

Gage R&R ANOVA Report

Date: 6/12/2018
 Gage: Micro
 Characteristic: Width
 Operators: 3
 Parts: 5
 Trials: 2

Process Sigma:
 USL: 305
 LSL: 225
 Analyzed by:

ANOVA Table with Interaction						
Source	df	SS	MS	F	p Value	
Part	4	12791	3197.8	247.730	0.000	
Operator	2	415.4	207.7	16.090	0.002	
Operator*Part	8	103.3	12.91	1.058	0.439	
Repeatability	15	183.0	12.20			
Total	29	13493				

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.

Significance level (alpha) to remove interaction term = 0.05.

*Operator*Part interaction is not significant and is removed in the calculations below.*

ANOVA Table without Interaction						
Source	df	SS	MS	F	p Value	
Part	4	12791	3197.8	256.925	0.000	
Operator	2	415.4	207.7	16.688	0.000	
Repeatability	23	286.3	12.45			
Total	29	13493				

% Contribution Based on Variance		
Source	Variance	% Contribution
Gage R&R	31.97	5.68%
Repeatability	12.45	2.21%
Reproducibility	19.53	3.47%
Operator	19.53	3.47%
Part-to-Part	530.9	94.32%
Total Variance	562.9	100.00%

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

Total variance based on parts used in the study.

AIAG Guidelines for 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.

% Based on Standard Deviation

Source	Standard Deviation (SD)	Study Var (6SD)	% Study Var	% Tolerance (SV/Tol)
Gage R&R	5.654	33.93	23.83%	42.41%
Repeatability	3.528	21.17	14.87%	26.46%
Reproducibility	4.419	26.51	18.63%	33.14%
Operator	4.419	26.51	18.63%	33.14%
Operator*Part				0.00%
Part-to-Part	23.04	138.2	97.12%	172.81%
Total Variation	23.72	142.3	100.00%	177.94%

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

Total variation based on parts used in the study.

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.

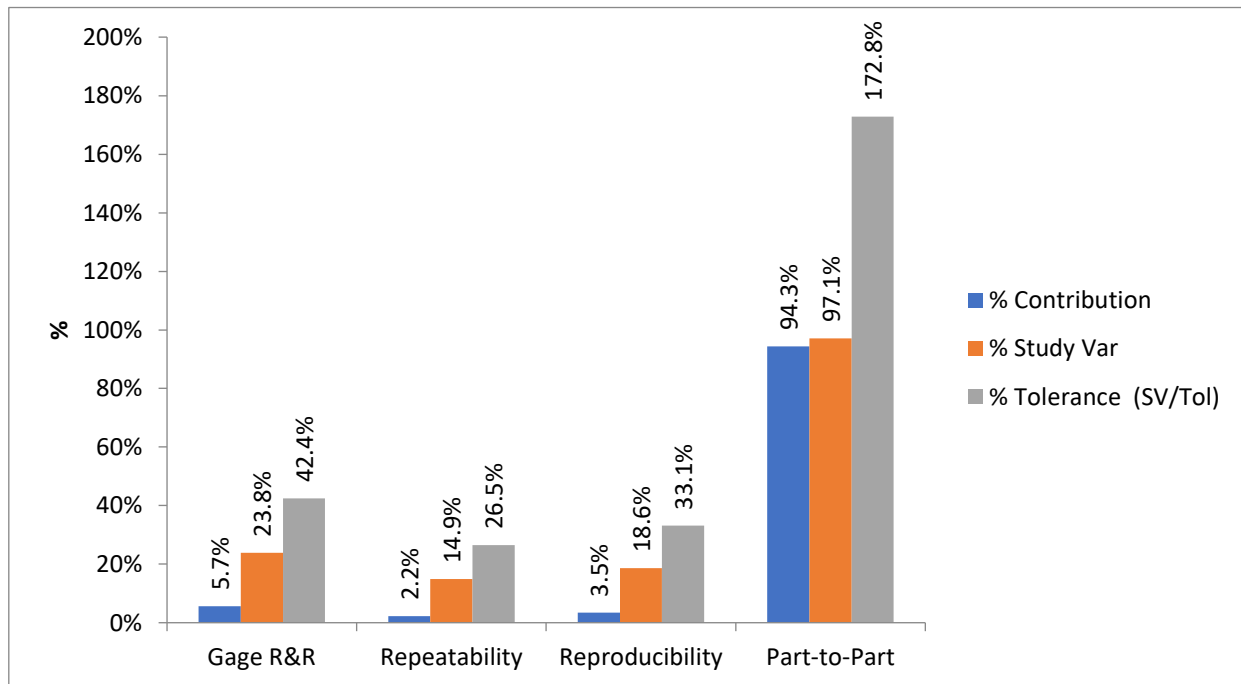
Number of Distinct Categories

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

AIAG Guidelines: NDC greater than or equal to 5.

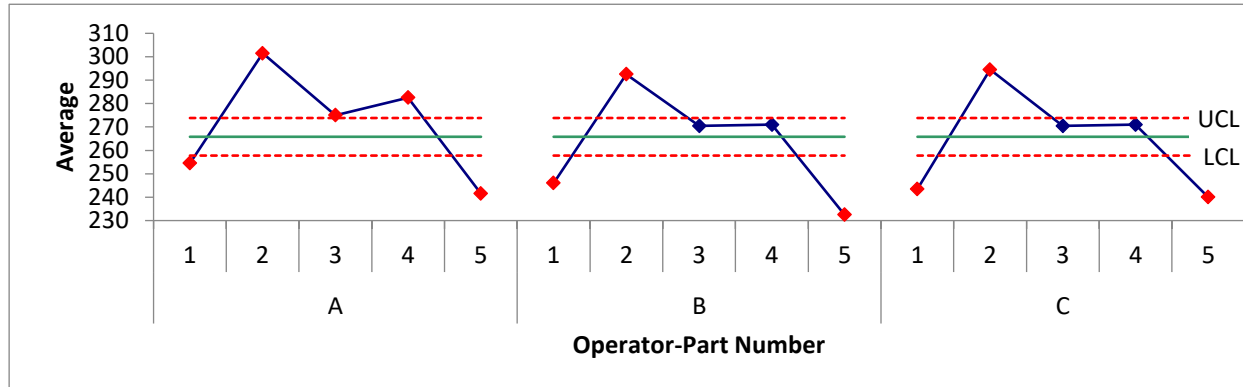
Number of Distinct Categories (NDC) = 5

Variance Components Chart

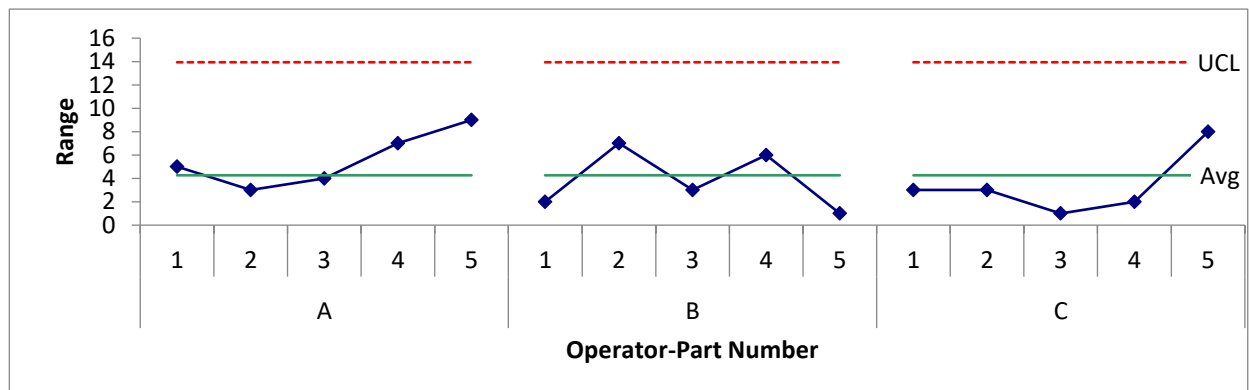


Operator-Part Control Charts

̄X Chart for Operator-Part Averages



R Chart for Operator-Part Ranges



Control Chart Calculations

<u>̄X Chart</u>	$\bar{\bar{X}}$ 265.8	$LCL = \bar{\bar{X}} - A_2\bar{R}$ 257.8	$UCL = \bar{\bar{X}} + A_2\bar{R}$ 273.8
<u>R Chart</u>	\bar{R} 4.267	$LCL = D_3\bar{R}$ -	$UCL = D_4\bar{R}$ 13.94

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

A_2 1.881	D_3 -	D_4 3.267
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̄X Chart Analysis

The \bar{X} chart shows the average value for each operator for each part.
 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.

11 out of 15 points are out of control on the chart.

R Chart Analysis

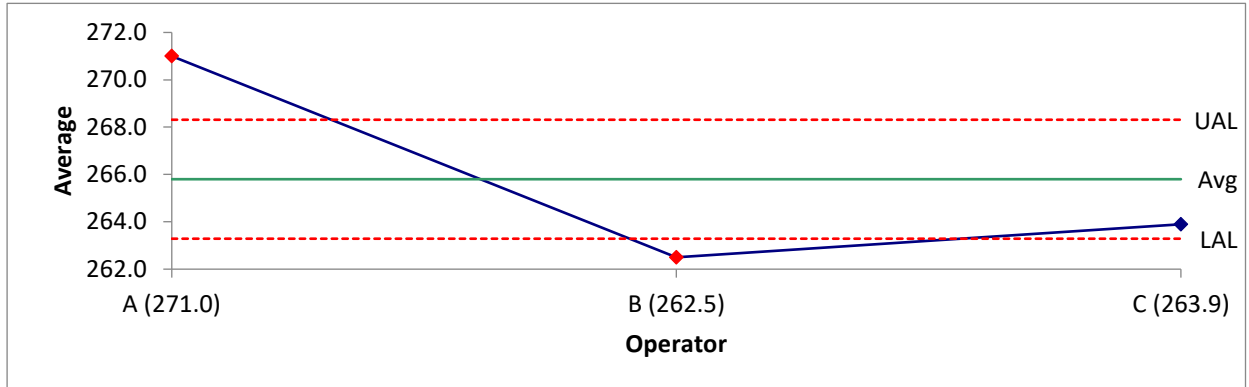
The R chart shows the results for the repeated measurements for each operator for each part. It is a check of the consistency of the measurement process between the operators.

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

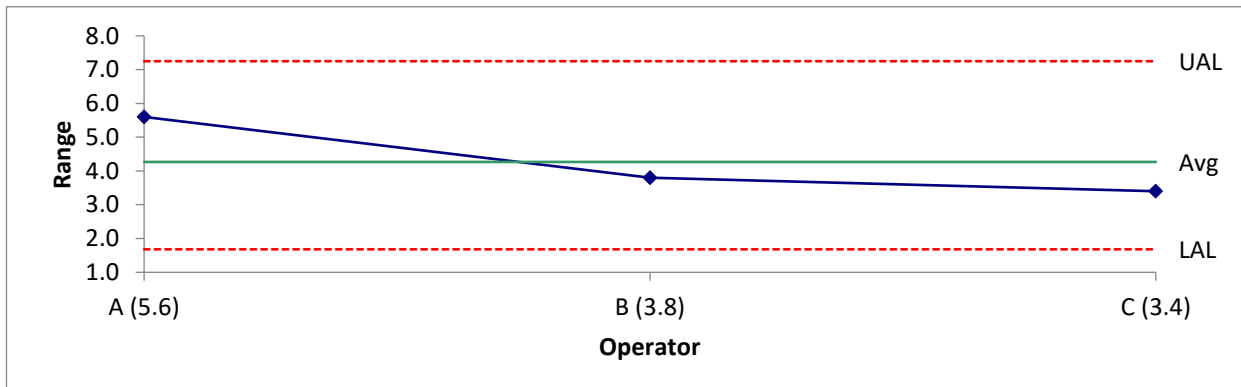
*There are 13.4 degrees of freedom associated with the average range.
It is recommended to have at least 10 degrees of freedom.*

ANOM Charts for Bias and Repeatability

Main Effects (0.05 ANOME) Chart



Mean Range (0.05 ANOMR) Chart



ANOM Calculations

<u>Main Effects</u>	$\bar{\bar{X}}$ 265.8	$LAL = \bar{\bar{X}} - ANOME_{0.05}\bar{R}$ 263.3	$UAL = \bar{\bar{X}} + ANOME_{0.05}\bar{R}$ 268.3
<u>Mean Range</u>	\bar{R} 4.267	$LAL = LMR_{0.05}\bar{R}$ 1.681	$UAL = UMR_{0.05}\bar{R}$ 7.249

where ANOME, LMR, and UMR are scaling factors that depend on the amount of data.

$ANOME_{0.05}$	$LMR_{0.05}$	$UMR_{0.05}$
0.589	0.394	1.699

Main Effects Chart Analysis

This chart plots the average part values for each operator. The purpose of the chart is to check for operator bias. Points beyond the control limits are indications that bias exists.

*There is evidence of detectable bias between the operators.
Review the ANOME chart for the differences.*

Mean Range Chart Analysis

This chart plots the average range values for each operator.
The purpose of the chart is to see if the test-retest error is the same for each operator.
Points beyond the control limits are indications that differences in repeatability exist.

There is no difference in the test-retest error between the operators.

Data

Run No.	Operator	Part	Result	Comment
1	A	1	257	90
16	A	1	252	
2	A	2	300	
17	A	2	303	
3	A	3	277	
18	A	3	273	
4	A	4	279	
19	A	4	286	
5	A	5	246	
20	A	5	237	
6	B	1	245	
21	B	1	247	
7	B	2	296	
22	B	2	289	
8	B	3	272	
23	B	3	269	
9	B	4	274	
24	B	4	268	
10	B	5	233	
25	B	5	232	
11	C	1	242	
26	C	1	245	
12	C	2	296	
27	C	2	293	
13	C	3	270	
28	C	3	271	
14	C	4	270	
29	C	4	272	
15	C	5	236	
30	C	5	244	