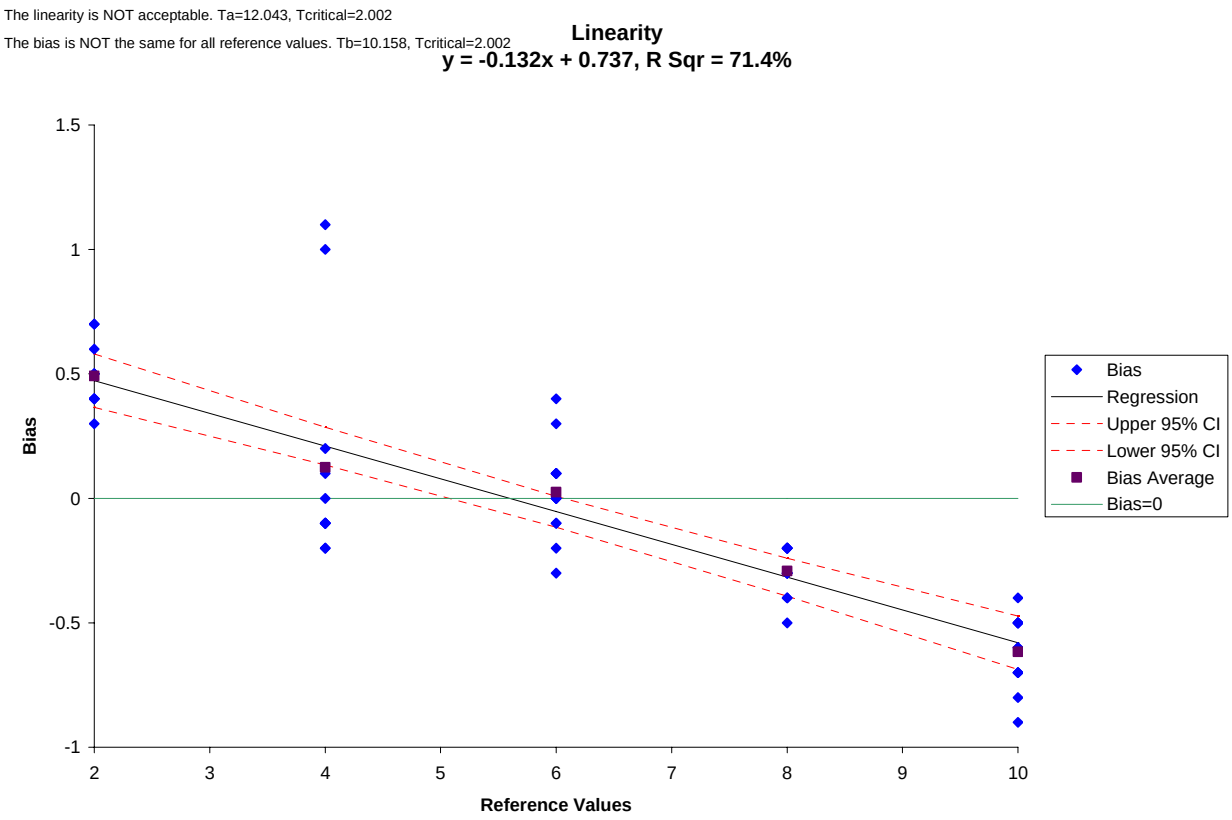
Instruction Manual for MSA Component in SPC for MS Excel V4.0



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Requirements: This program is a Microsoft Excel® add-in. You must Microsoft Excel® for this program to work. This program supports any version of Excel from 2000 on.

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Measurement Systems Analysis

This Measurement Systems Analysis used by the program is based on the following two sources:

1. *Measurement Systems Analysis*, Third Edition, AIAG, May 2003 (www.aiag.org)
2. *Evaluating the Measurement System* by Donald Wheeler and Richard Lyday, SPC Press, Knoxville, TN, 1989 (www.spcpress.com)

Both are excellent references for developing a better understanding of the measurement system. The program has the following components:

1. Average and Range Method to generate the classical Gage R&R report with the following chart options:
    a. Averages charts – stacked and unstacked
    b. Range charts – stacked and unstacked
    c. Run chart by part
    d. Scatter plots
    e. Whiskers charts
    f. Error charts
    g. Normalized histograms
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2. ANOVA Method that includes:
    a. ANOVA table
    b. Residuals plot
    c. ANOVA Gage R&R report
3. Range Method for Gage R&R
4. Bias Method – Independent Sample Method
5. Bias Method – Control Chart Method (checks Stability also)
6. Linearity Method
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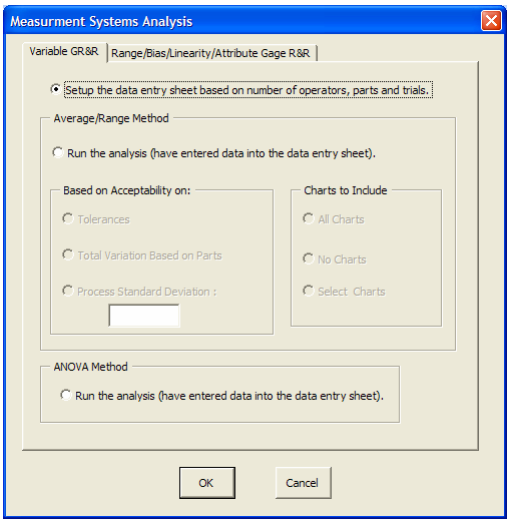
    a. Effectiveness table (attribute Gage R&R report)
    b. Crosstabulations
    c. Kappa values

These are explained in detail on the following pages.

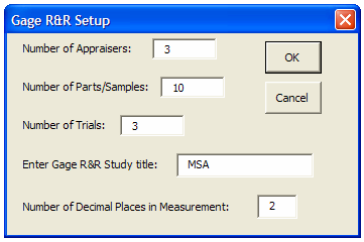
Average and Range Method

Set-up Data Entry

The example below uses the data from page 101 of *Measurement System Analysis, Third Edition*. Suppose you have completed a Gage R&R with 3 appraisers, 10 parts, and 3 trials. The first step in using the Gage R&R program is to setup the data entry page. Select the MSA icon on the SPC toolbar. You will get the form shown below.



Select the first option to setup the data entry sheet based on the number of operators, parts, and trials and then select OK. You will see the form below which has been filled in with the numbers for this example.



You must enter all the information. The number of decimal places in the measurement is VERY IMPORTANT. It controls how the data is rounded and shown. Entering zero when you have two or three decimal places in the data may lead to inaccurate results. After entering all the information, select OK. This will generate the data entry sheet shown below. The number of trials and parts can range from 2 to 20; the number of appraisers can range from 1 to 25 (with one appraiser you will only get a Gage R&R report based on the average and range method).

Enter the operator names in the upper right hand corner. The names will automatically appear in the first column. ***NOTE: The program uses Microsoft Excel's naming function to run. You cannot have spaces or certain characters (e.g. /). Instead of using John Smith, use John_Smith.*** Enter the rest of the information for Date, Gage Name, Gage Number, Gage Type, Product, Characteristic, Upper Specification Limit, Lower Specification Limit, and Performed By. None of this information is required to run the program with the possible exception of the specification limits. These are required if you are basing the acceptability of the measurement system on the tolerances. You then enter the data from the appraisers for each trial and each part. A completed data entry screen is shown on the next page.

Blank Data Entry Form:

Gage R&R Study			2	
Date:		Operator 1:	Enter Operator 1 Name Here	
Gage Name:		Operator 2:	Enter Operator 2 Name Here	
Gage Number:		Operator 3:	Enter Operator 3 Name Here	
Gage Type:				
Product:				
Characteristic:				
Upper Specification Limit:				
Lower Specification Limit:				
Performed By:				

Operator	Trial/Part	1	2	3	4	5	6	7	8	9	10
Enter Operator 1 Name Her	1										
Enter Operator 1 Name Her	2										
Enter Operator 1 Name Her	3										
Enter Operator 2 Name Her	1										
Enter Operator 2 Name Her	2										
Enter Operator 2 Name Her	3										
Enter Operator 3 Name Her	1										
Enter Operator 3 Name Her	2										
Enter Operator 3 Name Her	3										

Completed Data Entry Form:

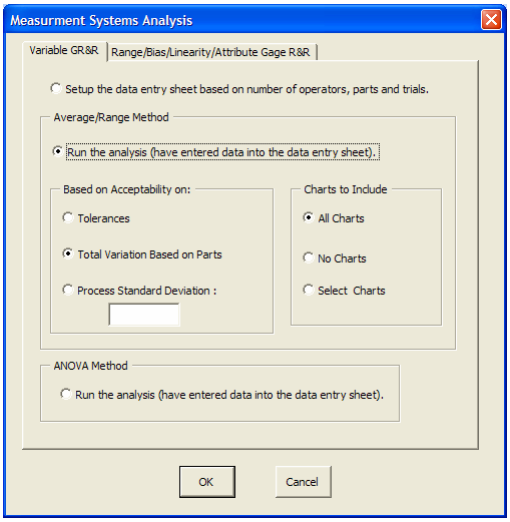
Gage R&R Study			2	
Date:	10/31/2005	Operator 1:	Hal	
Gage Name:	Thickness Gage	Operator 2:	Beth	
Gage Number:	T-101	Operator 3:	Loa	
Gage Type:	Thickness			
Product:	Widget			
Characteristic:	Thickness			
Upper Specification Limit:	3			
Lower Specification Limit:	-3			
Performed By:	Bill			

Operator	Trial/Part	1	2	3	4	5	6	7	8	9	10
Hal	1	0.29	-0.56	1.34	0.47	-0.8	0.02	0.59	-0.31	2.26	-1.36
Hal	2	0.41	-0.68	1.17	0.5	-0.92	-0.11	0.75	-0.2	1.99	-1.25
Hal	3	0.64	-0.58	1.27	0.64	-0.84	-0.21	0.66	-0.17	2.01	-1.31
Beth	1	0.08	-0.47	1.19	0.01	-0.56	-0.2	0.47	-0.63	1.8	-1.68
Beth	2	0.25	-1.22	0.94	1.03	-1.2	0.22	0.55	0.08	2.12	-1.62
Beth	3	0.07	-0.68	1.34	0.2	-1.28	0.06	0.83	-0.34	2.19	-1.5
Loa	1	0.04	-1.38	0.88	0.14	-1.46	-0.29	0.02	-0.46	1.77	-1.49
Loa	2	-0.11	-1.13	1.09	0.2	-1.07	-0.67	0.01	-0.56	1.45	-1.77
Loa	3	-0.15	-0.96	0.67	0.11	-1.45	-0.49	0.21	-0.49	1.87	-2.16

Generating the Results

You are now ready to run the program to generate the results. To run the program, select the icon on the SPC toolbar. You will get the form shown above when you have selected the "Run the analysis (have entered data into the data entry sheet)" under the Average/Range Method.

You have two things to decide at this point. First, on the left-hand side of the form is what to base acceptability of the measurement on. You have the following three options:

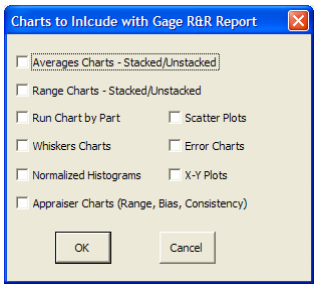


1. Tolerances: Use this option if your parts have very little variation or not representative of the total variation in your production process.
2. Total Variation Based on Parts: Use this option if your parts are representative of the total variation in your process
3. Process Standard Deviation: Use this if your parts are not representative of the total variation in your process and if you have a good estimate of the process standard deviation (e.g., from a control chart kept on the process).

On the right-hand side, you have three options for additional charts that can be generated along with the Gage R&R report. The options are:

1. All Charts: this will generate all the charts associated with the study (see the first page of this instructional manual for the list or the figure below)
2. No Charts: only the Gage R&R report will be generated
3. Select Charts: only the charts you select will be generated

If you select "Select Charts", you will get the dialog box below. You select the charts you want to include in the output and then select OK. This returns you to the form above.



Once you have selected your options, select OK and the program will generate the Gage R&R report as well as the charts you have selected (if any).

When finished, the program will display the Gage R&R report. The one generated from this data (using the Total Variation Based on Parts Option) is shown below. The report contains all the information in a classical Gage R&R study and bases the conclusion if the measurement system is acceptable based on one of the three options selected below.

Gage Repeatability and Reproducibility Report

Gage Name: Thickness Gage
Gage No. T-101
Gage Type: Thickness

Product: Widget
Characteristic: Thickness
USL: 3
LSL: -3

Date: 10/31/05
Performed by: Bill

Rbar= 0.341667 *XbarDiff*= 0.444667 *Rp*= 3.511111
K1= 0.5908 *K2*= 0.5231 *K3*= 0.3146

Measurement Unit Analysis	% Total Variation (TV)	% Tolerance
Repeatability - Equipment Variation (EV) EV = Rbar * K1 = 0.20186	% EV = 100(EV/TV) = 17.61%	% EV = 100(EV/(USL-LSL)/6) = 20.19%
Reproducibility - Appraiser Variation (AV) AV= Sqrt((XbarDiff * K2)^2 - (EV^2)/nr)) = 0.22967	% AV = 100(AV/TV) = 20.04%	% AV = 100(AV/(USL-LSL)/6) = 22.97%
Repeatability & Reproducibility (R & R) R&R= sqrt(EV^2 + AV^2) = 0.30577	% R&R = 100(R&R/TV) = 26.68%	% R&R = 100(R&R/(USL-LSL)/6) = 30.58%
Part Variation (PV) PV= Rp * K3 = 1.1046	% PV = 100(PV/TV) = 96.38%	% PV = 100(PV/(USL-LSL)/6) = 110.46%
Total Variation (TV) TV= sqrt(R&R^2 + PV^2) = 1.14614	ndc= 1.41(PV/R&R) = 5.093652	

Conclusion

% R&R under 10% of Total Variation: Measurement system is acceptable

****** % R&R from 10% to 30% of Total Variation: Measurement system may be acceptable based the application**

% R&R over 30% of Total Variation: Measurement system needs improvement

Any charts that were selected are generated on separate worksheets in the workbook. You can download a completed workbook with all the charts from our website (www.spcforexcel.com). A summary of each chart is given below.

- Stacked Averages Chart – the average of each appraiser on each part is plotted by appraiser using the part number as the index. There is one line for each appraiser. This helps determine how consistent the operators are. The overall average and control limits are also plotted. If the parts represent the total (true) variation in the process, at least half of theses points should be out of control. If this not the case, the measurement system does not have the ability to distinguish between samples (poor resolution) or the parts do not reflect the total variation in the process.
- Unstacked Averages Chart – same as the stacked chart but the appraisers are plotted together, not separately.
- Stacked Range Chart – used to show the range of each operator's trials on a part and includes the average range and control limits. There is one line for each appraiser. The chart is used to determine if the process is in control. If there are out of control points, the special causes need to be found and eliminated. Care should be taken with interpreting the Gage R&R results if there are special causes present. Special causes occur if there are points beyond the control limits.
- Unstacked Range Chart – same as the stacked range chart but the appraisers are plotted as one line.
- Run Chart by Part – plots the individual readings by part for all appraisers to help see if there are any outliers and to see the variation in the individual parts.
- Scatter Plot – plots the individual readings by part-by-appraiser to examine how consistent the appraisers are, to look for part-appraiser interactions, and to look for outliers.
- Whiskers Charts – plots the high, average, and low value by part for each appraiser to examine how consistent the appraisers are, to look for part-appraiser interactions, and to look for outliers (same items as for the scatter plot).
- Error Charts – plots the error (observed value – average measurement of the part) by part-appraiser to determine which operator may have bias and which operator has the most variability.
- Normalized Histograms – plots the normalized value (observed value – average measurement of part) as a histogram to determine how the error is distributed by appraiser.
- X-Y Plot – plots the average of the readings by each appraiser against the overall part averages to examine consistency in linearity between appraisers.
- Appraiser Charts – consists of three charts:
  - Range charts for each appraiser to determine if each is in control
  - Bias chart for all appraisers to determine if different appraisers display detectably different average values for the parts.
  - Consistency chart for all appraisers to determine if different appraisers display detectably different standard deviations for the parts.

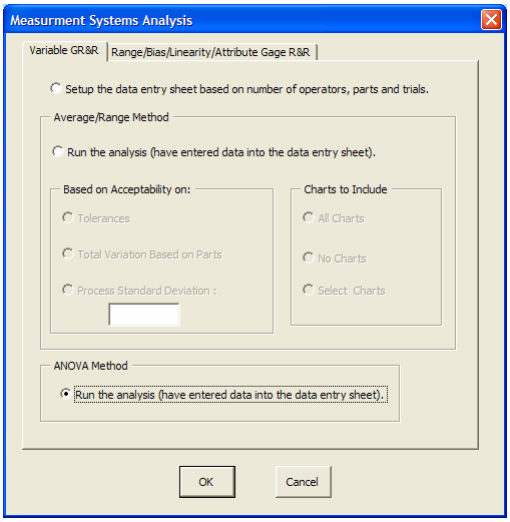
ANOVA Method

Set-up Data Entry

The set-up is the same as for the Average and Range Method. Please follow the instructions for set-up data entry as well as data entry for the Average and Range Method.

Generating the Results

After the data has been entered into the worksheet, select the MSA icon on the SPC toolbar. You will get the form below. Select the ANOVA Method option as shown in the form and then select OK.



The program generates two new worksheets. One (ANOVA Report) contains the Gage Repeatability and Reproducibility ANOVA Method Report as shown below. The acceptability of the measurement system is based on percent contribution, not on % Total Variation.

Gage Repeatability and Reproducibility ANOVA Method Report

Gage Name:	Thickness Gage	**Product:**	Widget	**Date:**	10/31/05
Gage No.	T-101	**Characteristic:**	Thickness	**Performed by:**	Bill
Gage Type:	Thickness	**USL:**	3		
		LSL:	-3		

	STD DEV.	% TOTAL VARIATION	PERCENT CONTRIBUTION
Repeatability (EV)	0.199933	18.42%	3.39%
Reproducibility (AV)	0.226838	20.90%	4.37%
Appraiser by Part (INT)	0	0.00%	0.00%
GRR	0.302372	27.86%	7.76%
Part (PV)	1.042327	96.04%	92.24%

% R&R under 10%: Measurement system is acceptable

Number of distinct data categories (ndc)=	4
Total Variation (TV) =	1.0853

The other worksheet (GRR ANOVA) contains the ANOVA table and the residuals plot as shown below. The residuals chart plots the residual versus the average for each appraiser for each part. The residual is the result minus that average. The points should be randomly scattered above and below zero.

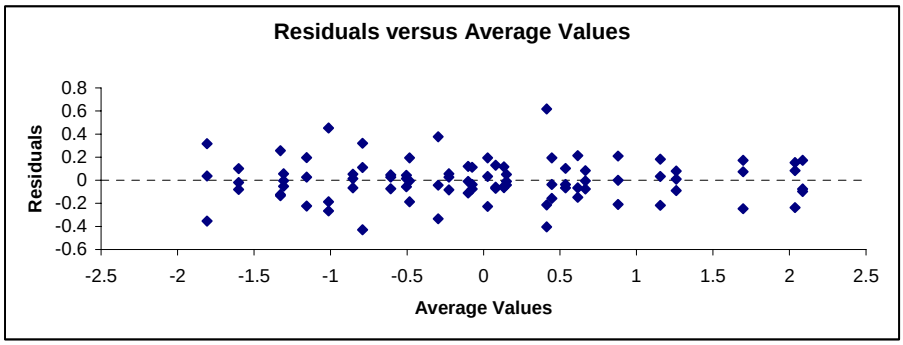
ANOVA Results

Source	df	SS	MS	F	Sig
Appraiser	2	3.16726222	1.58363111	*34.44*	0.0000
Part	9	88.3619344	9.81799272	*213.517*	0.0000
Appraiser by Part	18	0.35898222	0.01994346	0.434	0.9740
Equipment	60	2.75893333	0.04598222		
Total	89	94.6471122			

F values in italics are significant at alpha = 0.05 level

Source of Variation	Estimate of Variance	Std. Dev.	5.15 Std Dev.		% Total Variation	% Contribution
Equipment	0.03997328	0.19993318	EV =	1.02965588	18.42%	3.39%
Appraiser	0.05145526	0.22683752	AV =	1.16821324	20.90%	4.37%
Interaction	0	0	INT =	0	0.00%	0.00%
GRR	0.09142854	0.30237152	GRR =	1.55721334	27.86%	7.76%
Part	1.0864466	1.04232749	PV =	5.36798659	96.04%	92.24%
Total Variation	1.17787514	1.08529956	TV =	5.58929275	100.00%	

ndc = 4.86051648 or 4

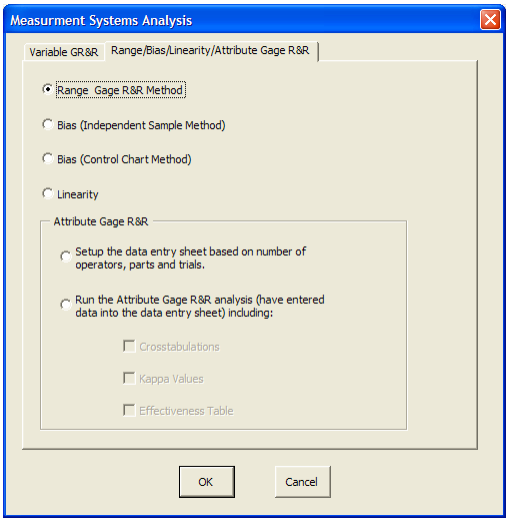


Range Method for Gage R&R

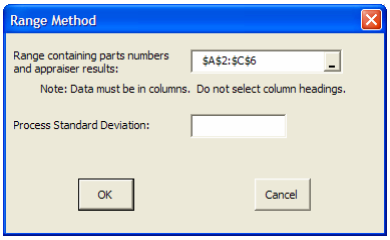
This method provides a quick look at measurement variability and requires that you have an estimate of the process standard deviation. This method typically uses two appraisers and five parts. Each appraiser measures the part ***one time only***. An example of the data input required is shown in the figure below and is based on the data from page 98 of *Measurement Systems Analysis*, Third Edition. The data can be anywhere on the worksheet.

	A	B	C
1	Part	Appraiser A	Appraiser B
2	1	0.85	0.8
3	2	0.75	0.7
4	3	1	0.95
5	4	0.45	0.55
6	5	0.5	0.6
7			

Select the data as highlighted above. Do not select the column headings. To run the program, select the icon on the SPC toolbar. You will see the first page of the form as usual. Select the second page tab labeled "Range/Bias/Linearity/Attribute Gage R&R."



Select the Range Gage R&R Method and select OK. The dialog below will appear.



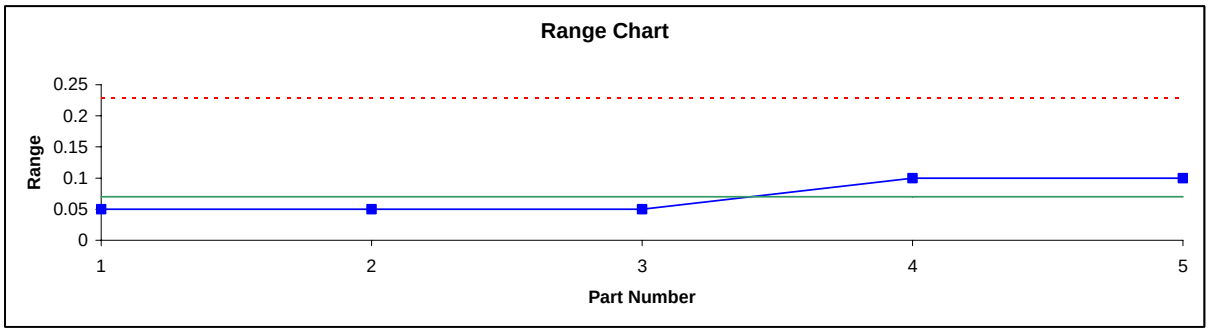
The range that appears in the "Range containing part numbers and appraiser results' is the range that is selected on the worksheet. You can save some time by selecting the data before selecting the icon on the toolbar. Enter

the process standard deviation. For the example, this standard deviation is 0.0777. Then select OK. A new worksheet will be added to the workbook with the following output.

Range Method for Gage R&R

Average Range (Rbar) =	0.07
Upper Control Limit =	0.22869
Lower Control Limits =	None
In Control?	Yes
GRR = Rbar/d2* =	0.058772
Process Standard Deviation =	0.0777
%GRR = 100(GRR/Process Standard Deviation =	75.6%

Conclusion: The measurement system needs improvement.



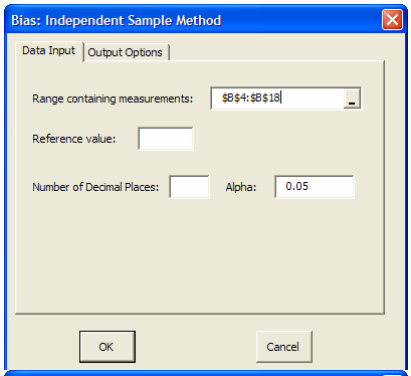
The results give the average range and control limits. The range chart is shown to check for special causes of variation. The % GRR is calculated and the conclusion given based on the % GRR.

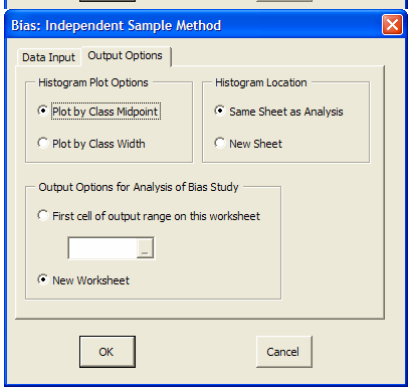
Bias – Independent Sample Method

This method determines if the measurement system is biased. It is done by using one sample and determining its reference value. The one appraiser measures the sample ten or more times. The data used in this example is from page 87 in *Measurement Systems Analysis,* Third Edition. An example of how the data is entered in the spreadsheet is given to the right. The data can be anywhere in the spreadsheet.

	A	B
1	Bias Example	
2		
3	Trial	Value
4	1	5.8
5	2	5.7
6	3	5.9
7	4	5.9
8	5	6.0
9	6	6.1
10	7	6.0
11	8	6.1
12	9	6.4
13	10	6.3
14	11	6.0
15	12	6.1
16	13	6.2
17	14	5.6
18	15	6.0
19		

Select the data as highlighted to the right. Do not select the column heading or the trial numbers – just the results of running the sample multiple times. To run the program, select the icon on the SPC toolbar. You will see the first page of the form as usual. Select the second page tab labeled "Range/Bias/Linearity/Attribute Gage R&R." Select the Bias (Independent Sample Method) option and select OK. You will then see the dialog below.





The range that appears in the dialog box is the range selected on the worksheet. You can change it here if it is not correct. Enter the reference value (which is 6.00 in this example); enter the number of decimal places (1), and alpha. The default value is 0.05 which gives 95% confidence limits.

The second page of the dialog box is output options. It is shown to the left. These options are available for both bias reports. There are two options for plotting the histogram – by midpoint or by class width. By midpoint is the default value. The histogram can be plotted on the same sheet as the analysis (recommended) or as a new sheet in the workbook. There are two output options for the analysis of bias study. You can place it in the worksheet where the data is or as a new sheet (recommended). You do not have to go to this page if you are satisfied with the default options.

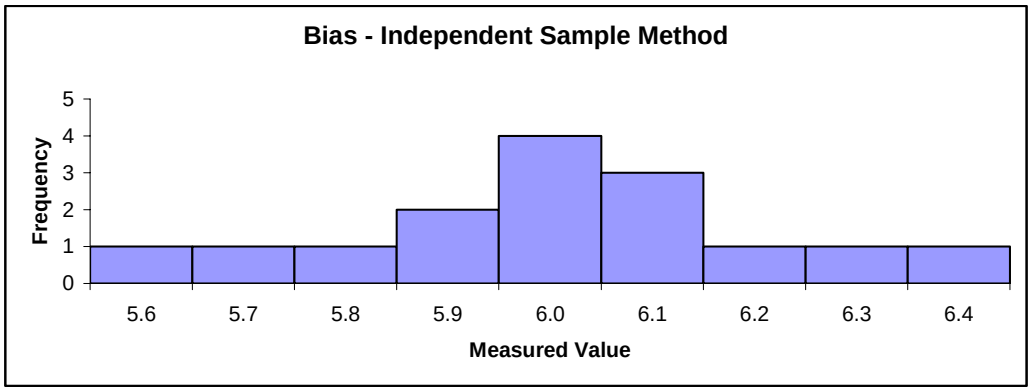
Select OK and the results are generated. A new worksheet is added with the results as shown on the next page. A histogram of the results is included along with the numerical calculation results. The numerical values include:

- n = number of readings
- Mean = average of the readings
- Reference Value = reference value of the sample
- Standard Deviation (s) = standard deviation of the readings
- t statistic = the t value based on the degrees of freedom
- df = degrees of freedom
- t value (2 tailed) = t value from the t tables
- Bias = average – reference value
- Lower = lower confidence interval (based on alpha)
- Upper = upper confidence interval (based on alpha)

A conclusion is also presented that states if you can assume the bias is zero.

	Alpha=0.05								Confidence Interval	
	n	Mean	Reference Value	Standard Deviation (σ)	t statistic	df	t value (2 tailed)	Bias	Lower	Upper
Measured Value	15	6.006667	6	0.21202	0.121781	14	2.144787	0.006667	5.889254	6.124079

There is no evidence that the average is significantly different than reference value. You may assume the bias is zero.

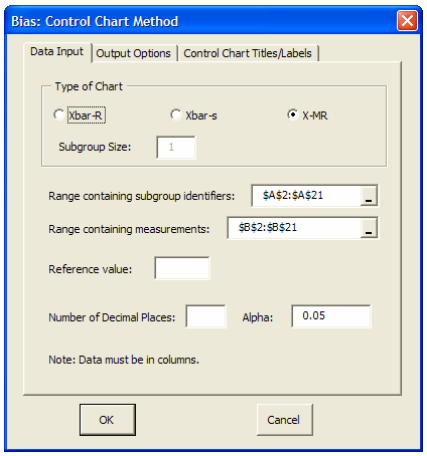


Bias – Control Chart Method

This method uses the control charts to determine if the measurement system is biased. It can also be used to check the stability of the measurement system. You must have a reference value for the sample. The control chart can be an individuals chart (X-MR), $\overline{X}$-R chart, or $\overline{X}$-s chart. The example below uses the X-MR chart. An example of the data entry requirements are shown to the right.

	A	B
1	Sample	Results
2	1	100.1
3	2	101.9
4	3	101
5	4	100.2
6	5	100.6
7	6	101.5
8	7	100.6
9	8	100.2
10	9	101.1
11	10	101.6
12	11	100.8
13	12	101.4
14	13	101.5
15	14	100.8
16	15	102
17	16	100.9
18	17	100.5
19	18	101.3
20	19	101.6
21	20	101.3
22		

Select the data as highlighted to the right. Do not select the column heading but do select the sample numbers. To run the program, select the icon on the SPC toolbar. You will see the first page of the form as usual. Select the second page tab labeled "Range/Bias/Linearity/Attribute Gage R&R." Select the Bias (Control Chart Method) option and select OK. You will then see the dialog below.

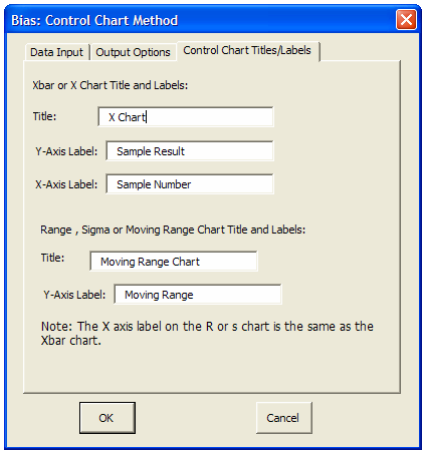


You have an option of selecting the type of chart you are using. The program selects what it thinks you have based on the selected area on the worksheet. You can change it if it is not correct. The dialog box also shows the range containing the subgroup identifiers (sample numbers) and the range containing the measurements. The subgroup identifiers are always assumed to be in the first column, followed by the data.

Enter the reference value, the number of decimal places in the data, and alpha (default is 0.05). In this example, the reference value is 100.3.

The second page in the dialog box contains the Output Options. These are the same as those given in the Bias – Independent Sample Method above. Please refer to that section for instructions.

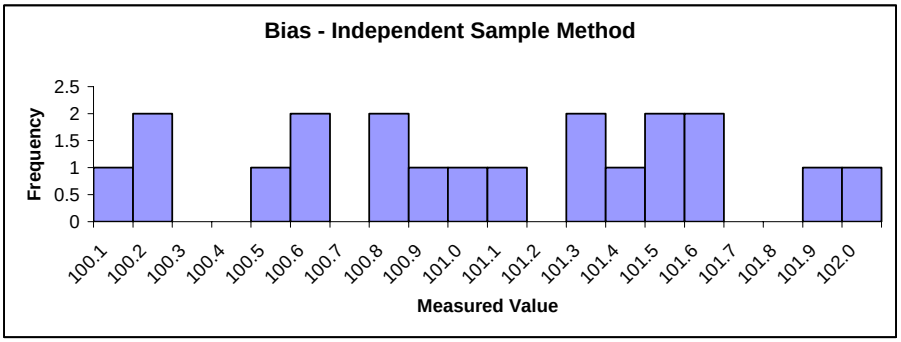
The third page of the dialog box contains the chart title and labels as shown below. You can use the default ones or change them. You can also change the titles and labels after the results are generated.

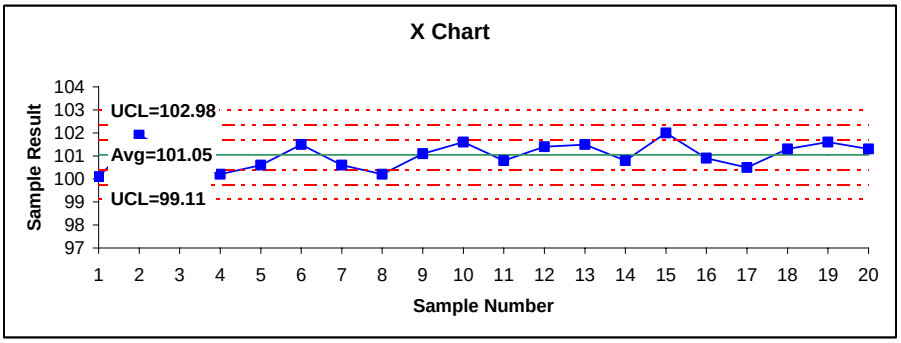


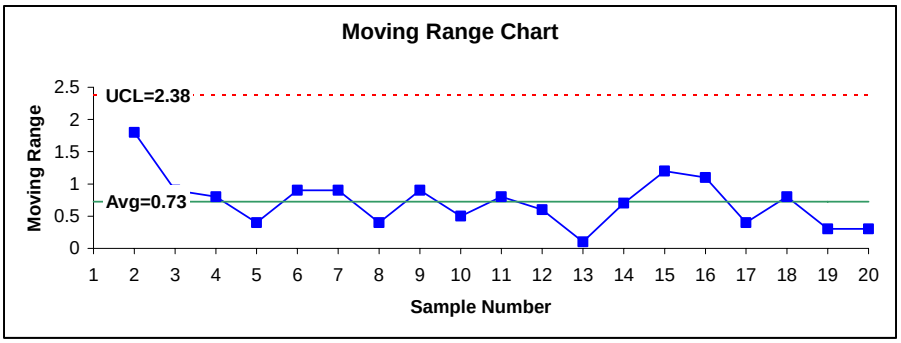
Once you have entered the information into the dialog box, select OK. A new worksheet is added to the workbook with the results as shown on the next page for this example.

	Alpha=0.05								Confidence Interval	
	n	Mean	Reference Value	Standard Deviation (σ)	t statistic	df	t value (2 tailed)	Bias	Lower	Upper
Measured Value	0	101.045	100.3	0.566127	5.885146	19	2.093024	0.745	100.78	101.31

There is evidence that the average is significantly different than the reference value. The bias is not zero.







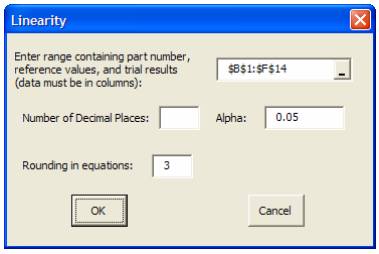
The output contains the same information as given in the Bias – Independent Sample Method. It also includes the control charts for the sample to help determine stability.

Linearity

Linearity is the difference of bias throughout the measurement range. To determine linearity, the samples you select must cover the expected operating range of the measurement system. You should use at least five samples that cover this range. One appraiser should measure each of the parts at least ten times. An example of the required data input is shown to the right (page 95, *Measurement Systems Analysis*, Third Edition). The data must be in columns. The first row of data contains the part number; the second row contains the reference values for each part; and the remaining rows contain the measurements.

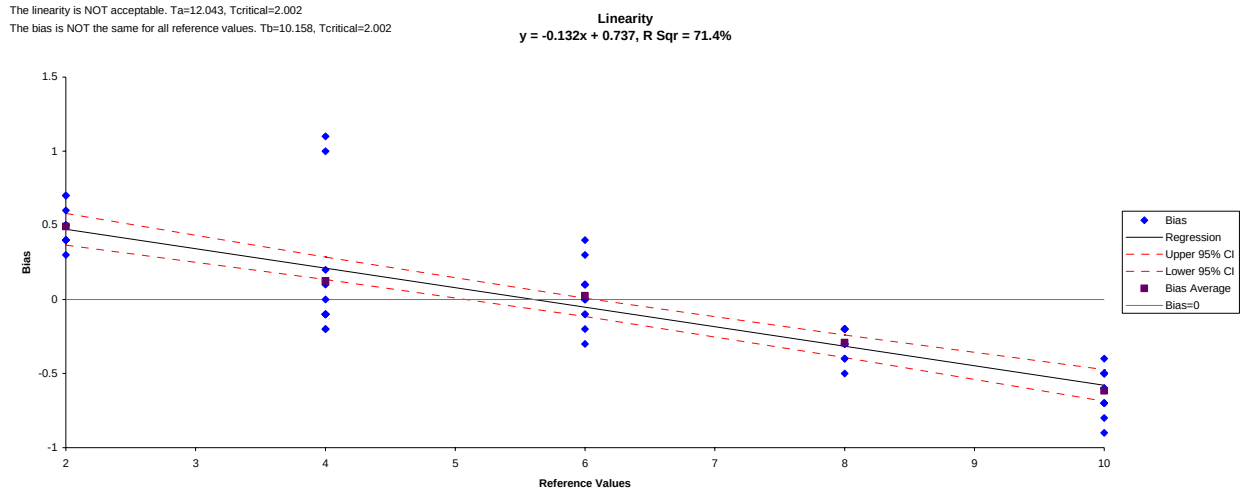
B1 = 1

	A	B	C	D	E	F
1	Part	1	2	3	4	5
2	Ref Value	2	4	6	8	10
3	Trail 1	2.7	5.1	5.8	7.6	9.1
4	Trail 2	2.5	3.9	5.7	7.7	9.3
5	Trail 3	2.4	4.2	5.9	7.8	9.5
6	Trail 4	2.5	5	5.9	7.7	9.3
7	Trail 5	2.7	3.8	6	7.8	9.4
8	Trail 6	2.3	3.9	6.1	7.8	9.5
9	Trail 7	2.5	3.9	6	7.8	9.5
10	Trail 8	2.5	3.9	6.1	7.7	9.5
11	Trail 9	2.4	3.9	6.4	7.8	9.6
12	Trail 10	2.4	4	6.3	7.5	9.2
13	Trail 11	2.6	4.1	6	7.6	9.3
14	Trail 12	2.4	3.8	6.1	7.7	9.4
15						



Select the data as highlighted above. Do not select the first column. To run the program, select the icon on the SPC toolbar. You will see the first page of the form as usual. Select the second page tab labeled "Range/Bias/Linearity/Attribute Gage R&R." Select the Linearity option and select OK. You will then see the dialog box to the left.

The range is the range selected on the worksheet before starting the program. Enter the number of decimal places and alpha (default is 0.05). The "Rounding in Equations" determines how the best fit equation is displayed. The default value is 3. Once you have entered the information, select OK and the program will generate a chart like the one below.



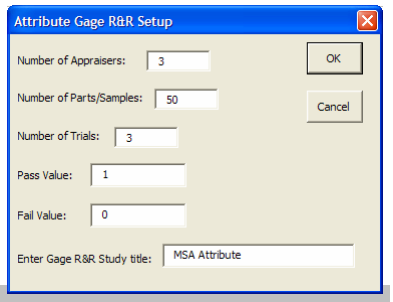
In the upper left-hand side of the chart, the conclusion is given for linearity. In this example, there is a prl0bem with linearity. The bias = 0 line (green on the chart) should be contained by the upper and lower 95% confidence intervals. The equation is the title is the best fit equation for the individual readings. The R squared value gives the % of variation in the bias that is explained by the variation in reference values.

Attribute Gage R&R

Set-up Data Entry

The attribute gage R&R component will generate the effectiveness table, crosstabulations and kappa scores. The example below uses the data from page 127 of *Measurement System Analysis, Third Edition*.
To set-up the data entry, select the icon on the SPC toolbar and then:

- Select the second page tab labeled "Range/Bias/Linearity/Attribute Gage R&R."
- Select the Attribute Gage R&R option.
- Select the first option to setup the data entry sheet based on the number of operators, parts and trials
- Select OK.



You will then see the dialog box to the right. Enter the number of appraisers, parts, and trials. Enter the pass value and fail value (e.g, 1 and 0, pass and fail, etc.). Then enter the name of the Gage R&R study. The values in the dialog box to the right are for this example. Then select OK. A new worksheet will be added containing the data entry sheet as shown below for this example (first 13 parts shown).

Attribute Gage R&R Study

Date:		Operator 1:	Enter Operator 1 Name Here
Gage Name:		Operator 2:	Enter Operator 2 Name Here
Gage Number:		Operator 3:	Enter Operator 3 Name Here
Gage Type:			
Product:			
Characteristic:			
Pass Value	1		
Fail Value	0		
Performed By:			

	Reference													
Operator	Trial/Part	1	2	3	4	5	6	7	8	9	10	11	12	13
Enter Operator 1 Name Here	1													
Enter Operator 1 Name Here	2													
Enter Operator 1 Name Here	3													
Enter Operator 2 Name Here	1													
Enter Operator 2 Name Here	2													
Enter Operator 2 Name Here	3													
Enter Operator 3 Name Here	1													
Enter Operator 3 Name Here	2													
Enter Operator 3 Name Here	3													

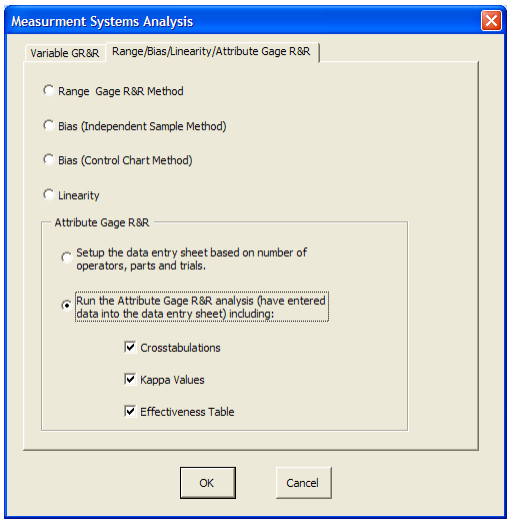
Enter the operator names in the upper right hand corner. The names will automatically appear in the first column. ***NOTE: The program uses Microsoft Excel's naming function to run. You cannot have spaces or certain characters (e.g. /). Instead of using John Smith, use John_Smith.*** Enter the rest of the information for Date, Gage Name, Gage Number, Gage Type, Product, Characteristic, Pass Value, Fail Value, and Performed By. None of this information is required to run the program except the Pass Value and Fail Value. Then fill in the data as shown below.

Attribute Gage R&R Study

Date:		Operator 1:	A
Gage Name:		Operator 2:	B
Gage Number:		Operator 3:	C
Gage Type:			
Product:			
Characteristic:			
Pass Value	1		
Fail Value	0		
Performed By:			

	Reference	1	1	0	0	0	1	1	1	0	1	1	0	1
Operator	Trial/Part	1	2	3	4	5	6	7	8	9	10	11	12	13
A	1	1	1	0	0	0	1	1	1	0	1	1	0	1
A	2	1	1	0	0	0	1	1	1	0	1	1	0	1
A	3	1	1	0	0	0	0	1	1	0	1	1	0	1
B	1	1	1	0	0	0	1	1	1	0	1	1	0	1
B	2	1	1	0	0	0	1	1	1	0	1	1	0	1
B	3	1	1	0	0	0	0	1	1	0	1	1	0	1
C	1	1	1	0	0	0	1	1	1	0	1	1	0	1
C	2	1	1	0	0	0	0	0	1	0	1	1	1	1
C	3	1	1	0	0	0	0	1	1	0	1	1	0	1

To generate the results, select the icon on the SPC toolbar. You will see the first page of the form as usual. Select the second page tab labeled "Range/Bias/Linearity/Attribute Gage R&R." You will see the form below. Select the Attribute Gage R&R option, followed by the Run the Attribute Gage R&R analysis.



There are three options: crosstabulations, kappa values, and the effectiveness table. Select the options you want and select OK. The program will generate the following results depending on options selected.

Crosstabulations

You will get a table like this one for each of the combinations of appraisers. The kappa value is given. If kappa is above 0.75 there is good agreement between the appraisers. If it is less than 0.40, there is poor agreement. The count information is as follows:

A and B both rate as fail
A rates as fail and B rates as pass
A rates as pass and B rates as fail
A and B both rate as pass

A * B Crosstabulation

			B			
			Fail	Pass	Total	Kappa
A	Fail	Count	44	6	50	0.86
		Expected Count	15.7	34.3	50.0	
	Pass	Count	3	97	100	
		Expected Count	31.3	68.7	100	
Total		Count	47	103	150	
		Expected Count	47.0	103.0		

These tables will help you determine how well the appraisers agree with one another.

Kappa Values

The output for Kappa values is shown on the next page. It includes the kappa values for the appraisers as well as the kappa value compared to the reference values (if there are any).

Effectiveness Table

The effectiveness table is shown on the next page. This table determines how effective each appraiser is.

Kappa Measures Output

Kappa Measures for the Appraisers

Kappa	A	B	C
A	-	0.86	0.78
B	0.86	-	0.79
C	0.78	0.79	-

There is good to excellent agreement since all kappa values are greater than 0.75

Kappa Values For Each Appraiser to Reference

	A	B	C
Kappa	0.88	0.92	0.77

There is good to excellent agreement since all kappa values are greater than 0.75

Effectiveness Table

Attribute Gage R&R Effectiveness

Gage Name: **Product:** **Date:**
Gage No. **Characteristic:** **Performed by:**
Gage Type:

	% Appraiser[1]			% Score vs Attribute[2]		
Source	A	B	C	A	B	C
Total Inspected	50	50	50	50	50	50
# Matched	42	45	40	42	45	40
False Negative (Appraiser biased toward rejection)				0	0	0
False Positive (Apprasier biased toward acceptance)				0	0	0
Mixed (Appraiser accepts and rejects the same part)				8	5	10
95% UCI	92.8%	96.7%	90.0%	92.8%	96.7%	90.0%
Calculated Score	**84.0%**	**90.0%**	**80.0%**	**84.0%**	**90.0%**	**80.0%**
95% LCI	70.9%	78.2%	66.3%	70.9%	78.2%	66.3%

	System % Effectiveness Score[3]	System % Effectiveness Score vs Reference[4]
Total Inspected	50	50
# in Agreement	39	39
95% UCI	88.5%	88.5%
Calculated Score	**78.0%**	**78.0%**
95% LCI	64.0%	64.0%

Notes:

(1) Appraiser agrees with him/herself on all trials
(2) Appraiser agrees on all trails with the known reference
(3) All appraisers agreed within and between themselves
(4) All appraisers agreed with and between themselves and agreed with the reference
(5) UCI and LCLI are the upper and lower confidence interval bounds respectively

If the calculated score for each appraiser falls within the confidence interval of the other appraisers, the effectiveness of the appraisers is the same.