

Report Example: Gage R&R Nested ANOVA Report

Description of Output

Date: 7/27/2018
 Gage: My Gage
 Characteristic: Thickness
 Operators: 3
 Batches: 10
 Samples/Batch: 2

Process Sigma: 2
 USL: 125
 LSL: 115
 Analyzed by: Bill

Print out of information entered by the user

ANOVA Table					
Source	df	SS	MS	F	p Value
Operator	2	2.668	1.334	0.282	0.7563
Batch (Operator)	27	127.9	4.737	21.722	0.0000
Repeatability	30	6.543	0.218		
Total	59	137.1			

Source: the source of the variation.
 df (degrees of freedom) = a measure of how much information you have for each SS.
 SS (sum of squares) = a measure of variation of squared deviations around an average.
 MS (mean square) = estimate of the variance for the source based on the degrees of freedom.
 F: the statistic is used to determine whether the sources of variation are statistically significant.
 p-value: is the probability that the source of variation is not statistically significant.
 Sources with low p values have a statistically significant impact on the results.
 Red p values are less than 0.05.

The Analysis of Variance table is given; the sources are defined below the table. The column to focus on is the p Value column. Values less than 0.05 are considered statistically significant and are turned red.

% Contribution Based on Variance		
Source	Variance	% Contr.
Gage R&R	0.218	5.45%
Repeatability	0.218	5.45%
Reproducibility	0.000	0.00%
Batch-to-Batch	3.782	94.55%
Total Variance	4.000	100.00%

Table provides the % variance due to each source based on the total variance.

Total variance based on process sigma entered by user.

AIAG Guidelines for Total Gage R&R:

% Gage R&R < 1%: measurement system is acceptable.

% Gage R&R 1% to 9%: measurement system may be acceptable for some applications.

% Gage R&R > 9%: measurement system is not acceptable.

Each source's variance is calculated and the % contribution of each source is determined. The % contribution is the % of the total variance.

If the process sigma is entered by the user, it is used to determine the total variance. If not, the batches and samples used in the study are used to determine the total variance.

AIAG guidelines are used to determine if the measurement system is acceptable.

% Based on Standard Deviation				
Source	Standard Deviation (SD)	Study Var (6SD)	% Study Var	% Tolerance (SV/Tol)
Gage R&R	0.467	2.802	23.35%	28.02%
Repeatability	0.467	2.802	23.35%	28.02%
Reproducibility	0.000	0.000	0.00%	0.00%
Batch-to-Batch	1.945	11.67	97.24%	116.68%
Total Variation	2.000	12.00	100.00%	120.00%

Table gives the % of spread consumed by each source based on the total variation.

Total variation based on process sigma entered by user.

AIAG Guidelines for Gage R&R:

% Gage R&R < 10%: measurement system is acceptable.

% Gage R&R 10% to 30%: measurement system may be acceptable for some applications.

% Gage R&R > 30%: measurement system is not acceptable.

The standard deviation from each source is calculated. The study variation is calculated as 6 times the standard deviation. The % of total study variation is calculated for each source.

If the process sigma is entered by the user, it is used for the total variation standard deviation. If not, the batches and the samples used in the study are used to determine the total variation standard deviation.

AIAG guidelines are used to determine if the measurement system is acceptable.

Number of Distinct Categories

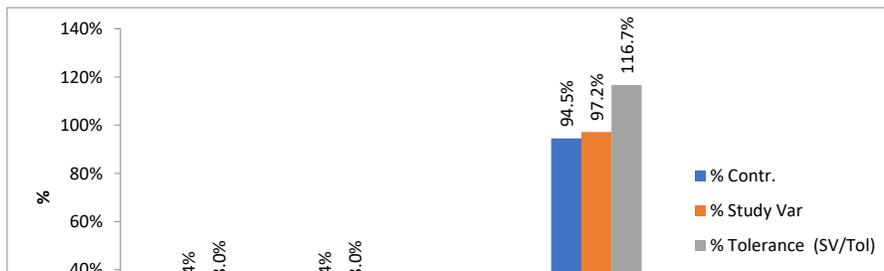
NDC represents the ability of the measurement systems to distinguish between batches.

AIAG Guidelines: NDC greater than or equal to 5.

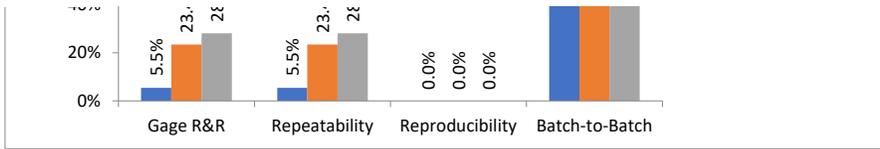
Number of Distinct Categories (NDC) = 5

The number of distinct categories is the number of data classifications that can be reliably distinguished by the resolution of the test method.

Variance Components Chart

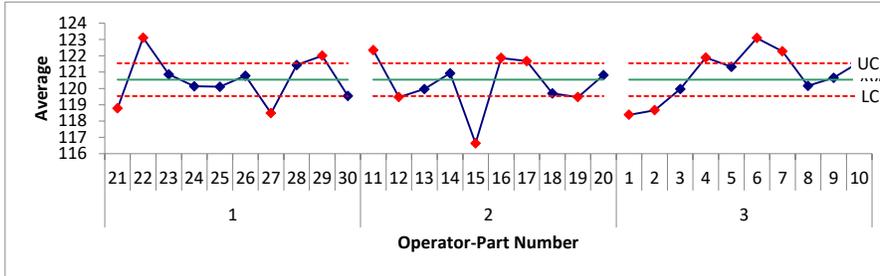


The % of variance and variation are plotted for each source. This is a chart of the results in the two tables above.



Operator-Batch Control Charts

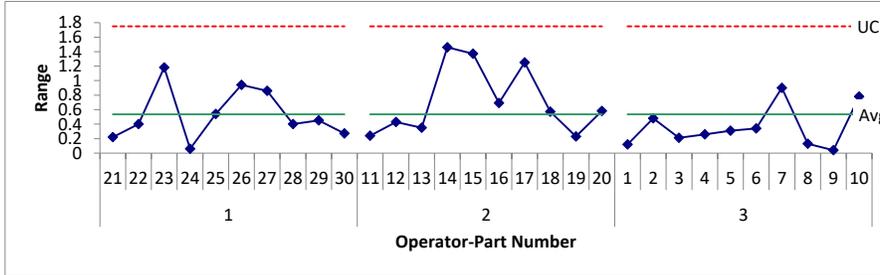
̄ Chart for Operator-Batch Averages



The \bar{X} chart is a plot of the subgroup averages for the operator-batch number combinations. The first subgroup is made up the results that Operator "1" got for batch 21. This operator ran two samples from this batch.

The average and control limits are calculated and added to the chart. The control limits on this chart depend on the average range from the range chart (see below).

R Chart for Operator-Batch Ranges



The R chart is a plot of the range of values within each operator-batch number subgroup. Each range value is a measure of the repeatability of the test method. The average range and control limits are calculated and added to the chart.

Control Chart Calculations

<u>̄ Chart</u>	$\bar{\bar{X}}$	$LCL = \bar{\bar{X}} - A_2\bar{R}$	$UCL = \bar{\bar{X}} + A_2\bar{R}$
	120.5	119.5	121.5
<u>R Chart</u>	\bar{R}	$LCL = D_3\bar{R}$	$UCL = D_4\bar{R}$
	0.535	-	1.749

The control chart calculations are given.

where A_2 , D_3 , and D_4 are control chart constants depending on subgroup size.

A_2	D_3	D_4
1.881	-	3.267

̄ Chart Analysis

The \bar{X} chart shows the average value for each operator for each batch. The control limits on the \bar{X} chart are based on the average range. The average range is representative of measurement error. The \bar{X} chart control limits represent the variation obscured by measurement error.

- The relative utility of the measurement system increases:
- * The more out of control points there are on the \bar{X} chart.
 - * The further the out of control points are away from the control limits.

16 out of 30 points are out of control on the chart.

The \bar{X} chart is analyzed. The control limits on this chart are based on the average range from the range chart. This average range represents measurement variability. If the test method is good, the measurement variability should be small. So, the average range should be small and the control limits should be tight around the average. The more out of control points the better.

R Chart Analysis

The R chart shows the results for the repeated measurements for each operator for each sample. It is a check of the consistency of the measurement process between the operators.

There are 0 out of control points on the R chart. The ranges are consistent.

There are 26.5 degrees of freedom associated with the average range. It is recommended to have at least 10 degrees of freedom.

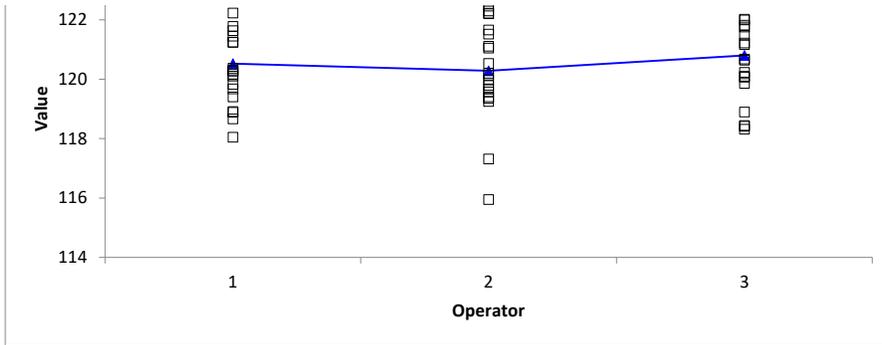
The R chart is analyzed. This checks the consistency between the operators. There should be no out of control points. If there are, the reason should be found and eliminated and the study repeated.

The study should contain sufficient data (degrees of freedom). This is checked here.

Run Chart by Operator

Look for the effects of operators on variation and for outliers.

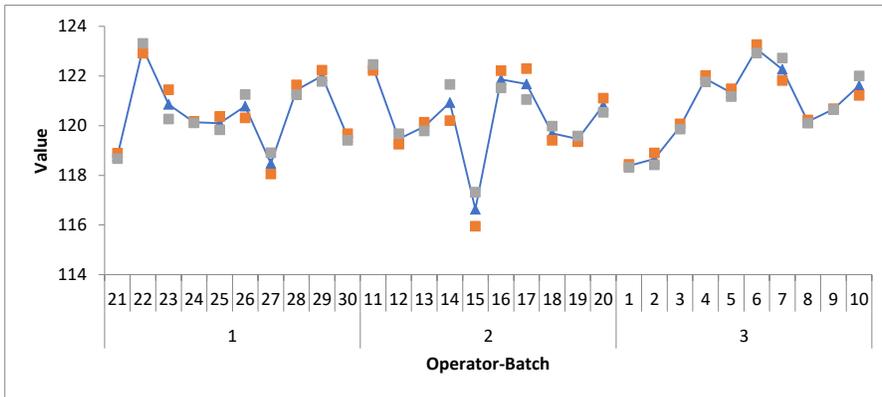




This chart is optional. The plots the results for each operator. The average of each operator is connected by the blue line. Look for outliers and differences between operators.

Run Chart by Batch(Operator)

Look at variation within a subgroup and differences in operators.



This chart is optional. It plots the individual sample results and subgroup averages (blue triangles connected by lines). Look for variation within subgroups and difference in operators.

Data

Optional Data Table

Run No.	Operator	Batch	Sample	Result
41	1	1	1	118.89
42	1	1	2	118.67
43	1	22	1	122.91
44	1	22	2	123.31
45	1	23	1	121.45
46	1	23	2	120.27
47	1	24	1	120.17
48	1	24	2	120.11
49	1	25	1	120.37
50	1	25	2	119.83
51	1	26	1	120.31
52	1	26	2	121.25
53	1	27	1	118.05
54	1	27	2	118.91
55	1	28	1	121.64
56	1	28	2	121.24
57	1	29	1	122.23
58	1	29	2	121.78
59	1	30	1	119.68
60	1	30	2	119.41
21	2	11	1	122.22
22	2	11	2	122.46
23	2	12	1	119.25
24	2	12	2	119.68
25	2	13	1	120.14
26	2	13	2	119.79
27	2	14	1	120.2
28	2	14	2	121.66
29	2	15	1	115.95
30	2	15	2	117.32
31	2	16	1	122.21
32	2	16	2	121.52
33	2	17	1	122.3
34	2	17	2	121.05
35	2	18	1	119.41
36	2	18	2	119.98
37	2	19	1	119.35

38	2	19	2	119.58
39	2	20	1	121.11
40	2	20	2	120.53
1	3	1	1	118.44
2	3	1	2	118.32
3	3	2	1	118.9
4	3	2	2	118.42
5	3	3	1	120.07
6	3	3	2	119.86
7	3	4	1	122.02
8	3	4	2	121.76
9	3	5	1	121.48
10	3	5	2	121.17
11	3	6	1	123.26
12	3	6	2	122.92
13	3	7	1	121.82
14	3	7	2	122.72
15	3	8	1	120.23
16	3	8	2	120.1
17	3	9	1	120.68
18	3	9	2	120.64
19	3	10	1	121.22
20	3	10	2	122