REPEATABILITY AND REPRODUCIBILITY STUDY

(Corrected 21 Feb 2006)

Aim: 1) To characterize the variation in a production process
2) To examine whether the measuring equipment is sufficient to control the manufacturing process.
3) To estimate the repeatability of the measuring equipment and reproducibility between observers in measurement.

Introduction: Measurement system capability studies are carried out to investigate two components of measurement error, commonly called repeatability and reproducibility of the gauge. **Reproducibility** is the variability due to different operators using the gauge (or different time periods, or different environments, or in general, different conditions) and **repeatability** is the basic inherent precision of the gage itself. If reproducibility is high, it points out to the need for better training of the operators in using the equipment, or in general, the need to study the variation with a view to its minimization.

Procedure:

1. Collect 25 (=n) balls (supposedly from a single batch in a manufacturing process), 0-25mm digital micrometer and holder for keeping the balls in identified positions.

2. Let any one observer measure all the balls one by one. Let another person note down the readings.

3. Repeat the measurement process with at least three observers. The earlier readings should be **hidden** from the observer, to avoid any bias. **Randomize** the order of measurement. Note the observations as in Table 1.

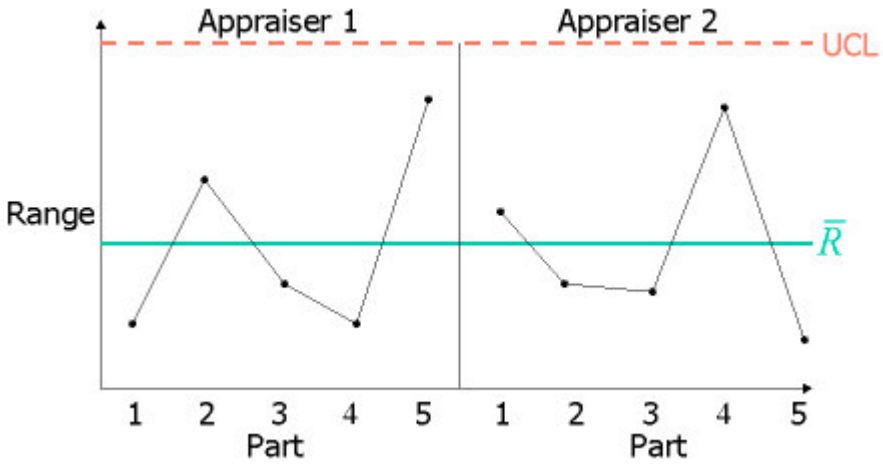

Fig 1 Repeatability Range Control Chart

4. Plot the ranges for each appraiser/part combination. See Fig. 1. $UCL_R = D_4\overline{\overline{R}}$, where D_4 =3.267 for 2 repeated measurements. Examine whether all points are below the control limit. If yes, then the appraisers are consistent. If not, it could be a result of appraiser technique, position error, or instrument inconsistency. These special causes should be corrected and the range chart brought into control before proceeding to the next step.

5. Plot the averages for each appraiser/part combination. See Fig 2. $UCL_{\bar{x}} = \bar{x}_P + A_2\overline{\overline{R}}$, $UCL_{\bar{x}} = \bar{x}_P - A_2\overline{\overline{R}}$, A_2 =1.880 for two appraisers, 1.023 for three, 0.729 for four and 0.577 for five appraisers. The area within the control limits represents the measurement error (noise). If one-half or more of the averages fall outside these limits, then the measurement system is adequate to detect part to part variations. Otherwise, the measurement system is inadequate.

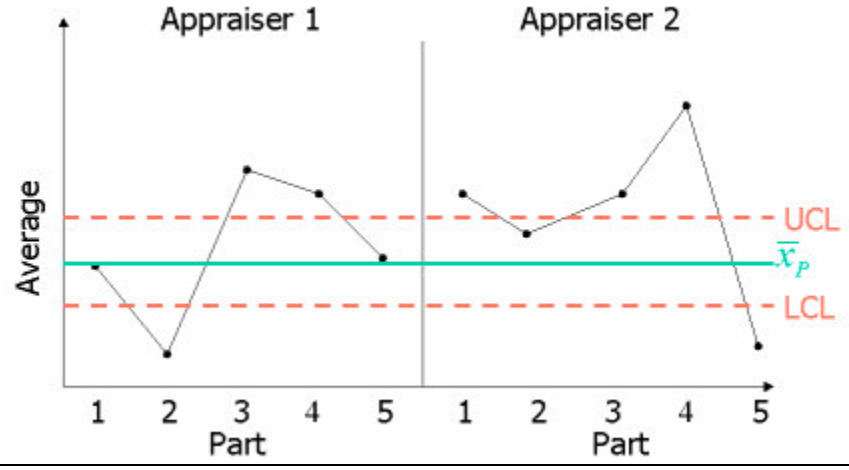

Fig 2 Part Appraiser Average Chart

6. The estimate of gauge repeatability is obtained from the average of the three ranges: $\overline{\overline{R}} = \frac{1}{3}\left(\bar{R}_A + \bar{R}_B + \bar{R}_C\right)$ and $\hat{\sigma}_{repeatability} = \frac{\overline{\overline{R}}}{d_2}$, d_2= 1.128 for 2 repeated measurements

7. To estimate reproducibility, $\bar{x}_{\max} = \max\left(\bar{x}_A, \bar{x}_B, \bar{x}_C\right)$, $\bar{x}_{\min} = \min\left(\bar{x}_A, \bar{x}_B, \bar{x}_C\right)$, $R_{\bar{x}} = \bar{x}_{\max} - \bar{x}_{\min}$, and $\hat{\sigma}_{reproducibility} = \frac{R_{\bar{x}}}{d_2}$, d_2= 1.693 if $R_{\bar{x}}$ is obtained from 3 samples.

Part No	Operator A				Operator B				Operator C				Part Average
	Measurement		Average	Range	Measurement		Average	Range	Measurement		Average	Range	
	1	2			1	2			1	2			
1	12.3	12.6	12.45	0.3									
2	12.4	12.6	12.5	0.2									
3	12.2	12.5	12.35	0.3									
4													
5													
.													
.													
.													
.													
.													
25													
Average			$\overline{x}_A$	$\overline{R}_A$			$\overline{x}_B$	$\overline{R}_B$			$\overline{x}_C$	$\overline{R}_C$	$\overline{x}_P$
													R_P