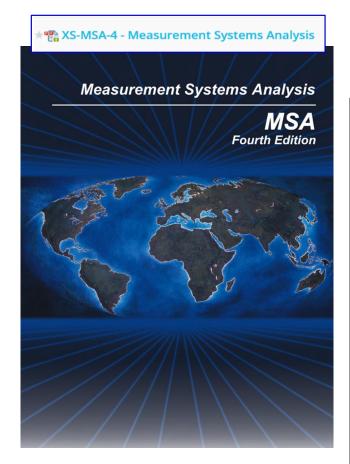
) Be sure to v ) This spread:	the shaded blocks.  write the Upper & Love sheet is set up for eit	ther a 5-parts (Shor		s (Long stud	d <b>y)</b> MSA. <u>Do</u>		E R&R STUE	<u>)Y</u>						
<ul> <li>Long study</li> <li>"Appraiser N</li> </ul>	y requires 2 Appraise y requires 3 Appraise Names" MUST be fille study' keep in blank	ers x 3 Replications ed in for the form to	work properly.											
		Gage Name:				Part Name:				Date:				
		Gage No.:				Operation No.:			Per	formed By:				
		Zero Equals:				Characteristic: Upper Tolerance		6	Δ	Area: ppraiser A:	Hug	0	Short / Long	studv
		Unit of Measure:				Nominal	.0:			ppraiser B:	Paco		Short / Long	
L		Part No:				Lower Tolerance	-2.1	6	А	ppraiser C:	Luis	3	Long stu	dy
) Select <b>5-par</b> ) Have <b>2 App</b>	or data collection: rts (Short study) or raisers (Short study results to determine	y) or 3 Appraisers (	Long study) measuath Repeatability and	ire each par	t independer		es each. Record resu	ilts below.						
	Appraiser A:		Hugo			Appraiser B:		Paco			Appraiser C:		Luis	
Sample	4	Replications		D (D)	Sample	4	Replications		P (Panga)	Sample		Replications		B (Banga)
Number 1	1 0.290	2 0.410	3 0.640	R (Range) 0.3500	Number 1	1 0.080	2 0.250	3 0.070	R ( <i>Range</i> ) 0.1800	Number 1	1 0.040	-0.110	-0.150	R ( <i>Range</i> ) 0.1900
2	-0.560	-0.680	-0.580	0.1200	2	-0.470	-1.220	-0.680	0.7500	2	-1.380	-1.130	-0.960	0.4200
3	1.340	1.170	1.270	0.1700	3	1.190	0.940	1.340	0.4000	3	0.880	1.090	0.670	0.4200
4	0.470	0.500	0.640	0.1700	4	0.010	1.030	0.200	1.0200	4	0.140	0.200	0.110	0.0900
5 6	-0.800 0.020	-0.920	-0.840 -0.210	0.1200 0.2300	5 6	-0.560 -0.200	-1.200 0.220	-1.280 0.060	0.7200 0.4200	5 6	-1.460 -0.290	-1.070 -0.670	-1.450 -0.490	0.3900
7	0.590	-0.110 0.750	0.660	0.2300	7	0.470	0.550	0.830	0.4200	7	0.020	0.010	0.210	0.3800
8	-0.310	-0.200	-0.170	0.1400	8	-0.630	0.080	-0.340	0.7100	8	-0.460	-0.560	-0.490	0.1000
9	2.260	1.990	2.010	0.2700	9	1.800	2.120	2.190	0.3900	9	1.770	1.450	1.870	0.4200
10	-1.360	-1.250	-1.310	0.1100	10	-1.680	-1.620	-1.500	0.1800	10	-1.490	-1.770	-2.160	0.6700
Totals X (Means)	1.9400	1.6600	2.1100	1.8400	Totals X (Means)	0.0100	1.1500	0.8900	5.1300	Totals X (Means)	-2.2300	-2.5600	-2.8400	3.2800
A (Wearis)	0.1940 <b>Xbar</b> <sub>1</sub>	0.1660 <b>Xbar</b> <sub>2</sub>	0.2110 <b>Xbar</b> <sub>3</sub>	0.1840 <b>Rbar</b> ₄	A (IVIEATIS)	0.0010 <b>Xbar</b> <sub>1</sub>	0.1150 <b>Xbar</b> <sub>2</sub>	0.0890 <b>Xbar</b> <sub>3</sub>	0.5130 Rbar <sub>B</sub>	A (Wearis)	-0.2230 <b>Xbar</b> <sub>1</sub>	-0.2560 <b>Xbar</b> <sub>2</sub>	-0.2840 <b>Xbar</b> <sub>3</sub>	0.3280 Rbar <sub>c</sub>
L	Xbar <sub>A</sub> =	Xbar	1 + Xbar <sub>2</sub> + Xbar <sub>3</sub> Replications	ribui g	I.	Xbar <sub>B</sub> =	Xbar	+ Xbar <sub>2</sub> + Xbar <sub>3</sub> Replications	в	I	Xbar <sub>C</sub> =	Xbar₁	+ Xbar <sub>2</sub> + Xbar <sub>3</sub> eplications	
	Xbar <sub>A</sub> =	0.19	903			Xbar <sub>B</sub> =	0.06	83			Xbar <sub>c</sub> =	-0.25	43	
					Te	est for Statis	tical Control	of Ranges						
Rbar <sub>1</sub> = _	Rbar <sub>A</sub> + Rbar Ope	<sub>B</sub> + Rbar <sub>C</sub> =	=	1.0	250 3	= [	0.3417							
UCL <sub>R</sub> =	ased on the number (	D <sub>4</sub> * Rbar <sub>1</sub> =	table below)	2.574	*	0.34	117 =	= [	0.87	95	= Range Upper Co	ontrol Limit		
10te. D <sub>4</sub> 13 D	ased on the number	or replications (see	table below)			Cogo D9	R Study Ana	alvoio						
Repeatability	(EQ - Equipment Va	riation)				Gage Ro	KK Study Alla	aiysis						
S <sub>GV</sub> =	Rbar <sub>1</sub> /	d <sub>2</sub> =	0.3417		/	1.69	930 =	= [	0.20	18				
lote: d <sub>2</sub> is ba	sed on the number o	of Replications (see	table below)						StudyVar (S	<sub>GV</sub> * 6) =	0.2018	* 6 =	1.2109	
Percent of E	Engineering Tolerand	ce Consumed by the	Equipment / Gage:											
Repe	eatability =		00 * S <sub>D</sub> ) elerance	=		1.2109 4.4200	=	27.40%	0					

oducibility (AV - App	raiser Variation	1																
Rbar <sub>2</sub> =	Xbar	Largest of ABC - Xbar <sub>Sma</sub>	allest of ABC =			0.1903			-		-0.25	43	=		0.44	447		
S <sub>ov</sub> =	$Rbar_2 / d_2^* =$		0.4447		/		1.912		=		0.23	26						
: d <sub>2</sub> * is based on the	number of Opera	tors (see table belo	w)												f parts =		10	
ercent of Engineering	Folerance consu	med by Appraiser /	Operator:										N	umber o	f trials = d <sub>2</sub> * =		3 1.912	
									StudyVar (S	ov * <b>6) =</b> (Rba	ar <sub>2</sub> ) X (6.0	0/d <sub>2</sub> *)} <sup>2</sup> - {(F	Repeatability	/) <sup>2</sup> / (No.	parts X No	o. trials)}	1.3778	
Reproducibility	v =	100 (6.00 * S <sub>OV</sub> ) Eng. Tolerance		= _		1.3778				31.17%						_		_
	<u>'</u>	Eng. I olerance				4.4200												
bined Reproducibility	and Repeatab	lity (Measurement	System)						Pro	oduct Sigma	1							
S <sub>MV</sub> =	$S_{OV}^2 + S_{GV}^2 =$		0.2326		+	0.2018		=		0.3079							nter "Produc	
Percent of Engineering	ıg Tolerance con	sumed by Measure	ment system:								1	new Gage F	ile for any	HS defir	ned KPCs/	/TKCs. En	ter the	2
Gage R & R =		100 (6.00 * S <sub>MV</sub> )		= _	1.847522			=		41.80%		-roduct sig	gma into the	e ualaba	se neiu ei	nilileu Ga	ige KK Stu	
Gage K & K =		Eng. Tolerance				4.4200				41.0070								
Porcont of Process To																		
reiceill di Fidcess Ti	olerance (Combi	ned Variability) cons	sumed by ivies	asurement s	system:				CALITIO	N. Doroont	Drococo T	oloropoo ve	due ie enly	olid for I	nort (Chr	ort otudu) o	r 10 port /l o	~
reitent of Flocess To		ned Variability) cons atability) <sup>2</sup> + (Reprod		asurement s =		1.8342			CAUTIO	N: Percent	Process 1		alue is only study) MSA		5-part (Sho	ort study) o	r 10-part (Loi	ıg
Gage R & R =	(Repe		lucibility) <sup>2</sup>	=				1.8342	CAUTIO		Process T				5-part (Sho	ort study) or		ng 80%
	(Repe	atability) <sup>2</sup> + (Reprod	lucibility) <sup>2</sup>	=	(R&R)/(6/d <sub>2</sub>	<sub>2</sub> )*Rbar <sub>CV =</sub>			*	3			study) MSA		5-part (Sho	ort study) o		_
	(Repe	atability) <sup>2</sup> + (Reprod	lucibility) <sup>2</sup>	=	(R&R)/(6/d <sub>2</sub>	<sub>2</sub> )*Rbar <sub>CV =</sub>			CAUTIO ion Guid	3			study) MSA		5-part (Sho	ort study) or		
Gage R & R =	(Repe:	atability) <sup>2</sup> + (Reprod	lucibility) <sup>2</sup> (Combined Va	= ariability) = (	(R&R)/(6/d <sub>2</sub>	<sub>2</sub> )*Rbar <sub>CV =</sub>			*	3			study) MSA		5-part (Sho	ert study) or		
Gage R & R =	(Reperior (Reper	atability) <sup>2</sup> + (Reprod	(Combined Va	= (ariability) = (	(R&R)/(6/d <sub>2</sub> <b>G</b> a	age R&R		Evaluat	*	3	3.0780		study) MSA 21.06		5-part (Sho	e E		_
Gage R & R =  1) Gage Cap. GC as a %	(Reperior Percent ability for Production of Eng. Tolerand	atability) <sup>2</sup> + (Reprod Process Tolerance of ict Acceptance (% ce = (Gage R&R / To	(Combined Va	= ariability) = (	(R&R)/(6/dg	age R&R		Evaluat	ion Guid	3	3.0780	1	study) MSA 21.06		5-part (Sho	ert study) or		_
Gage R & R =  1) Gage Capa GC as a % 2) Gage Capa	Percent  ability for Production of Eng. Tolerand	atability) <sup>2</sup> + (Reprod	(Combined Va	= ariability) = (	(R&R)/(6/dg	age R&R		Evaluat 4	ion Guid	3	3.0780	1	21.06		5-part (Sho	e e e e e e e e e e e e e e e e e e e		
Gage R & R =  1) Gage Capa GC as a % 2) Gage Capa	Percent  ability for Production of Eng. Tolerand	atability) <sup>2</sup> + (Reprod	(Combined Va	= ariability) = (	(R&R)/(6/dg	age R&R		Evaluat 4	ion Guid	3	3.0780	/ Tolerance	21.06		5-part (Sho	=		_
Gage R & R =  1) Gage Capa GC as a % 2) Gage Capa	Percent  ability for Production of Eng. Tolerand	atability) <sup>2</sup> + (Reprod	(Combined Va	= ariability) = (	(R&R)/(6/dg	age R&R		Evaluat 4	ion Guid 1.80% 6.80%	eline	% % ACCEPT	/ Tolerance % Study Va	21.06 21.06 (SV/Toler) rr (% SV)	67	UNACCE	= EPTABLE		_
Gage R & R =  1) Gage Capa GC as a % 2) Gage Capa	Percent  ability for Production of Eng. Tolerand	atability) <sup>2</sup> + (Reprod	(Combined Va	= ariability) = (	(R&R)/(6/dg	age R&R		Evaluat 4	ion Guid 1.80% 6.80%	eline  nd	3.0780 %	/ Tolerance % Study Va	21.06  (SV/Toler)	67 NAL	=	= EPTABLE 0 %		
Gage R & R =  1) Gage Capa GC as a % 2) Gage Capa	Percent  ability for Production of Eng. Tolerand	atability) <sup>2</sup> + (Reprod	(Combined Va	= ariability) = (	(R&R)/(6/dg	age R&R		Evaluat 4	ion Guid 1.80% 6.80% Lege	eline  nd	% ACCEPT 0 - 20	/ Tolerance % Study Va	21.06  (SV/Toler)  rr (% SV)	67 NAL	UNACCE > 20	= EPTABLE 0 %		
1) Gage Capi GC as a % 2) Gage Capi % of Proce	Percent  ability for Production of Eng. Tolerand	extability) <sup>2</sup> + (Reproduce of the Company of the C	(Combined Va	= ariability) = (	(R&R)/(6/d; Ga ce) ge) * 100 =	age R&R		Evaluat 4	1.80%  Lege Eng. Tc Process Tc	and olerance	% ACCEPT 0 - 20	/ Tolerance % Study Va	21.06  (SV/Toler)  rr (% SV)	67 NAL	UNACCE > 20	= EPTABLE 0 %		_
1) Gage Capi GC as a % 2) Gage Capi % of Proce	ability for Produ	extability) <sup>2</sup> + (Reproduce of the Company of the C	(Combined Va	= ariability) = (	(R&R)/(6/d)  Ga  ce) ge) * 100 =	age R&R		4-20 4-1.128 1.693	1.80% 6.80% Lege Eng. Tc	eline  nd elerance	% ACCEPT 0 - 20	/ Tolerance % Study Va	21.06  (SV/Toler)  rr (% SV)	67 NAL	UNACCE > 20	= EPTABLE 0 %		
1) Gage Capi GC as a % 2) Gage Capi % of Proce	ability for Produ	extability) <sup>2</sup> + (Reproduce of the Company of the C	(Combined Va	= ariability) = (	(R&R)/(6/d)  Ga  ce) ge) * 100 =			4: 20 d <sub>2</sub> 1.128	1.80%  Lege Eng. Tc Process Tc	eline  nd elerance	% ACCEPT 0 - 20	/ Tolerance % Study Va	21.06  (SV/Toler)  rr (% SV)	67 NAL	UNACCE > 20	= EPTABLE 0 %		_

readings, gage readability, ability to easily hold gage and/or part, etc.) that could influence the study results.

## AIAG - MSA Manual 4th Edition - Study Case (Pag 118 - 119)



Chapter III – Section B Variable Measurement System Study – Guidelines

## Gage Repeatability and Reproducibility Data Collection Sheet

Appraiser /Trial#		PART											
	1	2	3	4	5	6	7	8	9	10	AVE	RAGE	
A 1	0.29	-0.56	1.34	0.47	-0.80	0.02	0.59	-0.31	2.26	-1.36		0.194	
2	0.41	-0.68	1.17	0.50	-0.92	-0.11	0.75	-0.20	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	0.447	-0.607	1.260	0.537	-0.853	-0.100	0.667	-0.227	2.087	-1.307	$\overline{X}_a =$	0.190	
Range	0.35	0.12	0.17	0.17	0.12	0.23	0.16	0.14	0.27	0.11	R =	0.184	
B 1	0.08	-0.47	1.19	0.01	-0.56	-0.20	0.47	-0.63	1.80	-1.68		0.001	
2	0.25	-1.22	0.94	1.03	-1.20	0.22	0.55	0.08	2.12	-1.62		0.115	
3	0.07	-0.68	1.34	0.20	-1.28	0.06	0.83	-0.34	2.19	-1.50		0.089	
Average	0.133	-0.790	1.157	0.413	-1.013	0.027	0.617	-0.297	2.037	-1.600	$\bar{X}_{\flat} =$	0.068	
Range	0.18	0.75	0.40	1.02	0.72	0.42	0.36	0.71	0.39	0.18	R <sub>b</sub> =	0.513	
C 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	0.20	-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	-0.073	-1.157	0.880	0.150	-1.327	-0.483	0.080	-0.503	1.697	-1.807	$\bar{X}_{\epsilon} =$	-0.254	
Range	0.19	0.42	0.42	0.09	0.39	0.38	0.20	0.10	0.42	0.67	R =	0.328	
Part	0.169	-0.851	1.099	0.367	-1.064	-0.186	0.454	-0.342	1.940	-1.571	$\bar{\bar{X}} =$	.0014	
Average											$R_p =$	3.511	
([R] = 0.184	]+[R <sub>b</sub>	= 0.513]	+[Æ]=	0.328]	/[#OI	APPR	AISERS	= 3] = 0	.3417		$\overline{\overline{R}} =$	0.341	
$[\text{Max } \overline{X} = 0]$	.1903] –	[Min $\bar{X}$	= -0.25	43] = $\bar{X}$	0.0FF = 0.	4446							
* $[\overline{\overline{R}} = 0.$	3417] x	D4 = 2.5	58] = UC	$\mathcal{I}_{\mathcal{R}} = 0.3$	3816								
beyond this li	mit. Ident	ify the ca	ise and co	orrect. Re	peat these	readings	using th	e same ap	praiser and	unit as ori	ginally use	d or	
	$\begin{array}{c} 3 \\ \text{Average} \\ \text{Range} \\ \text{B} \\ 1 \\ 2 \\ 3 \\ 3 \\ \text{Average} \\ \text{Range} \\ \text{C} \\ 1 \\ 2 \\ 2 \\ 3 \\ \text{Average} \\ \text{Range} \\ \text{Range} \\ \text{[$\vec{R}_*$ = 0.1848 $\vec{X}$ = 0.00 $\vec{A}$]} \\ \text{Max $\vec{X}$} \\ \vec{R} = 0.5 $	3 0.64  Average 0.447  Range 0.35  B 1 0.08  2 0.25  3 0.07  Average 0.133  Range 0.18  C 1 0.04  2 -0.11  3 -0.15  Average -0.073  Range 0.19  Part Average [R, = 0.184] + [R, was 2 - 10.00]  [R = 0.447] × [R = 0.3447] × [R = 0.3447] × [R = 0.3471] × [R = 0.900 ftis limit is an item to include a second content of the co	3 0.64 0.58  Average 0.447 0.607  Range 0.55 0.12  B 1 0.08 0.47 2 0.25 1.22  3 0.07 0.68  Average 0.133 0.790  Range 0.18 0.75  C 1 0.04 1.38 2 0.15 1.096  Average 0.073 1.157  Range 0.19 0.42  Part Average 1.69 0.851  Average 0.093 1.61m X  [R = 0.184] + [R = 0.513]  Max X = 0.1903] - [Min X  [R = 0.3417] × [D = 2.5]  Up, 9-3.7 for 2 10 lentify the can discard values and re-average and discard values and re-a	3 0.64 -0.58 1.27  Average 0.447 -0.607 1.260  Range 0.35 0.12 0.17  B 1 0.00 -0.47 1.19 2 0.25 -1.22 0.94 3 0.07 -0.68 1.34  Average 0.133 -0.790 1.157  Range 0.18 0.75 0.40  C 1 0.04 -1.38 0.88 2 -0.11 -1.13 1.09 3 -0.15 -0.96 0.67  Average 0.073 -1.157 0.800  Range 0.19 0.42 0.42  Part Average 0.19 0.42 0.42  Part Average 0.19 0.42 0.42  [R = 0.184] + [R = 0.513] + [R = 0.512] + [R = 0.51	3 0.64 -0.58 1.27 0.64  Average 0.447 0.667 1.260 0.537  Range 0.55 0.12 0.17 0.17  B 1 0.08 0.47 1.19 0.01  2 0.25 1.22 0.94 1.03  3 0.07 -0.68 1.34 0.20  Average 0.133 0.790 1.157 0.413  Range 0.18 0.75 0.40 1.02  C 1 0.04 1.36 0.88 0.14  2 0.011 1.13 1.09 0.20  3 -0.15 -0.96 0.67 0.11  Average 0.073 1.157 0.880 0.150  Range 0.19 0.42 0.42 0.09  Part Average 0.19 0.45 1.099 0.367  Average 0.19 0.42 0.42 0.09  Max X = 0.1903   Thin X = 0.2543   X = X = X = X = X = X = X = X = X = X	3 0.64 0.58 1.27 0.64 -0.84  Average 0.447 -0.607 1.260 0.537 0.853  Range 0.35 0.12 0.17 0.17 0.12  B 1 0.08 -0.47 1.19 0.01 -0.56  2 0.25 -1.22 0.94 1.03 -1.20  3 0.07 -0.68 1.34 0.20 -1.28  Average 0.133 -0.790 1.157 0.413 -1.013  Range 0.18 0.75 0.40 1.02 0.72  C 1 0.04 -1.38 0.88 0.14 -1.46  2 -0.11 -1.13 1.09 0.20 -1.07  3 -0.15 -0.96 0.67 0.11 -1.45  Average -0.073 -1.157 0.880 0.159 -1.327  Range 0.19 0.42 0.42 0.09 0.39  Part Average .0.19 0.42 0.42 0.09 0.39  [R <sub>g</sub> = 0.184] + [R <sub>g</sub> = 0.513] + [R <sub>g</sub> = 0.328] / [= 0.14 0.14 0.14 0.14 0.14 0.14 0.14 0.14	3 0.64 -0.58 1.27 0.64 -0.84 -0.21 Average 0.447 -0.607 1.260 0.537 -0.853 0.100 Range 0.35 0.12 0.07 0.17 0.17 0.12 0.23 B 1 0.00 -0.47 1.19 0.01 -0.56 -0.20 2 0.25 -1.22 0.94 1.03 1.20 0.22 3 0.07 -0.68 1.34 0.20 -1.28 0.06 Average 0.133 -0.790 1.167 0.413 -1.013 0.027 Range 0.18 0.75 0.40 1.02 0.72 0.42 C 1 0.04 -1.38 0.88 0.14 -1.46 -0.29 2 0.11 -1.13 1.09 0.20 1.07 0.67 3 -0.15 -0.96 0.67 0.11 -1.45 -0.49 Average 0.09 0.67 0.11 -1.45 -0.49 Average 0.09 0.67 0.11 -1.45 0.49 Average 0.09 0.67 0.11 -1.45 0.49 Average 0.19 0.42 0.42 0.09 0.39 0.38 Range 0.19 0.42 0.42 0.09 0.39 0.38 0.18 0.18 0.18 $[R_{_{\parallel}} = 0.184] + [R_{_{\parallel}} = 0.513] + [R_{_{\parallel}} = 0.326] / [= 0.75 Approximately 0.180 0.1$	3 0.64 -0.58 1.27 0.64 -0.84 -0.21 0.66  Average 0.447 -0.607 1.260 0.537 0.853 -0.100 0.667  Range 0.35 0.12 0.17 0.17 0.17 0.12 0.23 0.16  B 1 0.08 -0.47 1.19 0.01 -0.55 -0.20 0.47  2 0.25 -1.22 0.94 1.03 -1.28 0.06 0.83  Average 0.133 0.79 1.157 0.413 -0.13 0.027 0.617  Range 0.16 0.75 0.40 1.02 0.72 0.42 0.36  C 1 0.04 -1.38 0.88 0.14 -1.46 0.29 0.02  2 0.11 -1.13 1.09 0.20 1.107 0.677 0.01  3 0.15 -0.96 0.87 0.11 1.45 0.49 0.21  Average 0.19 0.42 0.42 0.09 0.33 0.38 0.20  Part Average 0.19 0.42 0.42 0.09 0.39 0.38 0.20  Part Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454  ER = 0.144 + [R] = 0.513 + [R] = 0.228   F] = 0.7 APPRAISERS  Max \( \overline{K} = 0.941 \) - [Min \( \overline{K} = 0.228 \) - [Z = 0.8816 0.454 1.00 0.90 0.90 0.90 0.90 0.90 0.90 0.90	3 0.64 -0.58 1.27 0.64 -0.84 -0.21 0.66 -0.17  Average 0.447 0.667 1.260 0.537 -0.853 -0.100 0.667 0.227  Range 0.55 0.42 0.17 0.17 0.12 0.23 0.16 0.44  B 1 0.08 0.47 1.19 0.01 -0.56 -0.20 0.47 0.63  2 0.25 1.22 0.94 1.03 1.20 0.22 0.55 0.08  3 0.07 -0.68 1.34 0.20 1.28 0.06 0.83 -0.34  Average 0.133 0.790 1.157 0.413 1.013 0.027 0.617 0.27  Range 0.18 0.75 0.40 1.02 0.72 0.42 0.36 0.71  C 1 0.04 1.38 0.88 0.14 1.04 0.20 0.02 0.02 0.66  2 0.011 1.13 1.09 0.20 1.07 -0.67 0.01 0.56  3 -0.15 -0.96 0.67 0.11 1.45 0.49 0.21 0.49  Average 0.19 0.42 0.42 0.09 0.39 0.38 0.20 0.10  Part Average 0.19 0.42 0.42 0.09 0.39 0.38 0.20 0.10  Nax X = 0.1901 - 1.17 0.880 0.150 1.327 0.483 0.080 0.503  Range 0.19 0.42 0.42 0.09 0.39 0.38 0.20 0.10  Max X = 0.1901 - 1.17 0.880 0.150 1.327 0.483 0.080 0.503  Range 0.19 0.25 0.50 1.50 0.50 0.50 0.503  Average 0.19 0.25 0.50 0.50 0.50 0.503 0.38 0.20 0.10  Part Average 0.180 0.851 1.099 0.367 1.064 0.180 0.454 0.342  Average 0.180 0.851 1.099 0.367 2.064 0.180 0.454 0.342  Average 0.180 0.851 0.099 0.367 2.064 0.180 0.454 0.342  Average 0.180 0.851 0.099 0.367 2.064 0.180 0.454 0.342  Average 0.180 0.851 0.099 0.367 2.064 0.180 0.454 0.342  O.150 0.0851 0.099 0.367 2.064 0.180 0.454 0.342  Average 0.180 0.851 0.099 0.367 2.064 0.180 0.454 0.342  O.150 0.0851 0.099 0.367 2.064 0.180 0.	3 0.64 -0.58 1.27 0.64 -0.84 -0.21 0.66 -0.17 2.01  Average 0.447 -0.607 1.260 0.537 -0.853 0.100 0.667 0.227 2.087  Range 0.35 0.12 0.17 0.17 0.12 0.23 0.16 0.14 0.27  B 1 0.08 -0.47 1.19 0.01 -0.56 -0.20 0.47 -0.53 1.80  2 0.25 -1.22 0.94 1.03 -1.26 0.22 0.55 0.08 2.12  3 0.07 -0.68 1.34 0.20 -1.28 0.06 0.83 -0.34 2.19  Average 0.133 0.79 0.157 0.413 1.013 0.027 0.617 0.227 2.037  Range 0.18 0.75 0.40 1.02 0.72 0.42 0.36 0.71 0.39  C 1 0.04 -1.38 0.88 0.14 -1.46 0.29 0.02 0.46 1.35  3 -0.15 -0.96 0.87 0.11 -1.45 0.49 0.21 0.49 1.87  Average 0.073 1.157 0.890 0.150 1.327 0.483 0.890 0.503 1.897  Range 0.19 0.42 0.42 0.09 0.39 0.38 0.20 0.10 0.42  Part Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.42 0.42 0.99 0.367 -1.064 0.186 0.454 0.342 1.940  Average 0.19 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.4	3 0.64 -0.58 1.27 0.64 -0.84 -0.21 0.66 -0.17 2.01 -1.31  Average 0.447 0.607 1.260 0.537 -0.853 -0.100 0.697 0.227 2.087 -1.307  Range 0.55 0.12 0.17 0.17 0.12 0.23 0.16 0.14 0.27 0.11  B 1 0.08 -0.47 1.19 0.01 -0.56 -0.20 0.16 -0.16 0.14 0.27 0.11  B 1 1 0.08 -0.47 1.19 0.01 -0.56 -0.20 0.16 0.16 0.14 0.27 0.11  B 1 1 0.08 -0.47 1.19 0.01 -0.56 0.20 0.16 0.16 0.14 0.27 0.11  B 1 1 0.08 -0.47 1.19 0.01 -0.56 0.20 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.1	Average 0.447 0.667 1.260 0.597 0.853 0.100 0.667 0.227 2.087 -1.307 $\overline{X}_a = 0.0000000000000000000000000000000000$	

Figure III-B 15: Completed GR&R Data Collection Sheet

118

	Study	% Study	% of
Source	Variation	Variation	Tolerance
Total Gage R&R	1.8348	26.68%	41.51%
Repeatability	1.2114	17.62%	27.41%
Reproducibility	1.3782	20.04%	31.18%
Part to Part	6.6276	96.38%	149.95%
Total Variation	6.8766	100.00%	155.58%

Gage Repeatability and Reproducibility Report Part No. & Name From data sheet:  $\overline{R} = 0.3417$  $R_g = 3.511$ % Total Variation (T)  $\%EV = 100 \, [EV/TV]$ = 0.3417 × 0.5908 Trials X<sub>2</sub>
2 0.8862 = 100 [0.20188/1.14610] = 0.20188 = 17.62% Reproducibility - Appraiser Variation (AV)  $AV = \sqrt{(\overline{X}_{DSF} \times K_2)^2 - (EV^2/(nr))}$ %AV = 100 [AV/TV] $= \sqrt{(0.4446 \times 0.5231)^2 - (0.20188^2/(10 \times 3))}$ = 100 [0.22963/1.14610] Appraisers 2 3 = 20.04% K<sub>2</sub> 0.7071 0.5231 Repeatability & Reproducibility (GRR)  $GRR = \sqrt{EV^2 + AV^2}$ %GRR = 100 [GRR/TV] = 100 [= 0.30575/1.14610]  $=\sqrt{(0.20188^2+0.22963^2)}$ Parts K<sub>I</sub> 3 0.5231 Part Variation (PV) 4 0.4467 = 200 [1.10456/1.14610] = 1.10456 Total Variation (TV)  $TV = \sqrt{GRR^2 + PV^2}$  $=\sqrt{(0.30575^2+1.10456^2)}$ 9 0.3249  $ndc = 1.41 \binom{PV}{GRR}$ = 1.41(1.10456/0.30575) = 5.094 ~ 5 nts used in the form see MSA Reference Manual, Fourth edition. Figure III-B 16: Gage Repeatability and Reproducibility Report

119

