GAGE R&R STUDY

Instructions for this form:

1) Type only in the shaded blocks.
2) Be sure to write the Upper & Lower Tolerances.
3) This spreadsheet is set up for either a **5-parts (Short study)** or **10-parts (Long study)** MSA. **Do not use for any other quantity!!**
   - Short study requires 2 Appraisers x 2 Replications
   - Long study requires 3 Appraisers x 3 Replications
4) "Appraiser Names" MUST be filled in for the form to work properly.
   - For 'Short study' keep in blank the space of "Appraiser C"

Gage Name:		Part Name:		Date:		
Gage No.:		Operation No.:		Performed By:		
Graduations:		Characteristic:		Area:		
Zero Equals:		Upper Tolerance	838.8	Appraiser A:	Name 1	Short / Long study
Unit of Measure:		Nominal	838.7	Appraiser B:	Name 2	Short / Long study
Part No:		Lower Tolerance	838.6	Appraiser C:	Name 3	Long study

Instructions for data collection:

1) Select **5-parts (Short study)** or **10-parts (Long study)** at random and marking/identifying them 1 through "n".
2) Have **2 Appraisers (Short study)** or 3 **Appraisers (Long study)** measure each part independently, two or three times each. Record results below.
3) Analyze the results to determine variability due to both Repeatability and Reproducibility.

Appraiser A:	Name 1				*Appraiser* B:	Name 2				*Appraiser* C:	Name 3			
Sample Number	Replications 1	2	3	R (*Range*)	Sample Number	Replications 1	2	3	R (*Range*)	Sample Number	Replications 1	2	3	R (*Range*)
1	838.790	838.770	838.800	0.0300	1	838.780	838.770	838.790	0.0200	1	838.780	838.800	838.790	0.0200
2	838.690	838.680	838.700	0.0200	2	838.690	838.700	838.720	0.0300	2	838.720	838.690	838.730	0.0400
3	838.720	838.690	838.710	0.0300	3	838.700	838.710	838.730	0.0300	3	838.720	838.740	838.710	0.0300
4	838.750	838.740	838.730	0.0200	4	838.730	838.750	838.730	0.0200	4	838.760	838.760	838.720	0.0400
5	838.730	838.720	838.700	0.0300	5	838.710	838.730	838.720	0.0200	5	838.730	838.730	838.750	0.0200
6	838.770	838.790	838.790	0.0200	6	838.770	838.790	838.770	0.0200	6	838.780	838.790	838.780	0.0100
7	838.670	838.680	838.690	0.0200	7	838.700	838.690	838.660	0.0400	7	838.680	838.670	838.700	0.0300
8	838.600	838.610	838.620	0.0200	8	838.610	838.640	838.600	0.0400	8	838.620	838.600	838.620	0.0200
9	838.630	838.650	838.660	0.0300	9	838.660	838.630	838.650	0.0300	9	838.660	838.650	838.640	0.0200
10	838.780	838.780	838.770	0.0100	10	838.770	838.780	838.750	0.0300	10	838.770	838.750	838.760	0.0200
Totals	8387.1300	8387.1100	8387.1700	0.2300	**Totals**	8387.1200	8387.1900	8387.1200	0.2800	**Totals**	8387.2200	8387.1800	8387.2000	0.2500
X (*Means*)	838.7130	838.7110	838.7170	0.0230	**X (*Means*)**	838.7120	838.7190	838.7120	0.0280	**X (*Means*)**	838.7220	838.7180	838.7200	0.0250
	$Xbar_1$	**$Xbar_2$**	**$Xbar_3$**	**$Rbar_A$**		**$Xbar_1$**	**$Xbar_2$**	**$Xbar_3$**	**$Rbar_B$**		**$Xbar_1$**	**$Xbar_2$**	**$Xbar_3$**	**$Rbar_C$**

$Xbar_A = \frac{Xbar_1 + Xbar_2 + Xbar_3}{Replications}$ $Xbar_B = \frac{Xbar_1 + Xbar_2 + Xbar_3}{Replications}$ $Xbar_C = \frac{Xbar_1 + Xbar_2 + Xbar_3}{Replications}$

$Xbar_A$ = 838.7137 **$Xbar_B$ = 838.7143** **$Xbar_C$ = 838.7200**

Test for Statistical Control of Ranges

$Rbar_1 = \frac{Rbar_A + Rbar_B + Rbar_C}{Operators} = \frac{0.0760}{3} =$ **0.0253**

UCL_R = $D_4 * Rbar_1$ = 2.574 * 0.0253 = **0.0652** = **Range Upper Control Limit**

Note: D_4 is based on the number of Replications (see table below)

Gage R&R Study Analysis

Repeatability (EQ - Equipment Variation)

S_{GV} = $Rbar_1 / d_2$ = 0.0253 / 1.6930 = **0.0150**

Note: d_2 is based on the number of Replications (see table below)

StudyVar (S_{GV} * 6) = 0.0150 * 6 = **0.0898**

Percent of Engineering Tolerance Consumed by the Equipment / Gage:

Repeatability = $\frac{100\ (6.00 * S_D)}{Eng.\ Tolerance} = \frac{0.0898}{0.2000} =$ **44.89%**

Reproducibility (AV - Appraiser Variation)

$Rbar_2$ =	$Xbar_{Largest\ of\ ABC} - Xbar_{Smallest\ of\ ABC}$ =		838.7200	-	838.7137	=	**0.0063**	
S_{OV} =	$Rbar_2 / d_2^*$ =	0.0063	/	1.912	=	**0.0033**		

Note: d_2^* is based on the number of Operators (see table below)

Number of parts =	10
Number of trials =	3
d_2^* =	1.912

Percent of Engineering Tolerance consumed by Appraiser / Operator:

StudyVar (S_{OV} * 6) = $(Rbar_2) \times (6.00/d_2^*)\}^2 - \{(Repeatability)^2 / (No.\ parts \times No.\ trials)\}$ **0.0112**

Reproducibility = $\frac{100\ (6.00 * S_{OV})}{Eng.\ Tolerance} = \frac{0.0112}{0.2000}$ **5.62%**

Combined Reproducibility and Repeatability (Measurement System)

S_{MV} =	$S_{OV}^2 + S_{GV}^2$ =	0.0033	+	0.0150	=	**0.0153**	Product Sigma

*** SPECIAL SUPPLIER NOTE:** **Supplier needs to enter "Product Sigma" into HS Process Certification Database when creating a new Gage File for any HS defined KPCs/TKCs. Enter the Product Sigma into the database field entitled "Gage RR Std**

1) Percent of Engineering Tolerance consumed by Measurement system:

Gage R & R = $\frac{100\ (6.00 * S_{MV})}{Eng.\ Tolerance} = \frac{0.091955}{0.2000} =$ **45.98%**

2) Percent of Process Tolerance (Combined Variability) consumed by Measurement system:

$(Repeatability)^2 + (Reproducibility)^2$ = **0.0905**

CAUTION: Percent Process Tolerance value is only valid for 5-part (Short study) or 10-part (Long study) MSA.

Gage R & R = Percent Process Tolerance (Combined Variability) = $(R\&R)/(6/d_2)*Rbar_{CV}$ = 0.0905 * 3.0780 / 1.0667 = **26.11%**

Gage R&R Study Evaluation Guideline

1) Gage Capability for Product Acceptance (% of Engineering Tolerance)
GC as a % of Eng. Tolerance = (Gage R&R / Total Eng. Tolerance Range) * 100 = **45.98%** *% Tolerance (SV/Toler*

2) Gage Capability for Control Chart purposes (% of Process Tolerance)
% of Process Tolerance = (R&R / 6 x $Sigma_{CV}$) * 100 = **26.11%** *% Study Var (% SV)*

Legend	ACCEPTABLE	MARGINAL	UNACCEPTABLE
Eng. Tolerance	0 - 20 %	-	> 20 %
Process Tolerance	0 - 19 %	20 - 30%	> 30 %

Table of Factors used in calculations.

n	D_4	d_2	d_2^*
2	3.267	1.128	1.414
3	2.574	1.693	1.912
5		2.326	
10		3.078	

Study Observation

INSTRUCTIONS: Please record any significant observations, such as Operator/Inspector methodical differences, environmental factors (i.e., lighting, temperature, vibration, distractions, etc.), difiiculties in using the measurement system (i.e., obtaining readings, gage readability, ability to easily hold gage and/or part, etc.) that could influence the study results.

SAE RM13003 - *Study Case* (Pag 72)

Data:

	Operator A			Operator B			Operator C		
Part	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1	838.79	838.77	838.80	838.78	838.77	838.79	838.78	838.80	838.79
2	838.69	838.68	838.70	838.69	838.70	838.72	838.72	838.69	838.73
3	838.72	838.69	838.71	838.70	838.71	838.73	838.72	838.74	838.71
4	838.75	838.74	838.73	838.73	838.75	838.73	838.76	838.76	838.72
5	838.73	838.72	838.70	838.71	838.73	838.72	838.73	838.73	838.75
6	838.77	838.79	838.79	838.77	838.79	838.77	838.78	838.79	838.78
7	838.67	838.68	838.69	838.70	838.69	838.66	838.68	838.67	838.70
8	838.60	838.61	838.62	838.61	838.64	838.60	838.62	838.60	838.62
9	838.63	838.65	838.66	838.66	838.63	838.65	838.66	838.65	838.64
10	838.78	838.78	838.77	838.77	838.78	838.75	838.77	838.75	838.76

The mean average diameter for each part/operator combination was then calculated together with the range (maximum - minimum).

Operator A		
Part	Mean Average	Range
1	838.787	0.030
2	838.690	0.020
3	838.707	0.030
4	838.740	0.020
5	838.717	0.030
6	838.783	0.020
7	838.680	0.020
8	838.610	0.020
9	838.647	0.030
10	838.777	0.010
Overall averages	838.7137	0.0230

Operator B		
Part	Mean Average	Range
1	838.780	0.020
2	838.703	0.030
3	838.713	0.030
4	838.737	0.020
5	838.720	0.020
6	838.777	0.020
7	838.683	0.040
8	838.617	0.040
9	838.647	0.030
10	838.767	0.030
Overall averages	838.7143	0.0280

Operator C		
Part	Mean Average	Range
1	838.790	0.020
2	838.713	0.040
3	838.723	0.030
4	838.747	0.040
5	838.737	0.020
6	838.783	0.010
7	838.683	0.030
8	838.613	0.020
9	838.650	0.020
10	838.760	0.020
Overall averages	838.7200	0.0250

Calculating all the variance components from the above data gave us the following results, using the simpler Xbar R method:

Gauge R&R for Diameter:

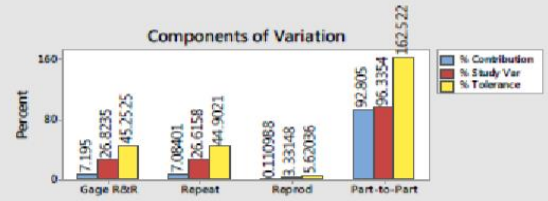
Source	Variance Component	% Contribution (of Variance Component)
Total gauge R&R	0.0002274	7.20
Repeatability	0.0002239	7.08
Reproducibility	0.0000035	0.11
Part-to-part	0.0029331	92.80
Total variation	0.0031605	100.00

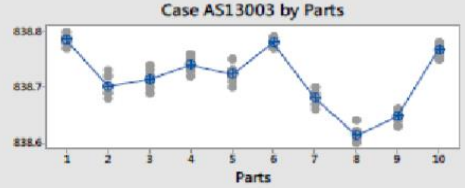
Source	Standard Deviation (SD)	Study Variation (6 * SD)	% Study Variation	% Tolerance (SV/Tolerance)
Total gauge R&R	0.0150811	0.090487	26.83	45.24
Repeatability	0.0149636	0.089781	26.62	44.89
Reproducibility	0.0018792	0.011275	3.34	5.64
Part-to-part	0.0541579	0.324948	96.33	162.47
Total variation	0.0562185	0.337311	100.00	168.66

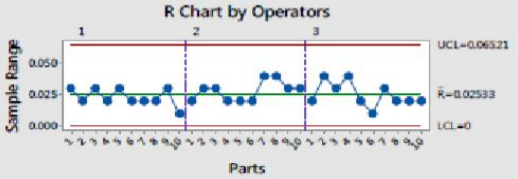
Comparisson study, Minitab 18 Vs. ASG Spreadsheet based on AIAG

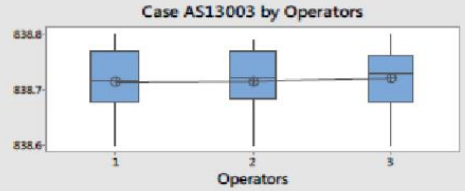
Gage name: Per AS13003
Date of study: 4/20/2020

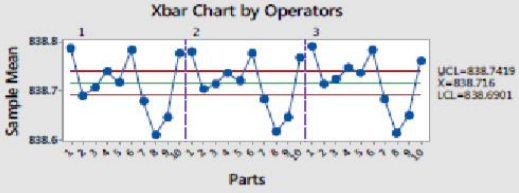
Reported by: Advanced Quality Team
Tolerance: 838.8-838.6
Misc: Comparisson study, Minitab 18 Vs. ASG Spreadsheet

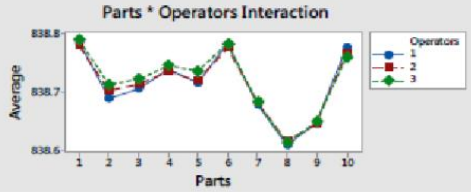












Gage R&R Study - XBar/R Method

Gage R&R for Case AS13003

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0002275	7.19
Repeatability	0.0002240	7.08
Reproducibility	0.0000035	0.11
Part-To-Part	0.0029348	92.81
Total Variation	0.0031624	100.00

Process tolerance = 0.2

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0150842	0.090505	26.82	45.25
Repeatability	0.0149674	0.089804	26.62	44.90
Reproducibility	0.0018735	0.011241	3.33	5.62
Part-To-Part	0.0541741	0.325045	96.34	162.52
Total Variation	0.0562349	0.337410	100.00	168.70

Number of Distinct Categories = 5

Gage R&R for Case AS13003