-conforming units** graphic.

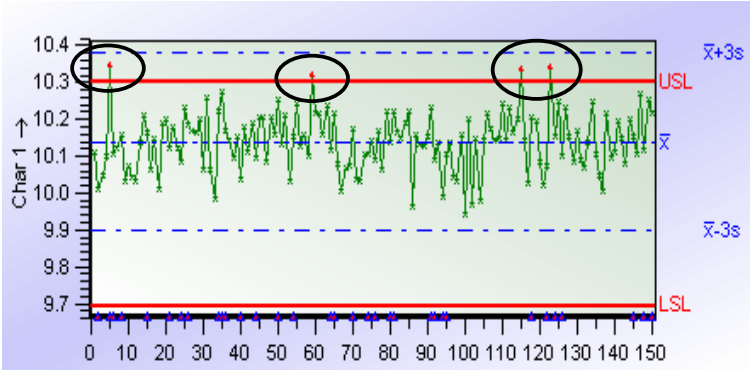


☞ *The scale on the left side shows the % of errors from the total.*
*For example: Char 1, 4/150 * 100 = 2.7*

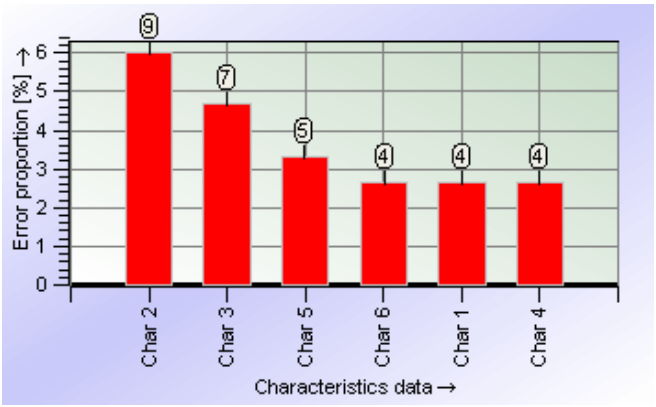
The numbers in the bubbles on top of the columns show the actual number of values that are defective or outside specification. These can be turned on by clicking the Special icon and the “No. of error on/off” icon.



Looking at the value chart for Char 1 shows that there are four values outside specification. Therefore on the Defects/ no. of non-conforming units graphic, there is a four above the column.

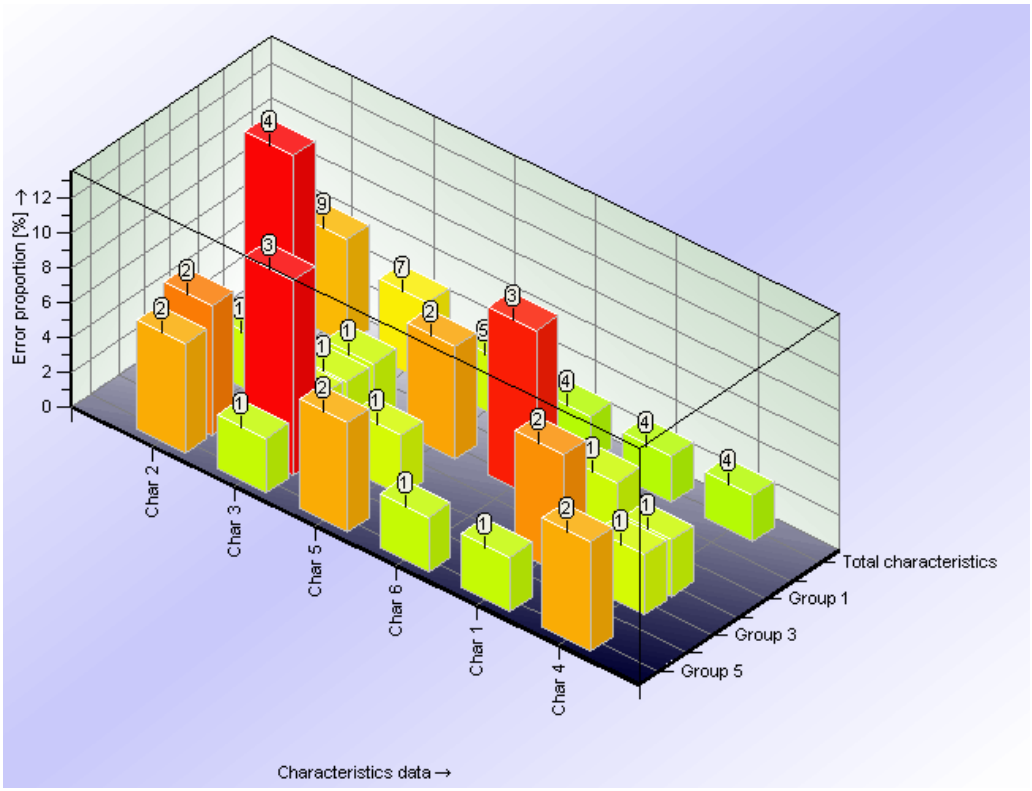


Another option is to sort the characteristics from most defects to least defects or vice-versa. To do this, click the “Sort” icon under Special.



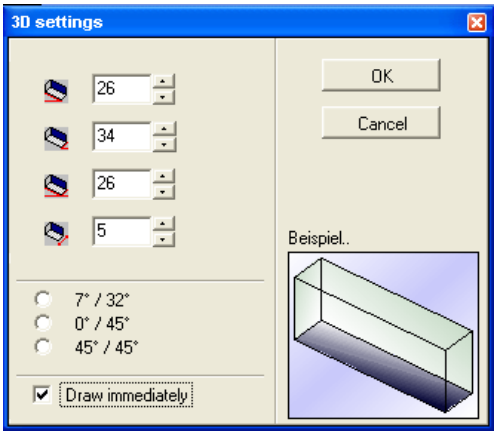
This example data (nonconforming.dfq) contains a mix of measurements from multiple machine, gages, cavities and operators. It may be useful to separate the data in this graphic by cavities, for example.

Under the Special icon, select the “Separate” icon and separate the characteristics by cavities, which is “Group numbers” according to the default catalog.

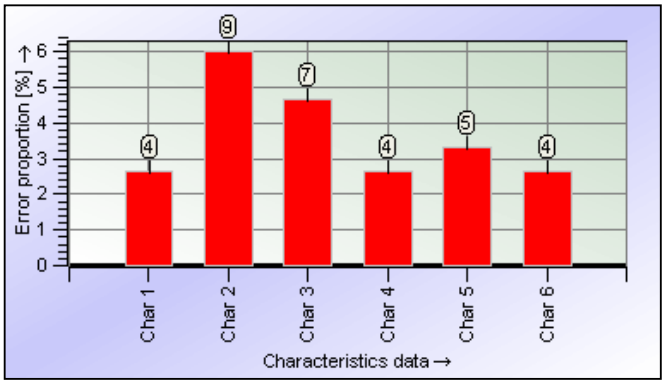


The Total characteristics column in the back row is difficult to see once the data has been separated. It is helpful to rotate the graphic and view it from above. Click the “Change display” icon, then click the “3-D display” icon.

Change display

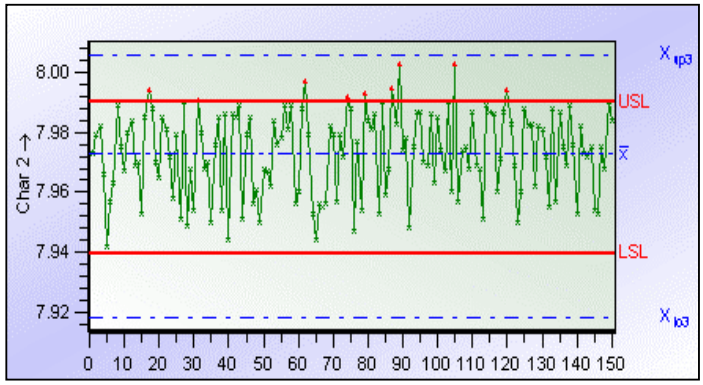


In the 3D settings window, check the Draw immediately box. This will give you a live display of the rotational changes being made. Increase the first two numbers in order to get a view from the top of the graphic such that all the rows are visible.



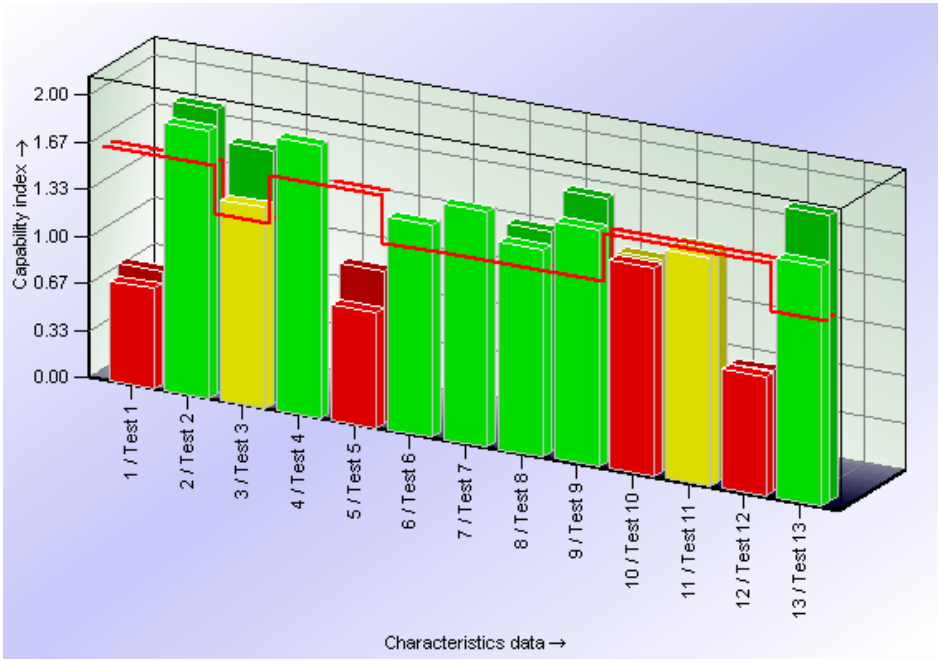
When multiple graphics are open, click this icon

to move all open graphics to the same characteristic.



To view the value chart for a specific characteristic, select the characteristic on the Defects chart, then drag-and-drop from the Defects chart to the Value chart. This will update the value chart to that characteristic.

3. Using Test_all.dfq (Q-DAS\QSSTAT_ME\TESTS), open the **C values** chart.



☞ *The back row is the Cp or Pp value, and the front row is the Cpk or Ppk value.*

The Cp or Pp abbreviation depends on your company's configuration of evaluation.

The solid horizontal red line is the required capability index for C_p/C_{pk}. The columns will then be green, yellow or red depending on whether they are above the requirement, borderline, or below the requirement, respectively.

The drag-and-drop feature used to select a characteristic and move the other graphics to that characteristic also works for the C value chart. See the explanation under the Defects/no. of non-conforming graphic information.

4. Open the **Characteristic Statistics 2** summary chart.

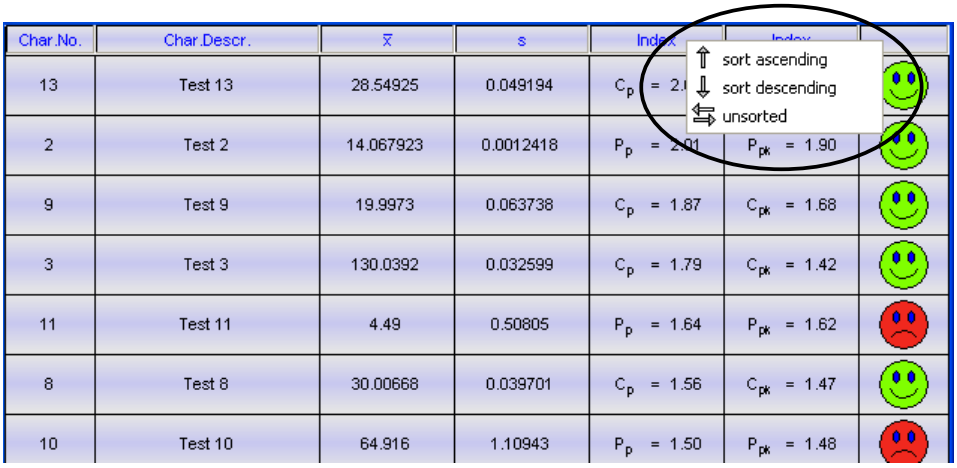
This report is similar to the C values chart but is displayed numerically instead of graphically. The green / red smiley face tells whether the required capability is being met.

Tp / Tpk signifies that the characteristic is UNSTABLE.

Characteristic # 4, 6, 7: the Cp or Pp is not calculated because they are unilateral tolerance features.

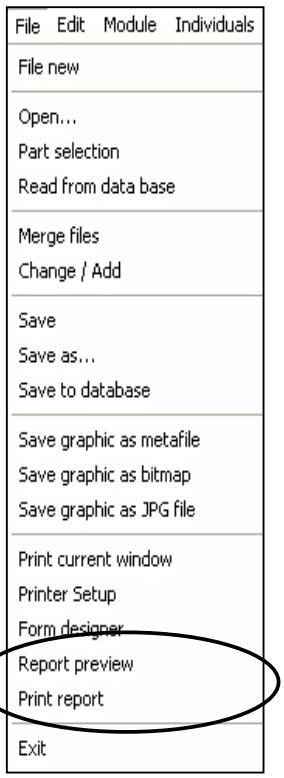
Char.No.	Char.Descr.	$\bar{x}$	s	Index	Index	
1	Test 1	20.00453	0.012554	T_p = 0.80	T_{pk} = 0.71	
2	Test 2	14.067923	0.0012418	P_p = 2.01	P_{pk} = 1.90	
3	Test 3	130.0392	0.032599	C_p = 1.79	C_{pk} = 1.42	
4	Test 4	0.50	0.36074	P_p =--- [915	P_{pk} = 1.93	--- [10]
5	Test 5	718	61.0306	P_p = 1.07	P_{pk} = 0.82	
6	Test 6	0.0253	0.013517	C_p =--- [915	C_{pk} = 1.51	
7	Test 7	0.0083	0.0046737	C_p =--- [915	C_{pk} = 1.67	
8	Test 8	30.00668	0.039701	C_p = 1.56	C_{pk} = 1.47	
9	Test 9	19.9973	0.063738	C_p = 1.87	C_{pk} = 1.68	
10	Test 10	64.916	1.10943	P_p = 1.50	P_{pk} = 1.48	
11	Test 11	4.49	0.50805	P_p = 1.64	P_{pk} = 1.62	
12	Test 12	26.4991	0.12480	T_p = 0.85	T_{pk} = 0.85	
13	Test 13	28.54925	0.049194	C_p = 2.03	C_{pk} = 1.70	

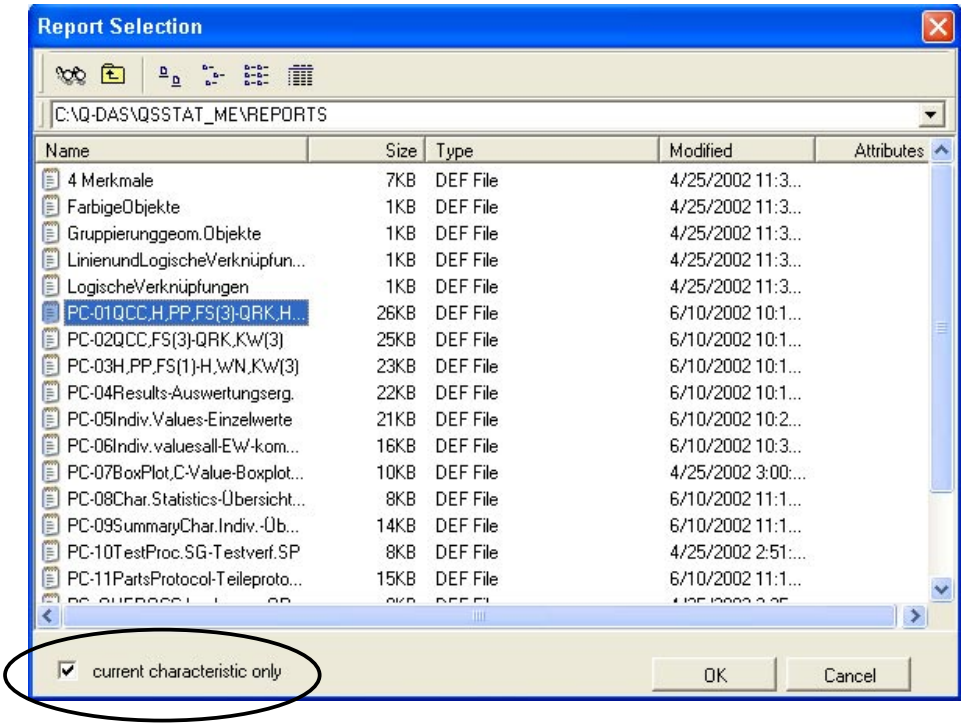
Right mouse click on one of the Index columns to sort the characteristics by ascending / descending capability.



This chart can be edited in the same fashion as the Form sheet. Under the special icon, switch the Edit mode to on. New fields or columns can be added from there to customize according to your needs.

5. The software comes with a default set of **Standard Reports**. These reports can be found under the File pull down menu, either "Report preview" or "Print report." Choose the PC-01 report from the selection.





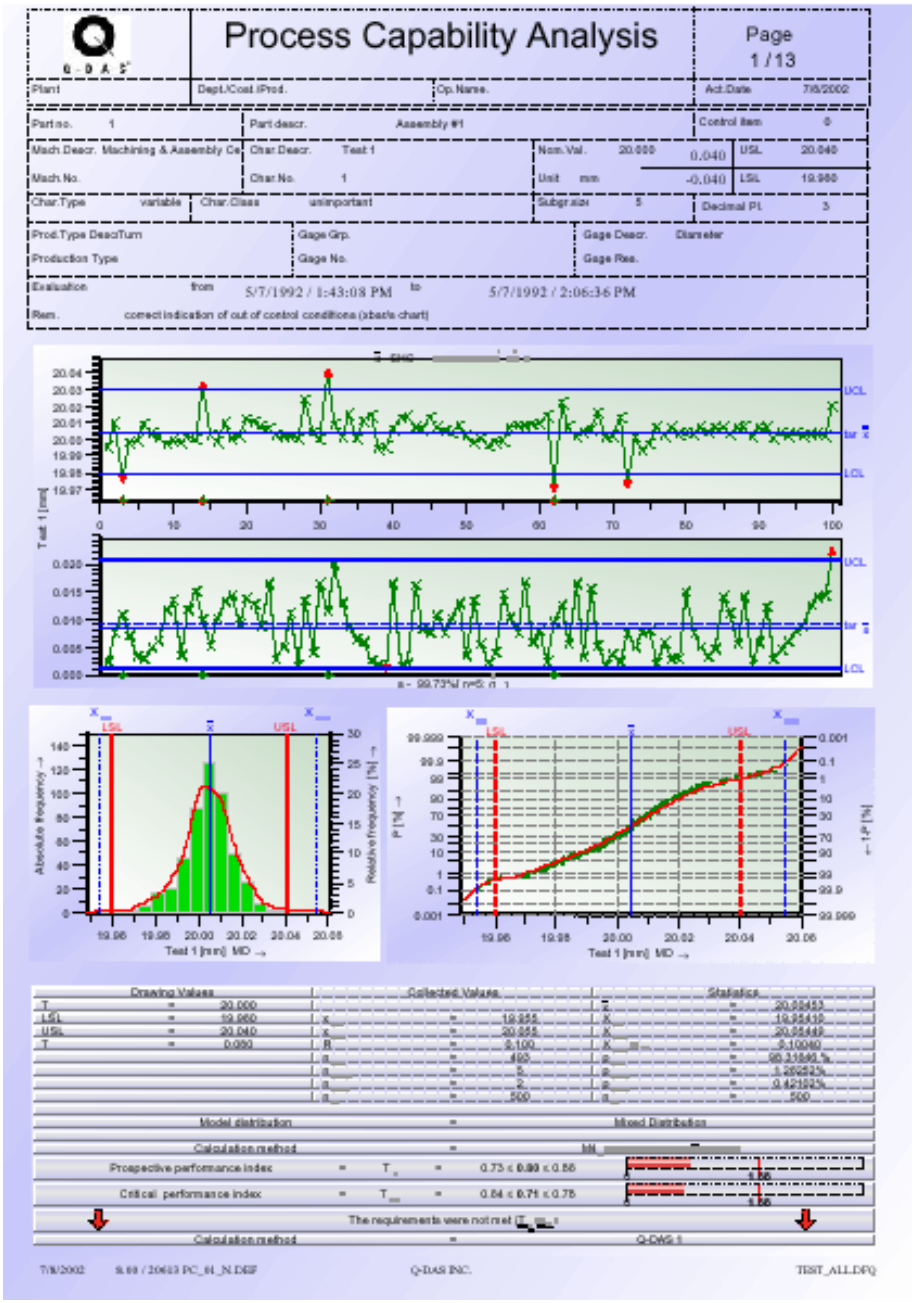
After highlighting the chosen report, check the box for "current characteristic only." If this is not checked, qs-STAT will print the chosen report for all active characteristics in the file.

PC-01 is a one page report including a Quality Control Chart (QCC), Histogram (H), Probability Plot (PP), and Form Sheet 3 (FS3). This report can be seen on the following page.

Some of the other reports such as "PC08 Char. Statistics" are summary reports that give details for all characteristics on one page.

Additional reports can be created by the user with the help of the Form Designer.

Summary Graphics



PC-01 QCC,H,PP,FS(3)

Objective:

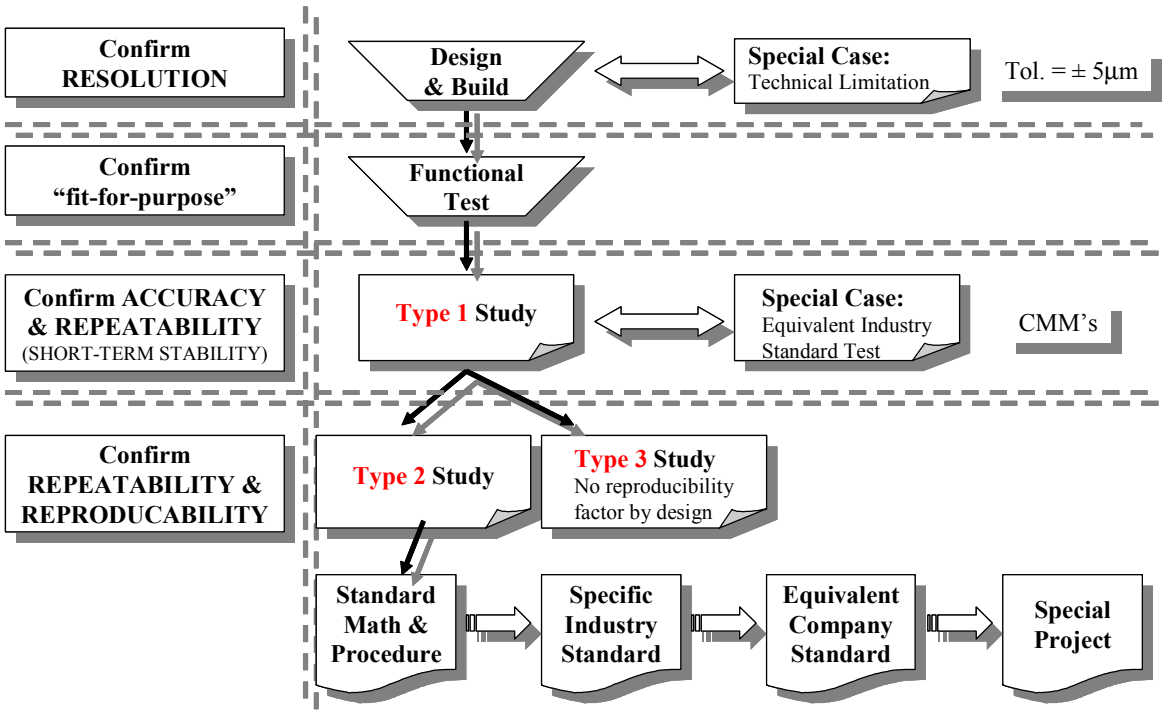
The goal of this task is to demonstrate the recording data interface and graphical features of the Measurement System Analysis Module (MSA). Three common gage studies will be outlined with a demonstration of how to configure qs-STAT for each. Typical requirements and graphics used in determining the capability of a measurement system will be discussed.

Highlights:

- ☑ Parts, Characteristics, Values Masks
- ☑ Data Handling
- ☑ Type 1, 2, 3 Study
- ☑ Value charts – Deviations / Variations
- ☑ Cg / Cgk

Background Information:

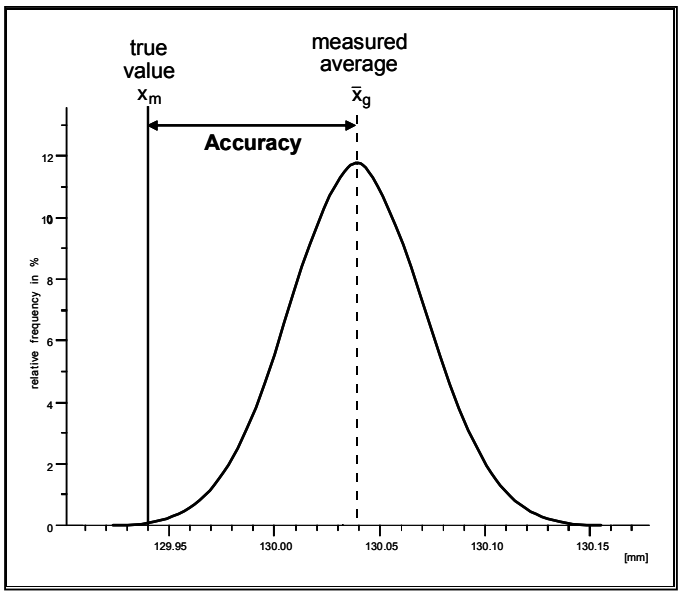
qs-STAT MSA module has been designed to comply with company standard and other industry related specifications for measurement system acceptance studies. The following three gage studies are the most common and will be discussed at length: Type 1, Type 2, and Type 3 Study. Note that additional gage studies have been incorporated into qs-STAT but will not be discussed at this time. Refer to your company's specifications for further details.



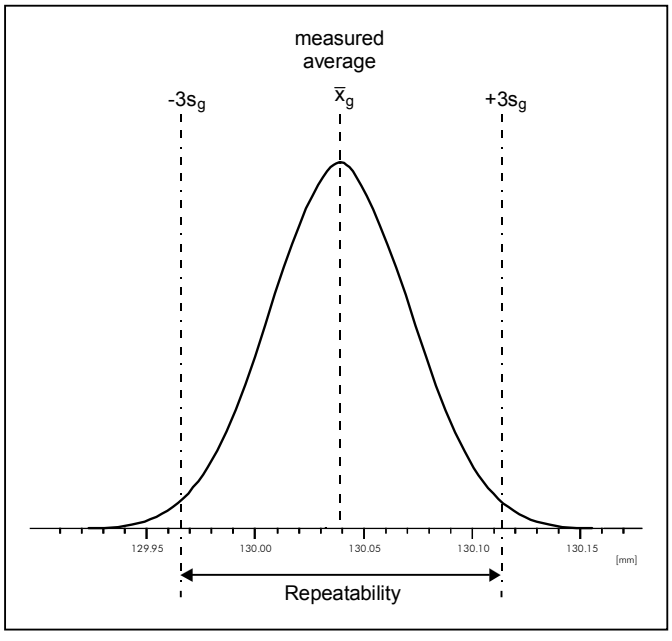
Type 1 Study –

Accuracy, Repeatability & Short Term Stability

Typically: 1 Part (known value), 50 Trials

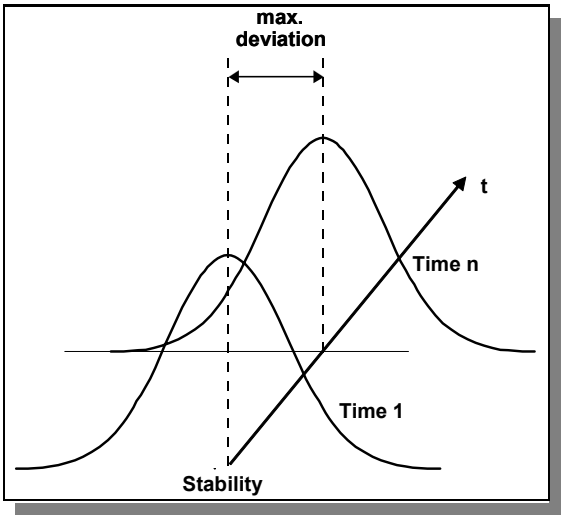


Accuracy is the difference between the average of the measured values and the true value of the master.



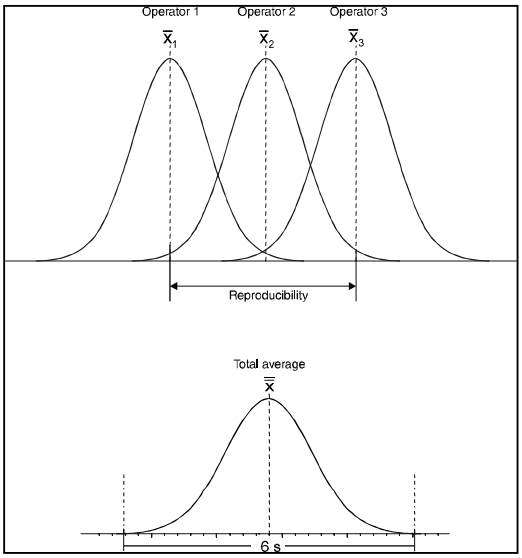
☞ *The standard deviation of the measured values is used to calculate Repeatability.*

Repeatability checks whether a gage can read the same value over and over again.



Stability measures the change in the average over time and for this reason is typically used in production phase.

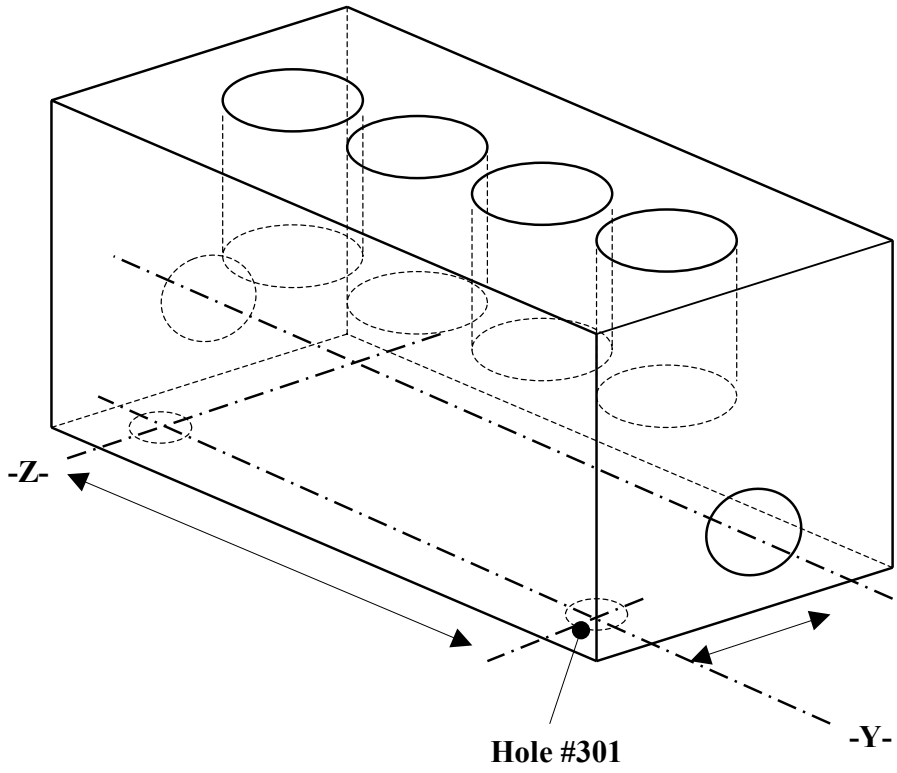
Type 2 Study – Repeatability & Reproducibility (R&R)
Typically: 10 Parts, 3 Operators, 3 Trials



☞ *Reproducibility is a measure of the overall variation with respect to the overall average.*

Reproducibility checks whether multiple operators can reproduce the same gaged results as one another.

Type 3 Study – Repeatability (special case of a Type 2, for a gage with NO Operator Influence)
Typically: 25 Parts, 2 Trials



Task:

Using the feature Hole #301 Diameter from the part sketch above, create a file in MSA module for a Type 1 study and view the results.

As a separate task, create a file for a Type 2 Study of the same feature and view these results.

The descriptions, tolerances and measured values for both the Type 1 study and Type 2 study are as follows:

Part No.	54321
Part Descr.	Op. 20 Block

Char. No.	H301D
Char. Descr.	Hole 301 Diameter
Nominal	---
USL	14.400
LSL	14.150
Units	mm

Additional Information:

Type 1 Study	
Resolution	0.001
Actual value	14.275

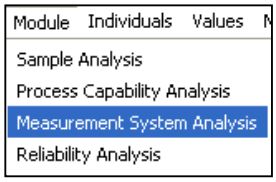
Block	Hole 301 Diameter
1	12.270
2	14.284
3	14.293
4	14.284
5	14.269
6	14.281
7	14.272
8	14.280
9	14.261
10	14.282
11	14.283
12	14.270
13	14.262
14	14.269
15	14.273
16	14.267
17	14.272
18	14.262
19	14.272
20	14.276

Additional Information:

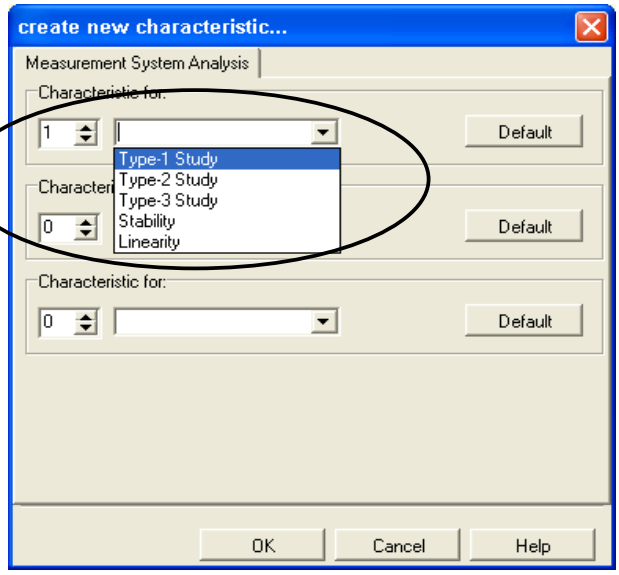
Type 2 Study	
Resolution	0.001
# parts	5
# operators	2
# measurements (trials)	3

	Operator 1			Operator 2		
Block	**Meas. 1**	**Meas. 2**	**Meas. 3**	**Meas. 1**	**Meas. 2**	**Meas. 3**
1	14.263	14.273	14.269	14.285	14.278	14.281
2	14.278	14.244	14.292	14.28	14.276	14.275
3	14.269	14.242	14.296	14.249	14.267	14.278
4	14.252	14.276	14.261	14.254	14.269	14.284
5	14.272	14.25	14.241	14.258	14.265	14.258

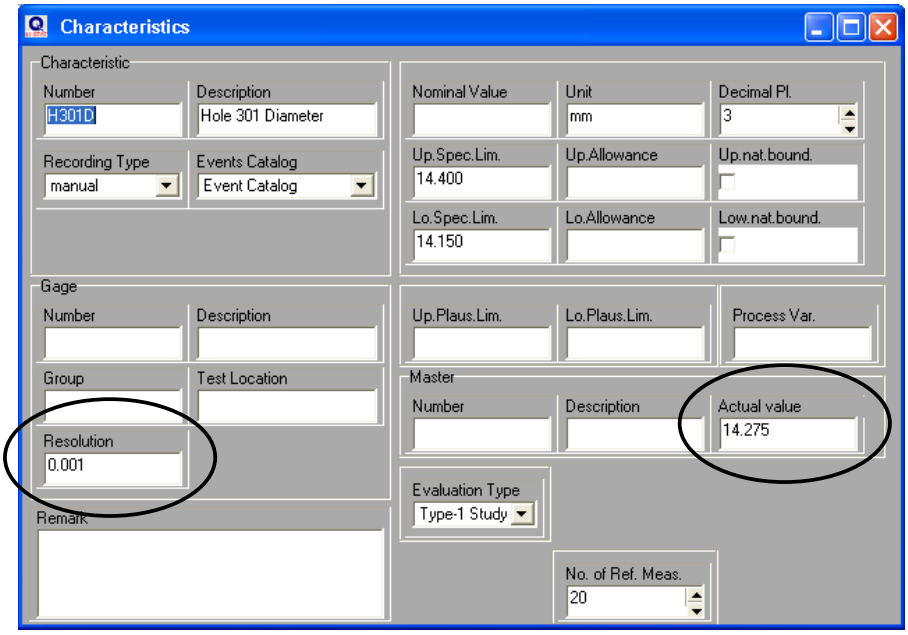
Procedure:



1. Switch to the Measurement System Analysis Module, then select “File new.” Create one new characteristic for a Type 1 Study.



2. Input the appropriate Part / Characteristic information.



For a Type 1 Study, the Resolution and the Actual value must be recorded in order to calculate the capability of the measurement system.

Resolution is the smallest scale graduation or digital unit of the measurement device.
Typical requirement for the resolution is:

Resolution / Tolerance * 100% < 5%
(resolution is less than five percent of the total tolerance)

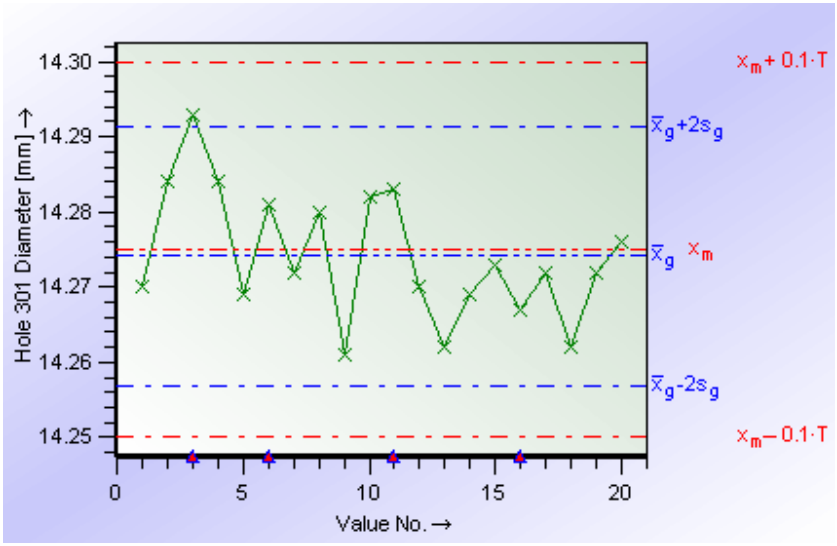
Actual value is the known value of the master part that is being measured repeatedly.

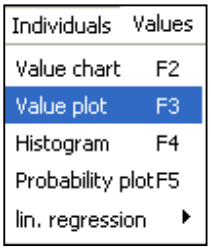
3. In the Value Mask, type in the measured values for the 20 blocks.

4. Click the “Execute evaluation” icon to calculate the results for this measurement system. Close down the three masks and open a Value chart Individuals.

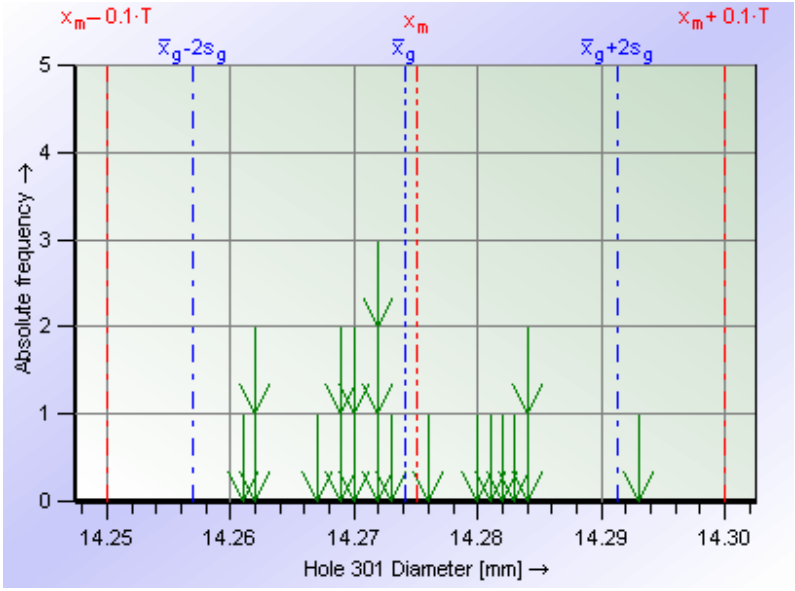
Execute evaluation

On the value chart, the Upper and Lower specification limits are turned off. This is because a Type 1 Study refers to the master value (x_m) ± 10% Tolerance.



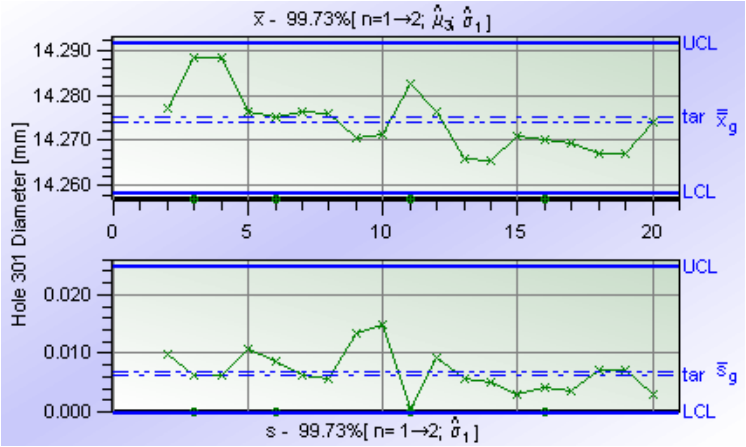


5. The Value Plot (Individuals pull down menu) can be used to check the gage resolution. Each green arrow is a measured value.



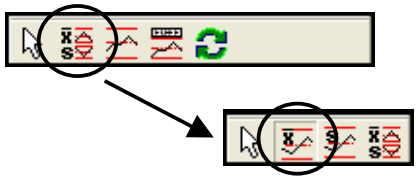
A typical requirement for gage resolution is less than 2% of Tolerance is acceptable.

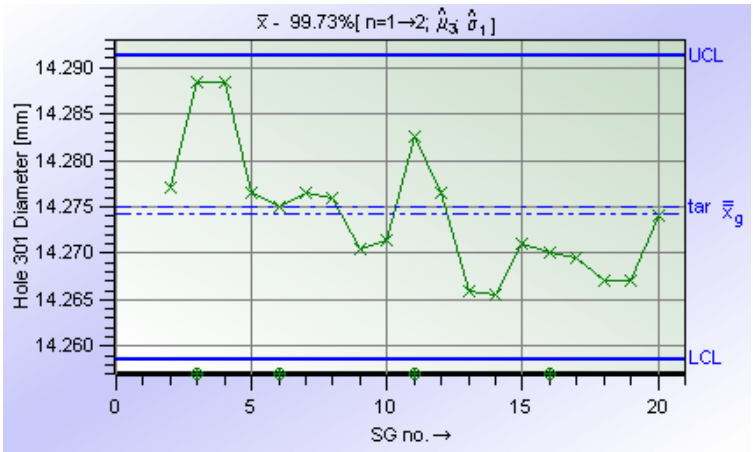
6. To check the Stability of the measuring system, open a Quality Control Chart.



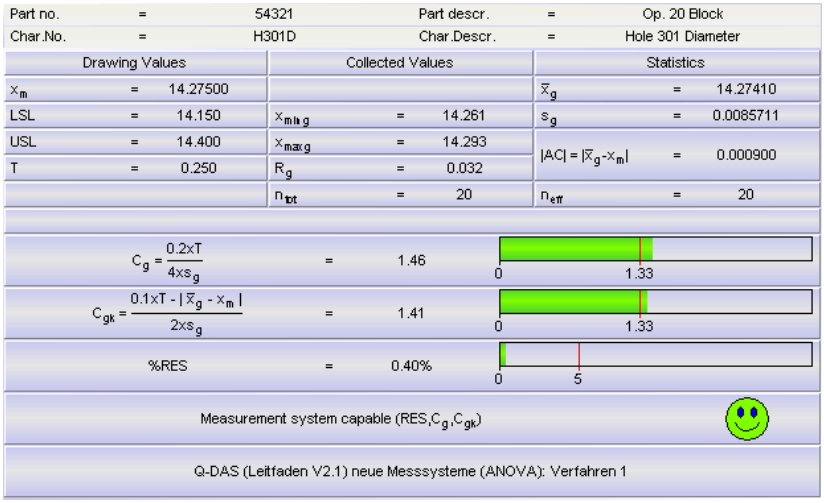
The chart will show both the moving average and moving standard deviation. This can be seen at the top or bottom of the graphic, n=1→2. For stability we are only interested in the moving average chart.

7. Turn off the moving standard deviation chart using the "Special" icon and click the "Display location and variation chart" icon. Then select the icon that only shows X_{bar}.



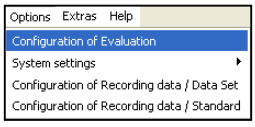


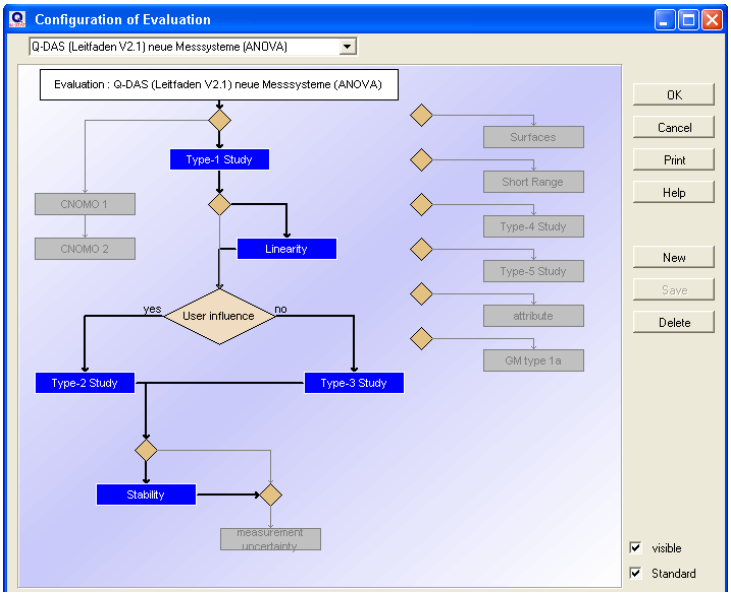
8. Open Form 1 to view the capability indices C_g / C_{gk}.



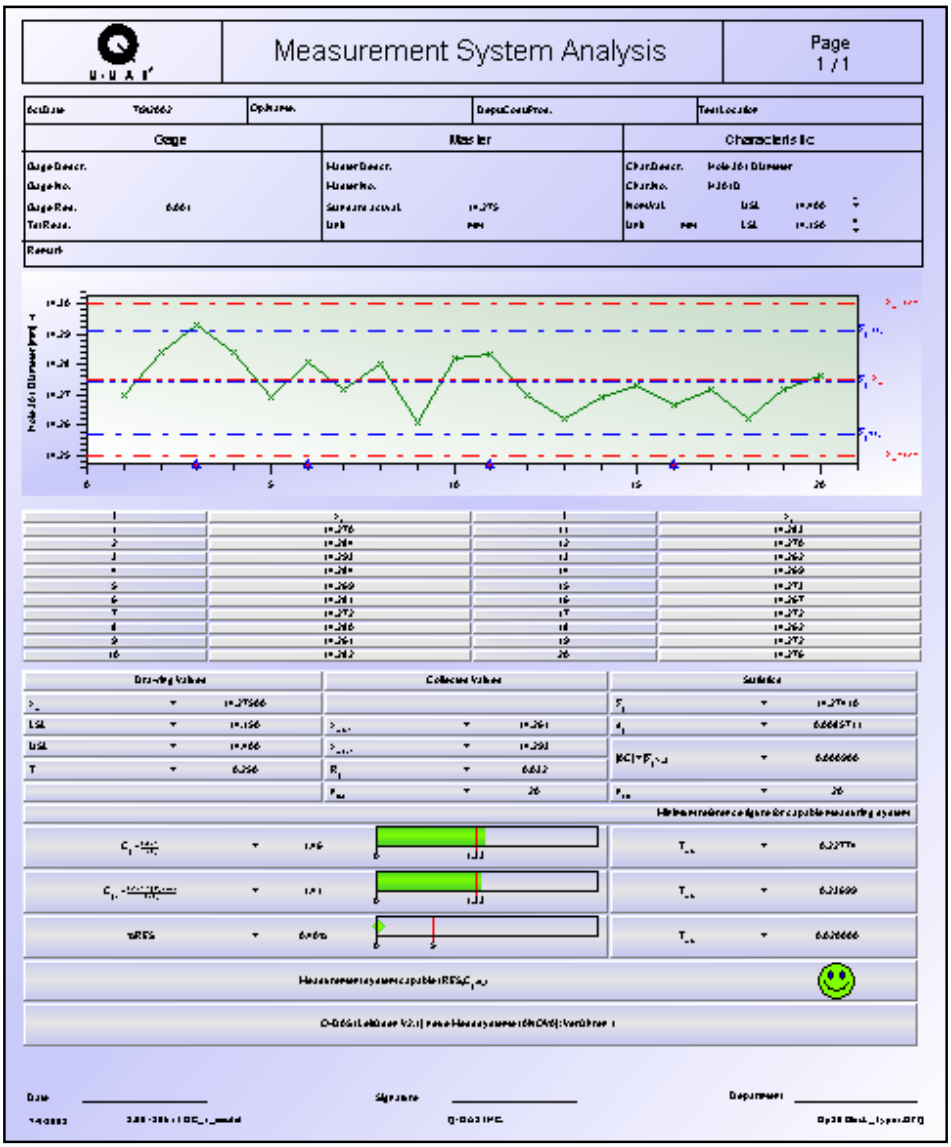
Form 1 shows the calculations for C_g / C_{gk} as well as the requirements which are set at 1.33 for this configuration of evaluation. The green bars and smiley face show that the measurement system is capable based on C_g, C_{gk} and resolution.

If these calculations or requirements do not meet your company's standards, you can make changes in the "Configuration of Evaluation."

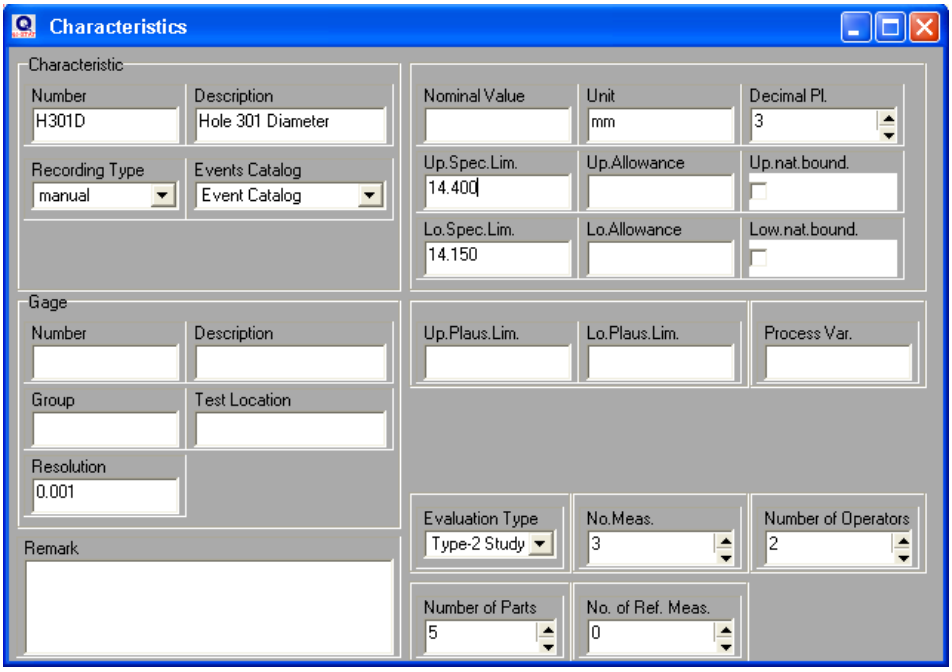


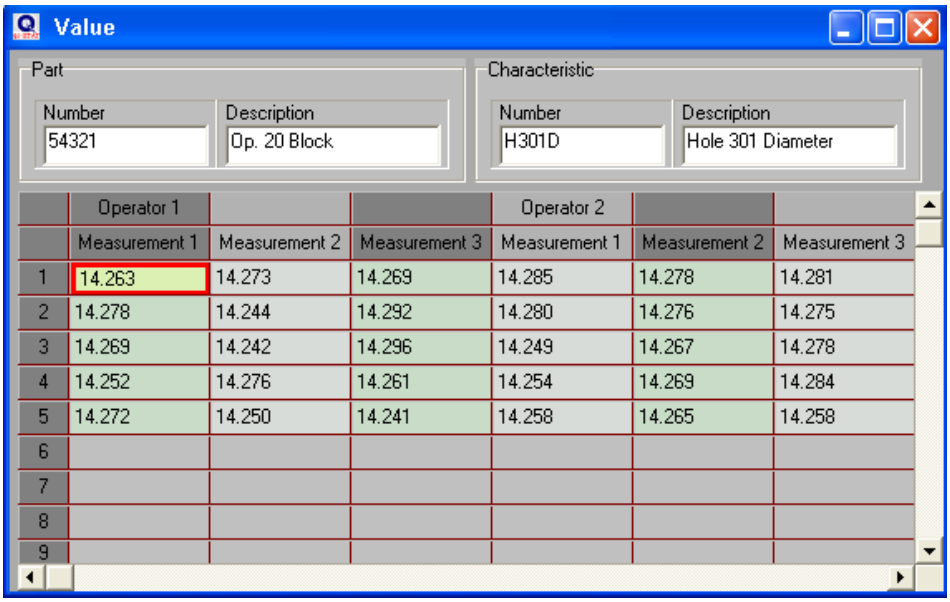


One of the standard reports for a Type 1 Study can be seen below. It contains the Value chart Individuals, the raw data and the Form sheet. This can be found under File – Print report.



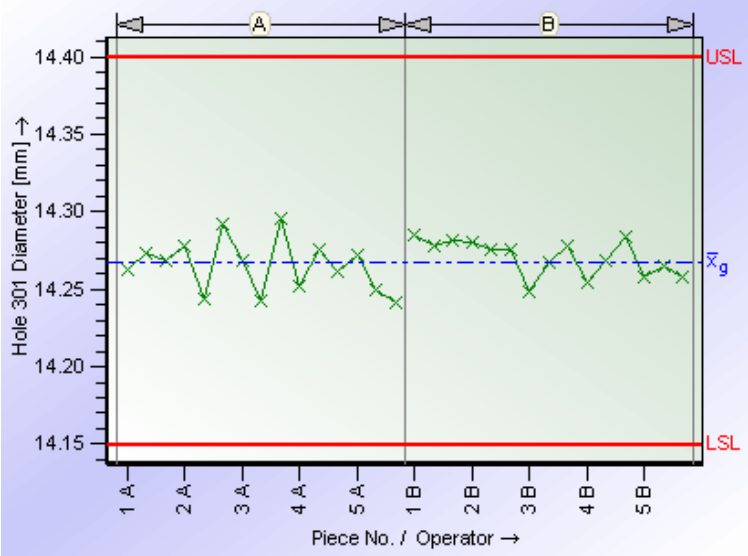
9. For the second part of the task, create a new file for a Type 2 study of the same feature. Fill in the appropriate Parts, Characteristics, and Values Mask information.





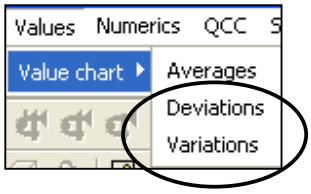
	Operator 1			Operator 2		
	Measurement 1	Measurement 2	Measurement 3	Measurement 1	Measurement 2	Measurement 3
1	14.263	14.273	14.269	14.285	14.278	14.281
2	14.278	14.244	14.292	14.280	14.276	14.275
3	14.269	14.242	14.296	14.249	14.267	14.278
4	14.252	14.276	14.261	14.254	14.269	14.284
5	14.272	14.250	14.241	14.258	14.265	14.258
6						
7						
8						
9						

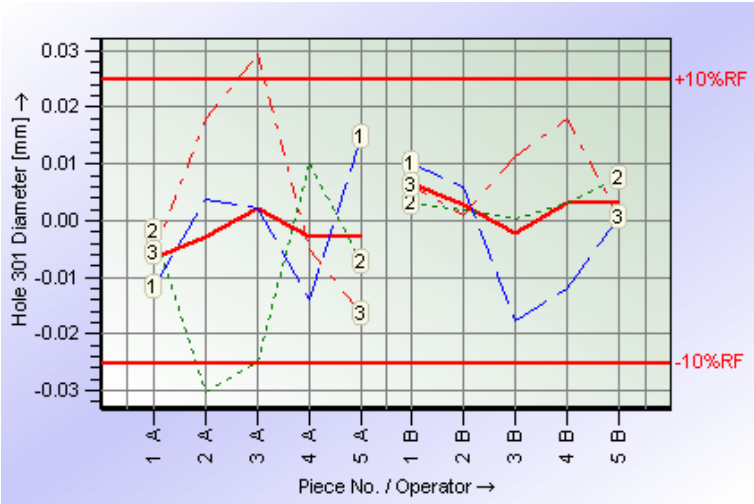
10. After completing all the recording data setup, click the "Execute evaluation" icon to calculate the results for this measurement system. Close down the three masks and open a Value chart Individuals.



The Value chart shows the measured values per operator (A & B), per part (1-5), and per trial. There are three X's at value 1A for the three trials.

11. From the "Values" pull down menu open the Value chart - Deviations and the Value chart – Variation.

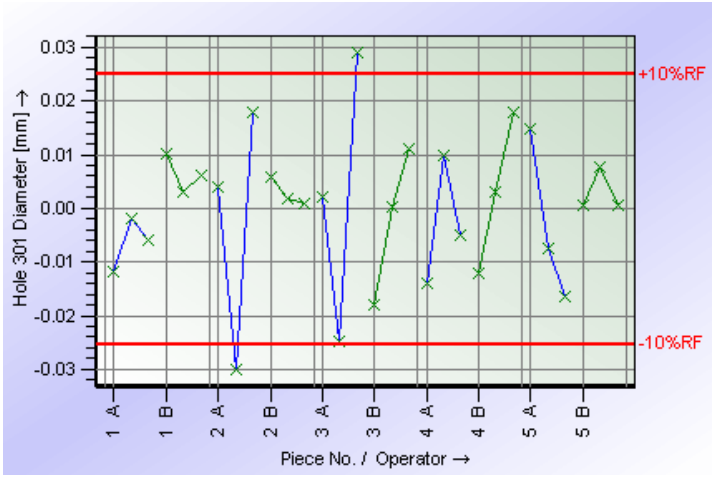




Value chart Deviations

The Deviations and Variations charts both compare the operator variation to overall part average.

- On the Deviations chart the dashed, colored lines are the individual trials per operator and the two solid red lines in the middle are the individual operator part averages.
- The Variations chart is displayed so that the three trials of part 1, operator A are directly compared to the three trials of part 1, operator B.



Value chart Variations

12. For a Type 2 Study, the criteria for a capable measurement system is based on the %R&R. A typical requirement is that the %R&R is less than 20%. This is best displayed on Form 3.

Part no.	=	54321		Part descr.	=	Op. 20 Block		
Char.No.	=	H301D		Char.Descr.	=	Hole 301 Diameter		
	Variance	Standard dev.						
Repeatability	0.000196	0.0140	EV	=	0.0564 ≤ **0.0722** ≤ 0.100	%EV	=	28.87%
Reproducibility	0.000000786	0.000887	AV	=	0.000 ≤ **0.00457** ≤ 0.606	%AV	=	1.83%
Interaction	0.000	0.000	IA	=	0.000	%IA	=	0.00%
Repeatability & Reproducibi	0.000197	0.0140	R&R	=	0.0702 ≤ **0.0723** ≤ 0.616	%R&R	=	28.92%
Tolerance	=	T	=	0.250	Confidence interval	=	1-α	= 95.000%
Resolution	=	%RES	=	0.40%	0 5			
Repeatability & Reproducibility	=	%R&R	=	28.92%	0 20			
Overall evaluation	=	The requirements were not met (RES,R&R)						
Q-DAS (Leitfaden V2.1) neue Messsysteme (ANOVA): Verfahren 2								

A standard report for a Type 2 Study is seen below. This report contains the Value chart Deviations, the raw data and the Form sheet.