
Symphony Technologies develop application-focused statistical software for the industry. It is our endeavor to provide software that is easy to use and at the same time is statistically rigorous and accurate. We constantly try to improve on our products and to ensure that our users get the results they can trust.

This documents outlines the methods we use to validate our software.

All the numerical calculations and graphical outputs from ProMSA Software are validated using the following methods:

- 1) Numerical results are verified by doing calculations by hand where possible. This enables validation of intermediate as well as final results.
- 2) Numerical results are also validated by using other or similar software capable of doing statistical calculations. For example, this may involve creating appropriate formulae in MS Excel. The intermediate and final results are verified against these calculations. Sometimes, graphical output is validated by plotting the graphs in MS Excel and comparing with ProMSA outputs.
- 3) ProMSA results are validated by inputting published data and comparing the outputs with published results. Such data can come from international standards e.g. The fourth edition of the MSA Manual published by the Automotive Industry Action Group (AIAG), Data published by OE manufacturers (e.g. Ford) for the purpose of software validation and calibration or from well known books and publications on the subject.

In most studies, ProMSA software has a "Demo Data" button. Pressing this button automatically loads the test data from the fourth edition of AIAG MSA manual. Thereafter, the calculated results can easily be verified by comparing them with the AIAG MSA Manual.

This document uses the raw data and results published by AIAG and Ford. It shows the results computed by ProMSA vis-à-vis those published by the AIAG and Ford.

ProMSA outputs the results on screen that can be printed directly or exported to various popular document formats such as MS Excel, Word or PDF. This validation kit also includes PDF samples of all the reports generated by ProMSA.

For any questions regarding proMSA Software, please write to us at products@symphonytech.com

A limited period evaluation version of ProMSA can be downloaded from our website at <http://www.symphonytech.com/promsa.htm>

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ProMSA: Validation Data Sets and Results



Gage R&R Test: Range-Average Method : AIAG Dataset

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 105(Table III-B 6a)

No. of Parts:	10
No. of Appraisers:	3
No. of Trials:	3
Coverage Factor:	60

99.73%

Study Data:

Appraiser	Trial #	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Part 7	Part 8	Part 9	Part 10
Appraiser1	1	0.29	-0.56	1.34	0.47	-0.8	0.02	0.59	-0.31	2.26	-1.36
	2	0.41	-0.68	1.17	0.5	-0.92	-0.11	0.75	-0.2	1.99	-1.25
	3	0.64	-0.58	1.27	0.64	-0.84	-0.21	0.66	-0.17	2.01	-1.31
Appraiser2	1	0.08	-0.47	1.19	0.01	-0.56	-0.2	0.47	-0.63	1.8	-1.68
	2	0.25	-1.22	0.94	1.03	-1.2	0.22	0.55	0.08	2.12	-1.62
	3	0.07	-0.68	1.34	0.2	-1.28	0.06	0.83	-0.34	2.19	-1.5
Appraiser3	1	0.04	-1.38	0.88	0.14	-1.46	-0.29	0.02	-0.46	1.77	-1.49
	2	-0.11	-1.13	1.09	0.2	-1.07	-0.67	0.01	-0.56	1.45	-1.77
	3	-0.15	-0.96	0.67	0.11	-1.45	-0.49	0.21	-0.49	1.87	-2.16

Numerical Results

Compare with Fig III-B 15 (Page 118) and Fig. III-B 16 (Page 119) MSA Manual

Param.	Src: MSA Manual	Source: ProMSA	Param.	Src: MSA Manual	Source: ProMSA
Xa_Bar	0.1903	0.19033	X_Double_Bar	0.0014	0.00144
Ra_Bar	0.184	0.18400	R_Double_Bar	0.3417	0.34167
Xb_Bar	0.0683	0.06833	Xbar_Diff	0.4446	0.44467
Rb_Bar	0.513	0.51300	Rp	3.511	3.5111
Xc_Bar	-0.2543	-0.25433	UCLr	0.8816	0.87945
Rc_Bar	0.328	0.32800			

Parameter	Src: MSA Manual	Source: ProMSA
EV	0.20188	0.20186
AV	0.22963	0.22968
RR	0.30575	0.30578
PV	1.10456	1.10445
TV	1.14610	1.14600
%EV	17.62	17.61
%AV	20.04	20.04
%RR	26.68	26.68
%PV	96.38	96.37
nDC	5.094 [~5]	5.093 [~5]

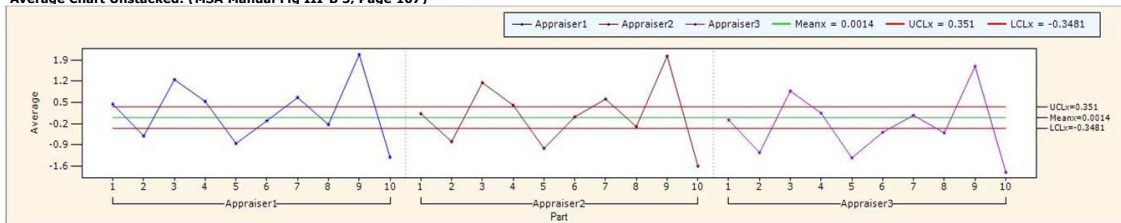
Intermediate Results from ProMSA: Compare with Fig III-B 15 (Page 118) and Fig. III-B 16 (Page 119) MSA Manual

Operators		Trials	Part										Average	
			1	2	3	4	5	6	7	8	9	10		
Appraiser1	1	0.29	-0.56	1.34	0.47	-0.8	0.02	0.59	-0.31	2.26	-1.36		0.194	
	2	0.41	-0.68	1.17	0.5	-0.92	-0.11	0.75	-0.2	1.99	-1.25		0.166	
	3	0.64	-0.58	1.27	0.64	-0.84	-0.21	0.66	-0.17	2.01	-1.31		0.211	
	Average	0.44667	-0.60667	1.26	0.53667	-0.85333	-0.1	0.66667	-0.22667	2.08667	-1.30667	Xa-Bar =	0.19033	
	Range	0.35	0.12	0.17	0.17	0.12	0.23	0.16	0.14	0.27	0.11	Ra-Bar =	0.184	
Appraiser2	1	0.08	-0.47	1.19	0.01	-0.56	-0.2	0.47	-0.63	1.8	-1.68		0.001	
	2	0.25	-1.22	0.94	1.03	-1.2	0.22	0.55	0.08	2.12	-1.62		0.115	
	3	0.07	-0.68	1.34	0.2	-1.28	0.06	0.83	-0.34	2.19	-1.5		0.089	
	Average	0.13333	-0.79	1.15667	0.41333	-1.01333	0.02667	0.61667	-0.29667	2.03667	-1.6	Xb-Bar =	0.06833	
	Range	0.18	0.75	0.4	1.02	0.72	0.42	0.36	0.71	0.39	0.18	Rb-Bar =	0.513	
Appraiser3	1	0.04	-1.38	0.88	0.14	-1.46	-0.29	0.02	-0.46	1.77	-1.49		-0.223	
	2	-0.11	-1.13	1.09	0.2	-1.07	-0.67	0.01	-0.56	1.45	-1.77		-0.256	
	3	-0.15	-0.96	0.67	0.11	-1.45	-0.49	0.21	-0.49	1.87	-2.16		-0.284	
	Average	-0.07333	-1.15667	0.88	0.15	-1.32667	-0.48333	0.08	-0.50333	1.69667	-1.80667	Xc-Bar =	-0.25433	
	Range	0.19	0.42	0.42	0.09	0.39	0.38	0.2	0.1	0.42	0.67	Rc-Bar =	0.328	
Part Average			0.16889	-0.85111	1.09889	0.36667	-1.06444	-0.18556	0.45444	-0.34222	1.94	-1.57111	Rp =	3.51111
[Ra-Bar =0.18400]+[Rb-Bar =0.51300]+[Rc-Bar =0.32800]/[# of Operators =3] =													RDBar =	0.34167
[Max XBar =0.19033] - [Min XBar=-0.25433] =													XBar(diff) =	0.44467
[RDBar =0.34167] x [D4 =2.574] =													UCLr =	0.87945

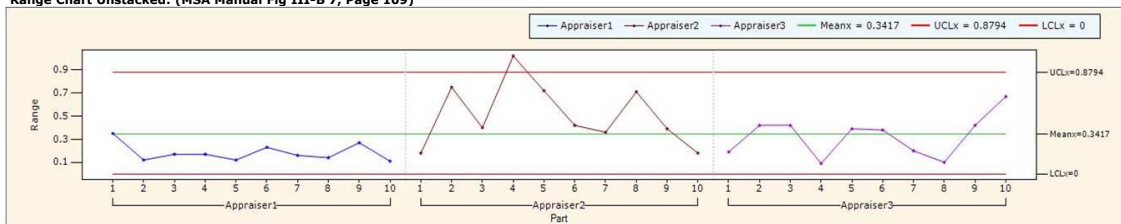
Measurement Systems Analysis	% Total Variation (TV)
Repeatability - Equipment Variation (EV) EV = $R\bar{D} \times K_1$ $0.34167 \times 0.590817514$ 0.20186	% EV = $100 [EV / TV]$ $100 [0.20186/1.14600]$ 17.61
Reproducibility - Appraiser Variation (AV) AV = $\sqrt{[(X\bar{B} \text{ Diff} \times K_2)^2 + (EV^2 / nr)]}$ $\sqrt{[(0.44467 \times 0.523135675)^2 + (0.20186^2/(10 \times 3))]}$ 0.22968	% AV = $100 [AV / TV]$ $100 [0.22968/1.14600]$ 20.04
Repeatability & Reproducibility (RR) RR = $\sqrt{[(EV^2 + AV^2)]}$ $\sqrt{[0.20186^2 + 0.22968^2]}$ 0.30578	% RR = $100 [RR / TV]$ $100 [0.30578/1.14600]$ 26.68
Part Variation (PV) PV = $R_p \times K_3$ $3.51111 \times 0.314559381$ 1.10445	% PV = $100 [PV / TV]$ $100 [1.10445/1.14600]$ 96.37
Total Variation (TV) TV = $\sqrt{[R\&R^2 + PV^2]}$ $\sqrt{[0.30578^2 + 1.10445^2]}$ 1.146	nDC = $1.41(PV / RR)$ $1.41 (1.10445/0.30578)$ 5.093 ~ 5

Graphical Results

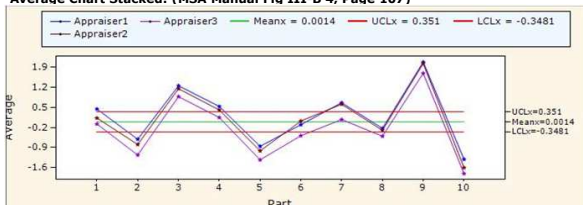
Average Chart Unstacked: (MSA Manual Fig III-B 5, Page 107)



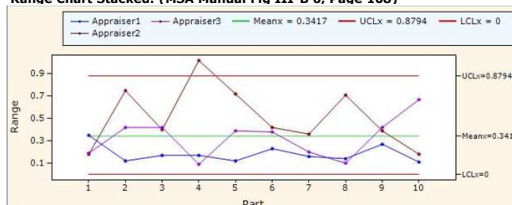
Range Chart Unstacked: (MSA Manual Fig III-B 7, Page 109)



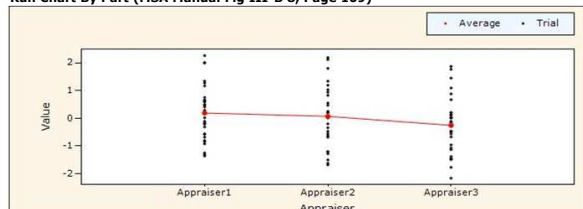
Average Chart Stacked: (MSA Manual Fig III-B 4, Page 107)



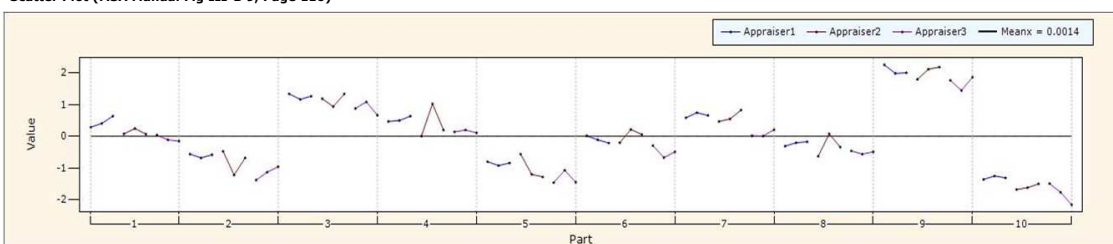
Range Chart Stacked: (MSA Manual Fig III-B 6, Page 108)



Run Chart By Part (MSA Manual Fig III-B 8, Page 109)



Scatter Plot (MSA Manual Fig III-B 9, Page 110)



1. Small differences may occur due to rounding off in the MSA manual.
2. ProMSA can report intermediate and final values up to 8 decimal places.
3. In ProMSA, Select Range-Average method from the R&R Method drop-down box and click on the button captioned 10x3x3 on R&R Study form to populate the grid with above data.
4. See AIAG_GRR_Range_Average.xls for a sample of full numerical and graphical report output from ProMSA.

Gage R&R Test: Crossed ANOVA Method: AIAG Dataset

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 105(Fig III-B 6a), 118(Fig III-B 15), 198(Table A4, A5)

No. of Parts:	10
No. of Appraisers:	3
No. of Trials	3
Coverage:	6 σ
Alpha(α):	0.05

Study Data: AIAG MSA Manual (4th Edition) : Page Nos. 105(Fig III-B 6a)

Appraiser	Trial #	Part									
		1	2	3	4	5	6	7	8	9	10
Appraiser1	1	0.29	-0.56	1.34	0.47	-0.8	0.02	0.59	-0.31	2.26	-1.36
	2	0.41	-0.68	1.17	0.5	-0.92	-0.11	0.75	-0.2	1.99	-1.25
	3	0.64	-0.58	1.27	0.64	-0.84	-0.21	0.66	-0.17	2.01	-1.31
Appraiser2	1	0.08	-0.47	1.19	0.01	-0.56	-0.2	0.47	-0.63	1.8	-1.68
	2	0.25	-1.22	0.94	1.03	-1.2	0.22	0.55	0.08	2.12	-1.62
	3	0.07	-0.68	1.34	0.2	-1.28	0.06	0.83	-0.34	2.19	-1.5
Appraiser3	1	0.04	-1.38	0.88	0.14	-1.46	-0.29	0.02	-0.46	1.77	-1.49
	2	-0.11	-1.13	1.09	0.2	-1.07	-0.67	0.01	-0.56	1.45	-1.77
	3	-0.15	-0.96	0.67	0.11	-1.45	-0.49	0.21	-0.49	1.87	-2.16

Numerical Results:

ANOVA Table Source: MSA Manual: Table A4, Page 198

Source	DF	Sum Square	Mean Square	F Value
Appraiser	2	3.1673	1.58363	79.41*
Parts	9	88.3619	9.81799	492.29*
App x Part	18	0.3590	0.01994	0.434
Equipment	60	2.7589	0.04598	
Total	89	94.6471		

Source: ProMSA

Source	DF	Sum Square	Mean Square	F Value
Appraiser	2	3.16726	1.58363	79.406*
Parts	9	88.36193	9.81799	492.291*
App x Part	18	0.35898	0.01994	0.434
Equipment	60	2.75893	0.04598	
Total	89	94.64711		

ANOVA Table without Interaction

Source: ProMSA

Source	DF	Sum Square	Mean Square	F Value
Appraiser	2	3.16726	1.58363	39.617
Parts	9	88.36193	9.81799	245.614
Equipment	78	3.11792	0.03997	
Total	89	94.64711		

ANOVA Analysis Source: MSA Manual: Table A5, Page 198

Source	Variance	Proc. Std. Dev.	6*St.Dev.	% Study	% Contrib
Equipment	0.039973	0.199933	1.199598	18.4	3.4
Appraiser	0.051455	0.226838	1.361028	20.9	4.4
GRR	0.091430	0.302373	1.814238	27.9	7.8
Parts	1.086447	1.042327	6.253962	96.0	92.2
Total	1.177875	1.085	6.51	100.0	
nDC	4.87 [~4]				

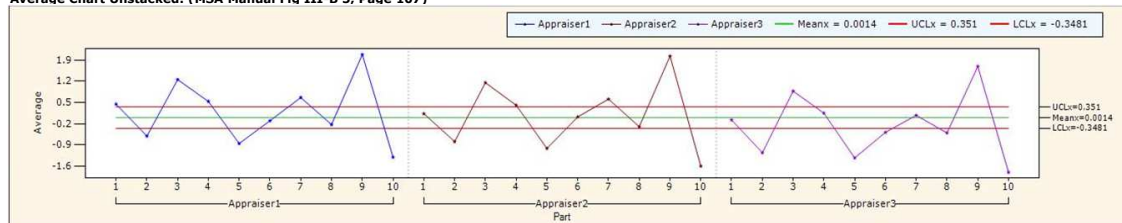
ANOVA Analysis Source: ProMSA

Source	Variance	Proc. Std. Dev.	6*St.Dev.	% Study	% Contrib
Equipment	0.039973	0.199933	1.199599	18.42	3.39
Appraiser	0.051455	0.226838	1.361025	20.90	4.37
GRR	0.091429	0.302372	1.814229	27.86	7.76
Parts	1.086447	1.042327	6.253965	96.04	92.24
Total	1.177875	1.085300	6.511797	100.00	100.00
nDC	4.860516 [~4]				

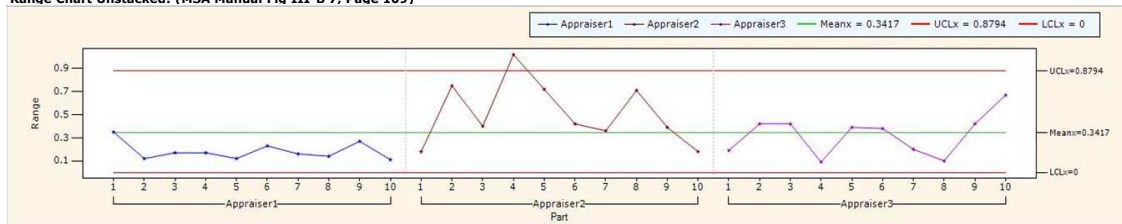
- Small differences may occur due to rounding off in the MSA manual.
- ProMSA can report intermediate and final values up to 8 decimal places.
- In ProMSA, Select Range-Average method from the R&R Method drop-down box and click on the button captioned 10x3x3 on R&R Study form to populate the grid with above data.
- See AIAG_GRR_Crossed_ANOVA.xls for a sample of full numerical and graphical report output from ProMSA.

Graphical Results

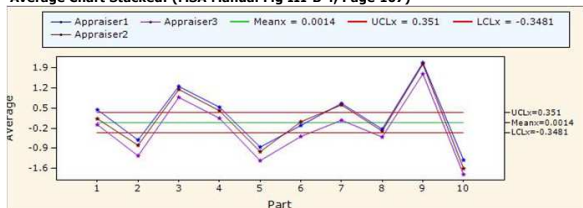
Average Chart Unstacked: (MSA Manual Fig III-B 5, Page 107)



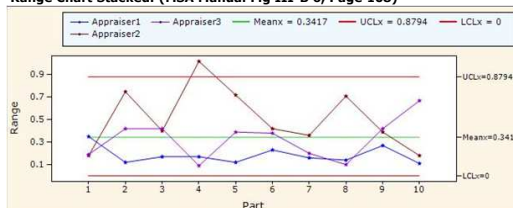
Range Chart Unstacked: (MSA Manual Fig III-B 7, Page 109)



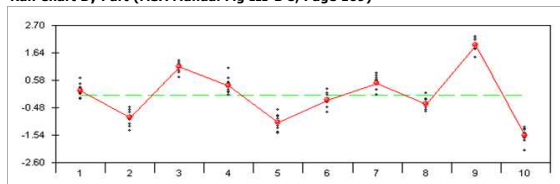
Average Chart Stacked: (MSA Manual Fig III-B 4, Page 107)



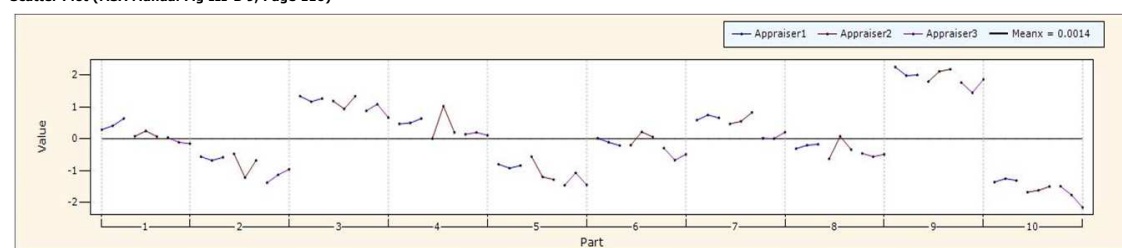
Range Chart Stacked: (MSA Manual Fig III-B 6, Page 108)



Run Chart By Part (MSA Manual Fig III-B 8, Page 109)



Scatter Plot (MSA Manual Fig III-B 9, Page 110)



Gage R&R Test: Ford Dataset

Data Source: Measurement System Software Calibration File: Measurement_System_Software_Callibration_Tables.xls *

Input Data for Statistical Software

Study Variation (Number of Standard Deviations)	6
Part specification	4.0 ± 1.0
Process Tolerance	2.0

Operators/Trials		Part									
		1	2	3	4	5	6	7	8	9	10
Appraiser1	1	3.63957	3.93548	3.84455	4.1651	4.28118	3.43333	3.80442	3.93066	4.14554	4.22784
	2	3.57531	3.93015	3.88189	4.22454	4.30886	3.44552	3.84481	3.90602	4.15316	4.21844
	3	3.61748	3.89916	3.79324	4.18314	4.25248	3.36779	3.78816	3.89789	4.19837	4.24714
Appraiser2	1	3.58826	3.91847	3.85039	4.16154	4.22682	3.40564	3.80264	3.86563	4.14732	4.22073
	2	3.62865	3.90653	3.84887	4.20828	4.23444	3.39446	3.80366	3.84912	4.09804	4.2187
	3	3.63094	3.94514	3.8509	4.23495	4.27788	3.39599	3.8001	3.87503	4.1237	4.21311
Appraiser3	1	3.57734	3.88087	3.85293	4.17678	4.26467	3.43282	3.81052	3.85141	4.14072	4.22352
	2	3.58268	3.87173	3.78054	4.16129	4.23876	3.37973	3.79959	3.8857	4.15189	4.21133
	3	3.62865	3.87351	3.7968	4.1745	4.19888	3.3998	3.78664	3.85217	4.12522	4.22454

Required Outputs from Statistical Software		
	Source: Ford	Source: ProMSA
Gauge R&R as a percent of tolerance using the ANOVA Method	8.23	8.23
Gauge R&R as a percent of study variation using the ANOVA Method	9.74	9.74
Gauge R&R as a percent of tolerance using the Average and Range Method	8.27	8.27
Gauge R&R as a percent of study variation using the Average and Range	10.28	10.28
Number of distinct categories	14	14

1. Small differences may occur due to rounding off in the MSA manual.
2. ProMSA can report intermediate and final values up to 8 decimal places.

- * See For Ford data and results, SEE Measurement_System_Software_Callibration_Tables.xls
 # See Ford_Crossed_ANOVA.xls for full numerical and graphical output from ProMSA.
 @ See Ford_Range_Average.xls for full numerical and graphical output from ProMSA.

Bias Test

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 87 - 92

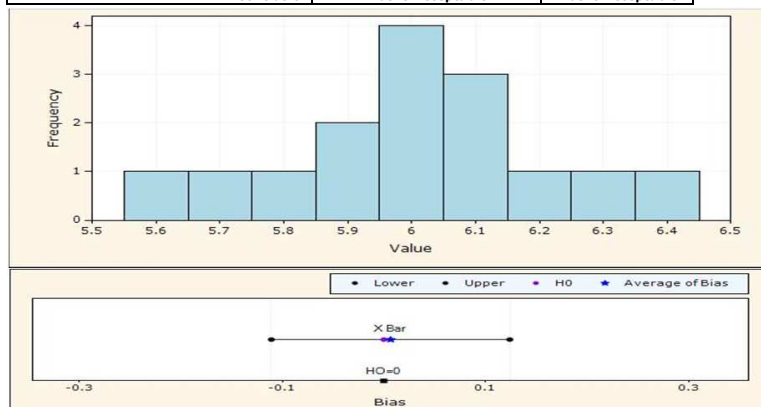
No of Readings:	15
Reference Value:	6.0
Confidence Interval:	95%
Alpha(α):	0.05

Study Data: MSA Manual Page 90, Table III-B 1.

Reading No.	Value	Bias (AIAG)
1	5.8	-0.2
2	5.7	-0.3
3	5.9	-0.1
4	5.9	-0.1
5	6.0	0.0
6	6.1	0.1
7	6.0	0.0
8	6.1	0.1
9	6.4	0.4
10	6.3	0.3
11	6.0	0.0
12	6.1	0.1
13	6.2	0.2
14	5.6	-0.4
15	6.0	0.0

Bias (ProMSA)
-0.2
-0.3
-0.1
-0.1
0.0
0.1
0.0
0.1
0.4
0.3
0.0
0.1
0.2
-0.4
0.0

Results:		
Parameter	Source: MSA Manual Page 92, Table III-B 2	Source: ProMSA
No of Readings, n	15	15
Average, \bar{X} Double Bar	6.0067	6.0067
Bias	0.0067	0.0067
Deg. Of Freedom, DF	14	14
σ_r : Repeatability Std Deviation	0.2120	0.2120
σ_b : Standard Error of Mean	0.0547	0.0547
t statistic	0.12	0.1218
$t_{(DF, 1-\alpha/2)}$: Significant t Value	2.14479	2.1448
95% Confidence Interval of the Bias		
Lower CI	-0.1107	-0.1107
Upper CI	0.1241	0.1241
Conclusion	Bias is Acceptable	Bias is Acceptable



Histogram of Bias Study: (MSA Manual : Figure III-B 2 Page 91)

- Small differences may occur due to rounding off in the MSA manual.
- ProMSA can report intermediate and final values up to 8 decimal places.
- In ProMSA, click on the Demo Data button on Bias Study form to populate the grid with above data.
- See AIAG_Bias.xls for a sample of full numerical and graphical report output from ProMSA.

Linearity Test

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 96 - 101

No of Ref Values:	5
No of Readings at each ref:	12
Confidence Interval:	95%
Alpha(α):	0.05

Study Data: AIAG MSA Manual (4th Edition) : Table III-B 4, Page 99

Level ->	1	2	3	4	5
No Ref. ->	2.00	4.00	6.00	8.00	10.00
1	2.70	5.10	5.80	7.60	9.10
2	2.50	3.90	5.70	7.70	9.30
3	2.40	4.20	5.90	7.80	9.50
4	2.50	5.00	5.90	7.70	9.30
5	2.70	3.80	6.00	7.80	9.40
6	2.30	3.90	6.10	7.80	9.50
7	2.50	3.90	6.00	7.80	9.50
8	2.50	3.90	6.10	7.70	9.50
9	2.40	3.90	6.40	7.80	9.60
10	2.40	4.00	6.30	7.50	9.20
11	2.60	4.10	6.00	7.60	9.30
12	2.40	3.80	6.10	7.70	9.40

Bias: AIAG MSA Manual (4th Edition) : Table III-B 5, Page 99

Level ->	1	2	3	4	5
No Ref. ->	2.00	4.00	6.00	8.00	10.00
1	0.70	1.10	-0.20	-0.40	-0.90
2	0.50	-0.10	-0.30	-0.30	-0.70
3	0.40	0.20	-0.10	-0.20	-0.50
4	0.50	1.00	-0.10	-0.30	-0.70
5	0.70	-0.20	0.00	-0.20	-0.60
6	0.30	-0.10	0.10	-0.20	-0.50
7	0.50	-0.10	0.00	-0.20	-0.50
8	0.50	-0.10	0.10	-0.30	-0.50
9	0.40	-0.10	0.40	-0.20	-0.40
10	0.40	0.00	0.30	-0.50	-0.80
11	0.60	0.10	0.00	-0.40	-0.70
12	0.40	-0.20	0.10	-0.30	-0.60
Average Bias	0.4916667	0.125	0.025	-0.291667	-0.616667

Intermediate Results: Source ProMSA

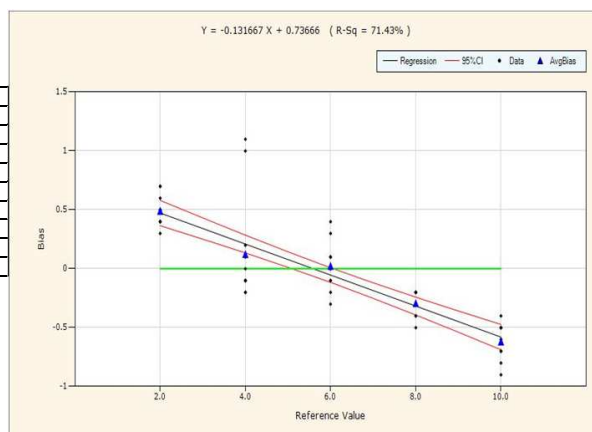
Intermediate Results: Source P1030A										
Level	1		2		3		4		5	
Ref. Val.	2	Bias	4	Bias	6	Bias	8	Bias	10	Bias
1	2.7	0.700	5.1	1.100	5.8	-0.200	7.6	-0.400	9.1	-0.900
2	2.5	0.500	3.9	-0.100	5.7	-0.300	7.7	-0.300	9.3	-0.700
3	2.4	0.400	4.2	0.200	5.9	-0.100	7.8	-0.200	9.5	-0.500
4	2.5	0.500	5.0	1.000	5.9	-0.100	7.7	-0.300	9.3	-0.700
5	2.7	0.700	3.8	-0.200	6.0	0.000	7.8	-0.200	9.4	-0.600
6	2.3	0.300	3.9	-0.100	6.1	0.100	7.8	-0.200	9.5	-0.500
7	2.5	0.500	3.9	-0.100	6.0	0.000	7.8	-0.200	9.5	-0.500
8	2.5	0.500	3.9	-0.100	6.1	0.100	7.7	-0.300	9.5	-0.500
9	2.4	0.400	3.9	-0.100	6.4	0.400	7.8	-0.200	9.6	-0.400
10	2.4	0.400	4.0	0.000	6.3	0.300	7.5	-0.500	9.2	-0.800
11	2.6	0.600	4.1	0.100	6.0	0.000	7.6	-0.400	9.3	-0.700
12	2.4	0.400	3.8	-0.200	6.1	0.100	7.7	-0.300	9.4	-0.600
Average	2.491667	0.491667	4.125000	0.125000	6.025000	0.025000	7.708333	-0.291667	9.383333	-0.616667

Results: Linearity Study: (MSA Manual : Figure III-B 3 Page 100)

Parameter	Source: MSA Manual	Source: ProMSA
Regression Line		
Equation	$Y = 0.736667 - 0.131667 X$	$Y = -0.131667 X + 0.736667$
Slope	-0.131667	-0.131667
Intercept	0.736667	0.736667
R-Squared	0.714 (71.4%)	0.7143 (71.43%)
t-Statistic		
ta	12.043	12.042559
tb	10.158	10.157519
$t_{58,0.975}$	2.00172	2.001716

Notes:

- Small differences may occur due to rounding off in the MSA manual.
- ProMSA can report intermediate and final values up to 8 decimal places.
- In ProMSA, click on the Demo Data button on Linearity Study form to populate the grid with above data.
- See AIAG_Linearity.xls for a sample of full numerical and graphical report output from ProMSA.



Attribute Gage R&R Test: Crosstabulation

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 134(Table III-C 1), 135 to 140

No. of Samples:	50
No. of Appraisers:	3
No. of Trials:	3

Study Data: MSA Manual Page 134 (Table III-C 1)

No.	Appraiser1			Appraiser2			Appraiser3			Ref. Decision	Code
	A-1	A-2	A-3	B-1	B-2	B-3	C-1	C-2	C-3		
1	1	1	1	1	1	1	1	1	1	1	+
2	1	1	1	1	1	1	1	1	1	1	+
3	0	0	0	0	0	0	0	0	0	0	-
4	0	0	0	0	0	0	0	0	0	0	-
5	0	0	0	0	0	0	0	0	0	0	-
6	1	1	0	1	1	0	1	0	0	1	x
7	1	1	1	1	1	1	1	0	1	1	x
8	1	1	1	1	1	1	1	1	1	1	+
9	0	0	0	0	0	0	0	0	0	0	-
10	1	1	1	1	1	1	1	1	1	1	+
11	1	1	1	1	1	1	1	1	1	1	+
12	0	0	0	0	0	0	0	1	0	0	x
13	1	1	1	1	1	1	1	1	1	1	+
14	1	1	0	1	1	1	1	0	0	1	x
15	1	1	1	1	1	1	1	1	1	1	+
16	1	1	1	1	1	1	1	1	1	1	+
17	1	1	1	1	1	1	1	1	1	1	+
18	1	1	1	1	1	1	1	1	1	1	+
19	1	1	1	1	1	1	1	1	1	1	+
20	1	1	1	1	1	1	1	1	1	1	+
21	1	1	0	1	0	1	0	1	0	1	x
22	0	0	1	0	1	0	1	1	0	0	x
23	1	1	1	1	1	1	1	1	1	1	+
24	1	1	1	1	1	1	1	1	1	1	+
25	0	0	0	0	0	0	0	0	0	0	-
26	0	1	0	0	0	0	0	0	1	0	x
27	1	1	1	1	1	1	1	1	1	1	+
28	1	1	1	1	1	1	1	1	1	1	+
29	1	1	1	1	1	1	1	1	1	1	+
30	0	0	0	0	0	1	0	0	0	0	x
31	1	1	1	1	1	1	1	1	1	1	+
32	1	1	1	1	1	1	1	1	1	1	+
33	1	1	1	1	1	1	1	1	1	1	+
34	0	0	1	0	0	1	0	1	1	0	x
35	1	1	1	1	1	1	1	1	1	1	+
36	1	1	0	1	1	1	1	0	1	1	x
37	0	0	0	0	0	0	0	0	0	0	-
38	1	1	1	1	1	1	1	1	1	1	+
39	0	0	0	0	0	0	0	0	0	0	-
40	1	1	1	1	1	1	1	1	1	1	+
41	1	1	1	1	1	1	1	1	1	1	+
42	0	0	0	0	0	0	0	0	0	0	-
43	1	0	1	1	1	1	1	1	0	1	x
44	1	1	1	1	1	1	1	1	1	1	+
45	0	0	0	0	0	0	0	0	0	0	-
46	1	1	1	1	1	1	1	1	1	1	+
47	1	1	1	1	1	1	1	1	1	1	+
48	0	0	0	0	0	0	0	0	0	0	-
49	1	1	1	1	1	1	1	1	1	1	+
50	0	0	0	0	0	0	0	0	0	0	-

0 indicates FAIL

1 indicated PASS

The Code signs -, + and x as calculated by ProMSA

ProMSA: Validation Data Sets and Results



Results:

Source: MSA Manual, Page 136, Table III-C 2

A*B Crosstabulation

			B		
			0	1	Total
A	0	Count	44	6	50
		Expected	15.7	34.3	50.0
	1	Count	3	97	100
		Expected	31.3	68.7	100.0
Total		Count	47	103	150
		Expected	47.0	103.0	150.0

A*C Crosstabulation

			C		
			0	1	Total
A	0	Count	43	7	50
		Expected	17.0	33.0	50.0
	1	Count	8	92	100
		Expected	34.0	66.0	100.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

B*C Crosstabulation

			C		
			0	1	Total
B	0	Count	42	5	47
		Expected	16.0	31.0	47.0
	1	Count	9	94	103
		Expected	35.0	68.0	103.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

Source: MSA Manual, Page 138, Table III-C 4

A*REF Crosstabulation

			REF		
			0	1	Total
A	0	Count	45	5	50
		Expected	16.0	34.0	50.0
	1	Count	3	97	100
		Expected	32.0	68.0	100.0
Total		Count	48	102	150
		Expected	48.0	102.0	150.0

B*REF Crosstabulation

			REF		
			0	1	Total
B	0	Count	45	2	47
		Expected	15.0	32.0	47.0
	1	Count	3	100	103
		Expected	33.0	70.0	103.0
Total		Count	48	102	150
		Expected	48.0	102.0	150.0

C*REF Crosstabulation

			REF		
			0	1	Total
C	0	Count	42	9	51
		Expected	16.3	34.7	51.0
	1	Count	6	93	99
		Expected	31.7	67.3	99.0
Total		Count	48	102	150
		Expected	48.0	102.0	150.0

Source: ProMSA

			Appraiser2		
			0	1	Total
Appraiser1	0	Count	44	6	50
		Expected	15.7	34.3	50.0
	1	Count	3	97	100
		Expected	31.3	68.7	100.0
Total		Count	47	103	150
		Expected	47.0	103.0	150.0

			Appraiser3		
			0	1	Total
Appraiser1	0	Count	43	7	50
		Expected	17.0	33.0	50.0
	1	Count	8	92	100
		Expected	34.0	66.0	100.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

			Appraiser3		
			0	1	Total
Appraiser2	0	Count	42	5	47
		Expected	16.0	31.0	47.0
	1	Count	9	94	103
		Expected	35.0	68.0	103.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

Source: ProMSA

Note: Crosstabulation with reference is calculated if Reference Decisions are specified

			REF		
			0	1	Total
Appraiser1	0	Count	45	5	50
		Expected	16.0	34.0	50.0
	1	Count	3	97	100
		Expected	32.0	68.0	100.0
Total		Count	48	102	150
		Expected	48.0	102.0	150.0

			REF		
			0	1	Total
Appraiser2	0	Count	45	2	47
		Expected	15.0	32.0	47.0
	1	Count	3	100	103
		Expected	33.0	70.0	103.0
Total		Count	48	102	150
		Expected	48.0	102.0	150.0

			REF		
			0	1	Total
Appraiser3	0	Count	42	9	51
		Expected	16.3	34.7	51.0
	1	Count	6	93	99
		Expected	31.7	67.3	99.0
Total		Count	48	102	150
		Expected	48.0	102.0	150.0

Kappa Parameter: Interrator Agreement

Source: MSA Manual, Page 137, Table III-C 3

kappa	A	B	C
A	---	0.86	0.78
B	0.86	---	0.79
C	0.78	0.79	---

Kappa Parameter: Appraiser Vs Standard Reference

Source: MSA Manual, Page 138

kappa	A	B	C
Ref	0.88	0.92	0.77

Source: ProMSA

kappa	App 1	App 2	App 3
App 1	---	0.863	0.776
App 2	0.863	---	0.788
App 3	0.776	0.788	---

kappa	App 1	App 2	App 3
Ref	0.879	0.923	0.774

Note: Kappa with reference is calculated if Reference Decisions are specified

Effectiveness Calculations:

Source: MSA Manual, Page 139, Table III-C 5

Effectiveness	% Appraiser			% Score Vs Attribute		
	Appraiser A	Appraiser B	Appraiser C	Appraiser A	Appraiser B	Appraiser C
Total Inspected	50	50	50	50	50	50
# Matched	42	45	40	42	45	40
False Negative				0	0	0
False Positive				0	0	0
Mixed				8	5	10
95% UCI	93%	97%	90%	93%	97%	90%
Calculated Score	84%	90%	80%	84%	90%	80%
95% LCI	71%	78%	66%	71%	78%	66%
			System% Effective Score	System% Effective Score Vs Ref.		
Total Inspected	50	50	50	50	50	50
# in Agreement	39	39	39	39	39	39
95% UCI						
Calculated Score						
95% LCI						

Source: ProMSA

Effectiveness	% Appraiser			% Score Vs Attribute		
	Appraiser1	Appraiser2	Appraiser3	Appraiser1	Appraiser2	Appraiser3
Total Inspected	50	50	50	50	50	50
# Matched	42	45	40	42	45	40
False Negative				0	0	0
False Positive				0	0	0
Mixed				8	5	10
95% UCI	92.83%	96.67%	89.97%	92.83%	96.67%	89.97%
Calculated Score	84.00%	90.00%	80.00%	84.00%	90.00%	80.00%
95% LCI	70.89%	78.19%	66.28%	70.89%	78.19%	66.28%
			System% Effective Score	System% Effective Score Vs Ref.		
Total Inspected	50	50	50	50	50	50
# in Agreement	39	39	39	39	39	39
95% UCI	88.47%	88.47%	88.47%	88.47%	88.47%	88.47%
Calculated Score	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%
95% LCI	64.04%	64.04%	64.04%	64.04%	64.04%	64.04%

Note: % Score Vs Attribute and System% Effective Score Vs Ref. are calculated if Reference Decisions are specified.

Effectiveness, False Alarm and Miss Rate

Source: MSA Manual, Page 140, Table III-C 7

	Effectiveness	Miss Rate	False Alarm Rate
A	84.00%	6.3%	4.9%
B	90.00%	6.3%	2.0%
C	80.00%	12.5%	8.8%

Source: ProMSA

	Effectiveness	Miss Rate	False Alarm Rate
App 1	84.00%	6.25%	4.9%
App 2	90.00%	6.25%	1.96%
App 3	80.00%	12.5%	8.82%

Note: Miss Rate and False Alarm Rate are calculated if Reference Decisions are specified.

- Small differences may occur due to rounding off in the MSA manual.
- In ProMSA, click on the Demo Data button on CrossTab Study form to populate the grid with above data.
- See AIAG_Attribute_CrossTab.xls for a sample of full numerical and graphical report output from ProMSA.

Attribute Gage R&R Test: Signal Detection Method

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 134(Table III-C 1), 143-144

No. of Samples:	50
No. of Appraisers:	3
No. of Trials:	3
Tolerance	0.1

Study Data: MSA Manual Page 134 (Table III-C 1)

No.	Appraiser1			Appraiser2			Appraiser3			Ref. Value	Code
	A-1	A-2	A-3	B-1	B-2	B-3	C-1	C-2	C-3		
25	0	0	0	0	0	0	0	0	0	0.599581	-
48	0	0	0	0	0	0	0	0	0	0.587893	-
3	0	0	0	0	0	0	0	0	0	0.576459	-
5	0	0	0	0	0	0	0	0	0	0.57036	-
42	0	0	0	0	0	0	0	0	0	0.566575	-
4	0	0	0	0	0	0	0	0	0	0.566152	-
30	0	0	0	0	0	1	0	0	0	0.561457	x
12	0	0	0	0	0	0	0	1	0	0.559918	x
26	0	1	0	0	0	0	0	0	1	0.547204	x
22	0	0	1	0	1	0	1	1	0	0.545604	x
6	1	1	0	1	1	0	1	0	0	0.544951	x
36	1	1	0	1	1	1	1	0	1	0.543077	x
13	1	1	1	1	1	1	1	1	1	0.542704	+
16	1	1	1	1	1	1	1	1	1	0.531939	+
23	1	1	1	1	1	1	1	1	1	0.529065	+
29	1	1	1	1	1	1	1	1	1	0.523754	+
28	1	1	1	1	1	1	1	1	1	0.521642	+
19	1	1	1	1	1	1	1	1	1	0.520496	+
17	1	1	1	1	1	1	1	1	1	0.519694	+
15	1	1	1	1	1	1	1	1	1	0.517377	+
10	1	1	1	1	1	1	1	1	1	0.515573	+
24	1	1	1	1	1	1	1	1	1	0.514192	+
41	1	1	1	1	1	1	1	1	1	0.513779	+
2	1	1	1	1	1	1	1	1	1	0.509015	+
32	1	1	1	1	1	1	1	1	1	0.50585	+
31	1	1	1	1	1	1	1	1	1	0.503091	+
27	1	1	1	1	1	1	1	1	1	0.502436	+
8	1	1	1	1	1	1	1	1	1	0.502295	+
40	1	1	1	1	1	1	1	1	1	0.501132	+
35	1	1	1	1	1	1	1	1	1	0.498698	+
46	1	1	1	1	1	1	1	1	1	0.493441	+
11	1	1	1	1	1	1	1	1	1	0.488905	+
38	1	1	1	1	1	1	1	1	1	0.488184	+
33	1	1	1	1	1	1	1	1	1	0.487613	+
47	1	1	1	1	1	1	1	1	1	0.486379	+
18	1	1	1	1	1	1	1	1	1	0.484167	+
49	1	1	1	1	1	1	1	1	1	0.483803	+
20	1	1	1	1	1	1	1	1	1	0.477236	+
1	1	1	1	1	1	1	1	1	1	0.476901	+
44	1	1	1	1	1	1	1	1	1	0.470832	+
7	1	1	1	1	1	1	1	0	1	0.465454	x
43	1	0	1	1	1	1	1	1	0	0.46241	x
14	1	1	0	1	1	1	1	0	0	0.454518	x
21	1	1	0	1	0	1	0	1	0	0.45231	x
34	0	0	1	0	0	1	0	1	1	0.449696	x
50	0	0	0	0	0	0	0	0	0	0.446697	-
9	0	0	0	0	0	0	0	0	0	0.437817	-
39	0	0	0	0	0	0	0	0	0	0.427687	-
45	0	0	0	0	0	0	0	0	0	0.412453	-
37	0	0	0	0	0	0	0	0	0	0.409238	-

0 indicates FAIL
 1 indicated PASS
 # The Code signs -, + and x as calculated by ProMSA
 The data here is shown as ordered by Reference Values.

Results:

Source: MSA Manual, Page 144

Width of Region II (Upper)	d-USL	0.023448
Width of Region II (Lower)	d-LSL	0.024135
Average Width of Region II	d-AVG	0.0237915
Gage R&R	%GRR	24%

Source: ProMSA

Width of Region II (Upper)	d-USL	0.023448
Width of Region II (Lower)	d-LSL	0.024135
Average Width of Region II	d-AVG	0.0237915
Gage R&R	%GRR	23.79%

ProMSA: Validation Data Sets and Results



Results: Source: MSA Manual, Page 136, Table III-C 2

A*B Crosstabulation

			B		
			0	1	Total
A	0	Count	44	6	50
		Expected	15.7	34.3	50.0
	1	Count	3	97	100
		Expected	31.3	68.7	100.0
Total		Count	47	103	150
		Expected	47.0	103.0	150.0

A*C Crosstabulation

			C		
			0	1	Total
A	0	Count	43	7	50
		Expected	17.0	33.0	50.0
	1	Count	8	92	100
		Expected	34.0	66.0	100.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

B*C Crosstabulation

			C		
			0	1	Total
B	0	Count	42	5	47
		Expected	16.0	31.0	47.0
	1	Count	9	94	103
		Expected	35.0	68.0	103.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

Source: MSA Manual, Page 137, Table III-C 3

Kappa Parameter: Interrator Agreement

kappa	A	B	C
A	---	0.86	0.78
B	0.86	---	0.79
C	0.78	0.79	---

Effectiveness Calculations:

Source: MSA Manual, Page 139, Table III-C 5

Effectiveness	% Appraiser			% Score Vs Attribute		
Source	Appraiser A	Appraiser B	Appraiser C	Appraiser A	Appraiser B	Appraiser C
Total Inspected	50	50	50	50	50	50
# Matched	42	45	40	42	45	40
False Negative				0	0	0
False Positive				0	0	0
Mixed				8	5	10
95% UCI	93%	97%	90%	93%	97%	90%
Calculated Score	84%	90%	80%	84%	90%	80%
95% LCI	71%	78%	66%	71%	78%	66%
	System% Effective Score			System% Effective Score Vs Ref.		
Total Inspected	50	50	50	50	50	50
# in Agreement	39	39	39	39	39	39
95% UCI		89%			89%	
Calculated Score		78%			78%	
95% LCI		64%			64%	

Source: MSA Manual, Page 140, Table III-C 7

	Effectiveness
A	84.00%
B	90.00%
C	80.00%

Source: ProMSA

			Appraiser2		
			0	1	Total
Appraiser1	0	Count	44	6	50
		Expected	15.7	34.3	50.0
	1	Count	3	97	100
		Expected	31.3	68.7	100.0
Total		Count	47	103	150
		Expected	47.0	103.0	150.0

			Appraiser3		
			0	1	Total
Appraiser1	0	Count	43	7	50
		Expected	17.0	33.0	50.0
	1	Count	8	92	100
		Expected	34.0	66.0	100.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

			Appraiser3		
			0	1	Total
Appraiser2	0	Count	42	5	47
		Expected	16.0	31.0	47.0
	1	Count	9	94	103
		Expected	35.0	68.0	103.0
Total		Count	51	99	150
		Expected	51.0	99.0	150.0

Source: ProMSA

kappa	App 1	App 2	App 3
App 1	---	0.863	0.776
App 2	0.863	---	0.788
App 3	0.776	0.788	---

Source: ProMSA

Effectiveness	% Appraiser			% Score Vs Attribute		
Source	Appraiser1	Appraiser2	Appraiser3	Appraiser1	Appraiser2	Appraiser3
Total Inspected	50	50	50	50	50	50
# Matched	42	45	40	-	-	-
False Negative				-	-	-
False Positive				-	-	-
Mixed				8	5	10
95% UCI	92.83%	96.67%	89.97%	-	-	-
Calculated Score	84.00%	90.00%	80.00%	-	-	-
95% LCI	70.89%	78.19%	66.28%	-	-	-
	System% Effective Score			System% Effective Score Vs Ref.		
Total Inspected	50	50	50	50	50	50
# in Agreement	39	39	39	-	-	-
95% UCI	88.47%	88.47%	88.47%	-	-	-
Calculated Score	78.00%	78.00%	78.00%	-	-	-
95% LCI	64.04%	64.04%	64.04%	-	-	-

Note: % Score Vs Attribute and System% Effective Score Vs. Ref is not calculated as the Reference decision is not available.

Source: ProMSA

	Effectiveness
App 1	84.00%
App 2	90.00%
App 3	80.00%

- Small differences may occur due to rounding off in the MSA manual.
- In ProMSA, click on the Demo Data button on Signal Detection Study form to populate the grid with above data.
- See AIAG_Attribute_Signal_Detection.xls for a sample of full numerical and graphical report output from ProMSA.

Attribute Gage R&R Test: Analytic Method

Data Source: AIAG MSA Manual (4th Edition) : Page Nos. 145-150

Significance	0.05
Coverage Factor	5.15 σ

Results:

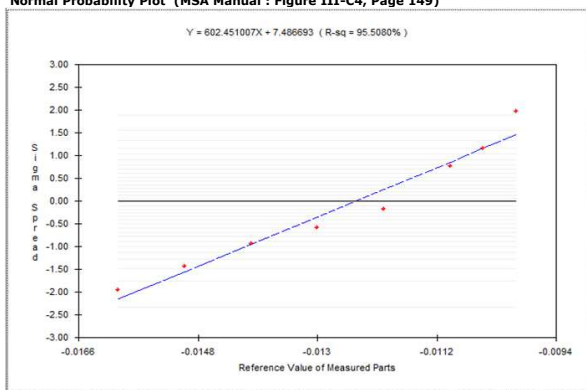
Linearity Study: (MSA Manual : Figure III-B 3 Page 100)

Study Data: MSA Manual Page 147

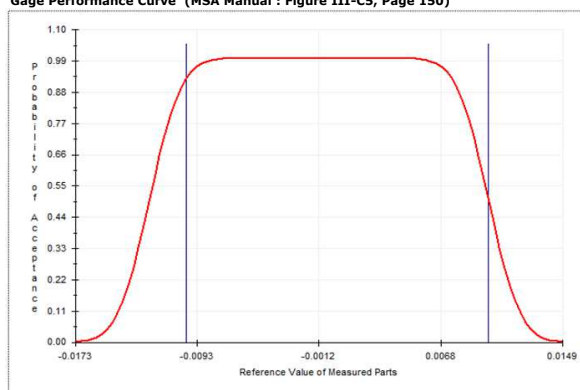
No.	XT	a	P'a
1	-0.016	0	0.025
2	-0.015	1	0.075
3	-0.014	3	0.175
4	-0.013	5	0.275
5	-0.012	8	0.425
6	-0.011	16	0.775
7	-0.0105	18	0.875
8	-0.01	20	0.975
9	-0.008	20	1

Parameter	Source: MSA Manual	Source: ProMSA
Bias	0.0023	0.002427
Repeatability	0.0079	0.008551
Repeatability Std Dev.	0.00142	0.00166
Repeatability (Adj.)	0.73	0.007918
Repeatability Std Dev. (Adj)	0.00142	0.001537
Calculated t-Value	9.83	9.595028
Critical t (@Alpha=0.05)	2.093	2.093024
Result	Bias is significant	Bias is significant

Normal Probability Plot (MSA Manual : Figure III-C4, Page 149)



Gage Performance Curve (MSA Manual : Figure III-C5, Page 150)



1. Small differences may occur due to rounding off in the MSA manual.
2. In ProMSA, click on the Demo Data button on Signal Detection Study form to populate the grid with above data.
3. See AIAG_Attribute_Signal_Detection.xls for a sample of full numerical and graphical report output from ProMSA.