1.

Shaft:

mean = 0.995

standard deviation = 0.0025

holes:

mean = 1.003

standard deviation = 0.0033

(a) Shaft:

$0.995 \pm 3\sigma$:

$\boxed{0.995 \pm 0.0075}$

holes: $\boxed{1.003 \pm 0.0099}$

If we express in another way using the unilateral notation for the same size distributions

holes: $0.9933_{0}^{+0.0198}$

shafts: $1.0024_{-0.015}^{0}$

(b) (0.9933)-(1.0024) = -0.0091

$\therefore$ Inteference of 0.0091

(c) $\sqrt{0.0075^2 + 0.0099^2} = 0.0124$

2.

Prob 2.

1	2	3	4	5	6	7	8	9	10	11	12	average	STD
0.35	0.95	0.2	-0.55	-0.83	-0.22	0.75	0.12	0.33	-0.68	-0.85	0.22	-0.018	0.6045
0.368	0.968	0.218	-0.533	-0.813	-0.203	0.768	0.138	0.348	-0.663	-0.833	0.238	Ra	Rq
0.368	0.968	0.218	0.533	0.813	0.203	0.768	0.138	0.348	0.663	0.833	0.238	**0.507**	**0.579**

(a) $$R_a = \frac{\sum |y_i - \bar{y}|}{N} = \frac{3.368 + 0.968 + 0.218 + 0.533 + 0.813 + 0.203 + 0.768 + 0.138 + 0.348 + 0.663 + 0.833 + 0.238}{12}$$

$$= \frac{240.333}{12} \quad (\because \bar{y} \cong 0.507)$$

$$=0.507$$

(b) $$R_q = \sqrt{\frac{\sum (y_i - \bar{y})^2}{N}}$$

$$= \sqrt{\frac{0.368^2 + 0.968^2 + 0.218^2 + 0.533^2 + 0.813^2 + 0.203^2 + 0.768^2 + 0.138^2 + 0.348^2 + 0.663^2 + 0.833^2 + 0.283^2}{12}}$$

$$= 0.579$$

(c) $$0.507 \sqrt{0.030 \atop \perp}$$

3.

$$\overline{\overline{x}} = 0.566 \quad \sigma_{\overline{x}} = 0.0182$$
$$\overline{\mathrm{R}} = 0.041 \quad \sigma_{\mathrm{R}} = 0.0146$$

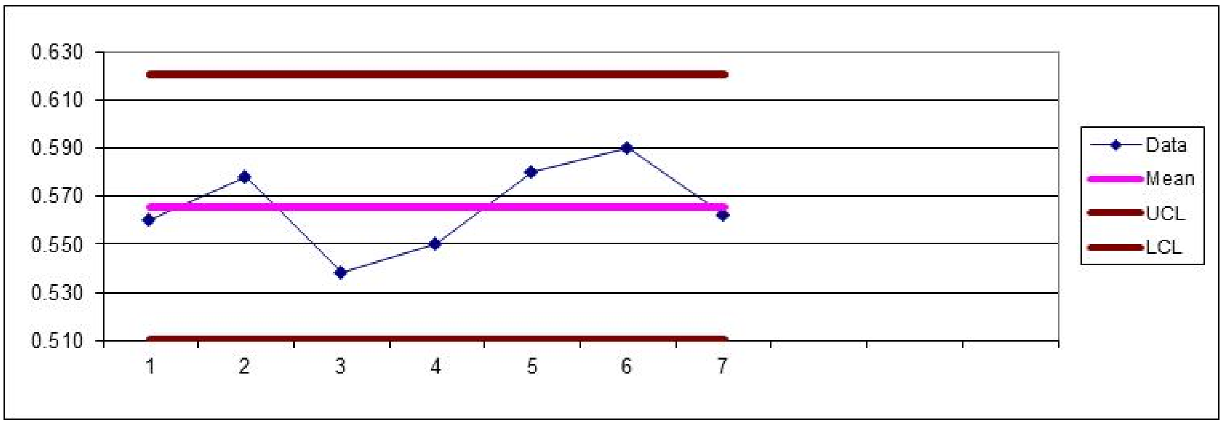
(a) $\mathrm{UCL}_{\overline{x}} = \overline{\overline{x}} + 3\sigma_{\overline{x}} = 0.565 + 3 \times 0.0182 = 0.620$

$\mathrm{LCL}_{\overline{x}} = \overline{\overline{x}} - 3\sigma_{\overline{x}} = 0.565 - 3 \times 0.0182 = 0.511$

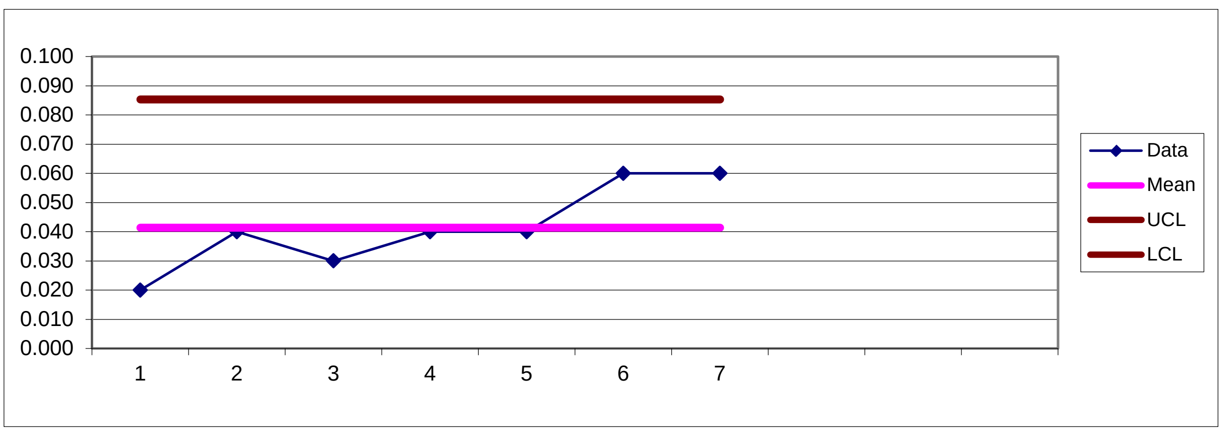
$\mathrm{UCL}_{\overline{\mathrm{R}}} = \overline{\mathrm{R}} + 3\sigma_{\mathrm{R}} = 0.040 + 3 \times 0.0146 = 0.0838$

$\mathrm{LCL}_{\overline{\mathrm{R}}} = \overline{\mathrm{R}} - 3\sigma_{\mathrm{R}} = 0.040 - 3 \times 0.0146 \cong 0$

(b) control charts for x



control chart for R



(c) Solution based on σ calculated in (a)

$$C_p = \frac{\mathrm{UCL}_{\bar{x}} - \mathrm{LCL}_{\bar{x}}}{6\hat{\sigma}}$$
$$= \frac{0.620 - 0.511}{6 \times 0.0182} = 0.998$$

$$\mathrm{C_{pk}} = \frac{\min\left\{\left|\mathrm{UCL}_{\bar{x}} - \bar{x}\right|, \left|\mathrm{LCL}_{\bar{x}} - \bar{x}\right|\right\}}{3\sigma}$$
$$= \frac{\min\left\{\left|0.620 - 0.565\right|, \left|0.511 - 0.565\right|\right\}}{3 \times 0.0182}$$
$$= \frac{0.055}{3 \times 0.0182} = 1.00$$

(d)

$$\mathrm{UCL}_{\bar{x}} = \bar{\bar{x}} + \mathrm{A_2}\bar{\mathrm{R}} \qquad \mathrm{A_2} = 0.577 \text{ for } n = 5$$
$$=0.565+0.577 \times 0.041=0.589$$
$$\mathrm{LCL}_{\bar{x}} = \bar{\bar{x}} - \mathrm{A_2}\bar{\mathrm{R}}$$
$$=0.565-0.577 \times 0.041=0.541$$

$$\hat{\sigma}_x = \frac{\bar{R}}{d_2} = \frac{0.040}{2.326} = 0.017$$
$$C_p = \frac{\mathrm{UCL}_{\bar{x}} - \mathrm{LCL}_{\bar{x}}}{6\hat{\sigma}}$$
$$= \frac{0.588 - 0.542}{6 \times 0.017} = 0.45$$

$$\mathrm{C_{pk}} = \frac{\min\left\{\left|\mathrm{UCL}_{\bar{x}} - \bar{x}\right|, \left|\mathrm{LCL}_{\bar{x}} - \bar{x}\right|\right\}}{3\sigma}$$
$$= \frac{\min\left\{\left|0.588 - 0.565\right|, \left|0.542 - 0.565\right|\right\}}{3 \times 0.017}$$
$$= \frac{0.023}{3 \times 0.0117} = 0.45$$

(e) Solution based on σ calculated in (a)

$$C_p = \frac{\mathrm{UCL}_{\bar{x}} - \mathrm{LCL}_{\bar{x}}}{6\hat{\sigma}}$$
$$= \frac{0.620 - 0.52}{6 \times 0.0182} = 0.916$$

$$\mathrm{C_{pk}} = \frac{\min\left\{\left|\mathrm{UCL}_{\bar{x}} - \bar{x}\right|, \left|\mathrm{LCL}_{\bar{x}} - \bar{x}\right|\right\}}{3\sigma}$$
$$= \frac{\min\left\{\left|0.620 - 0.565\right|, \left|0.52 - 0.565\right|\right\}}{3 \times 0.0182}$$
$$= \frac{\min(0.055, 0.045)}{3 \times 0.0182} = 0.824$$

4.

A: 1.01, 0.95, 1.03, 0.98, 1.02, 1.02

Average=1.002 σ=0.0306

B: 1.02, 1.01, 1.03, 1.01, 1.02, 0.97

Average=1.010 σ=0.0210

A is more accurate

B is more precise