Measurement Systems Analysis (Rev 2_16)

$$\sigma^2{}_{Total} = \sigma^2{}_{Part} + \sigma^2{}_{Measurement}$$

Gage Repeatability and Reproducibility Data Collection Sheet (partial)

Appraiser	Trial #	PART										
		1	2	3	4	5	6	7	8	9	10	
A	1											
	2											
	3											
Average												$\bar{X}_A =$
Range												$\bar{R}_A =$
Other appraisers – same as above												
Part Average												$\bar{\bar{X}} =$
												$R_p =$

$$\bar{\bar{R}} = \frac{(\bar{R}_A + \bar{R}_B + \bar{R}_C)}{3}$$

$$\bar{X}_{DIFF} = [Max\ \bar{X}] - [Min\ \bar{X}]$$

$$UCL_R = \bar{\bar{R}} * D_4 \quad \text{(D4 = 3.27 for 2 trials, and 2.58 for 3 trials)}$$

Repeatability – Equipment Variation EV $$EV = \sigma_{repeatability} = \bar{\bar{R}} * K_1$$	n=#of parts r=# of trials = # times each part measured
Reproducibility – Appraiser Variation $$AV = \sigma_{reproducibility} = \sqrt{(\bar{X}_{DIFF} * K_2)^2 - \left[EV^2/nr\right]}$$	
Gage Repeatability and Reproducibility (GRR) $$GRR = \sigma_m = \sqrt{EV^2 + AV^2}$$	Part Variation (PV) $$PV = \sigma_p = R_p * K_3$$
Total Variation (TV) $$TV = \sqrt{GRR^2 + PV^2}$$	Number of distinct categories $$ndc = 1.41\frac{PV}{GRR}$$

$$\%EV = \left(\frac{EV}{TV}\right) * 100\%$$

$$\%AV = \left(\frac{AV}{TV}\right) * 100\%$$

$$\%GRR = \left(\frac{GRR}{TV}\right) * 100\%$$

$$\%PV = \left(\frac{PV}{TV}\right) * 100\%$$

$$\%Tolerance = \left(\frac{6 * GRR}{Tolerance}\right) * 100\%$$

r Trials	K_1		n # of Parts	K_3
2	.8862		5	.4030
3	.5908		6	.3742
			7	.3534
Appraisers	K_2		8	.3375
2	.7071		9	.3249
3	.5231		10	.3146

Constants from MSA Reference Manual, 3rd edition