

# INDIAN STATISTICAL INSTITUTE

MS in QMS

## TEST ON STATISTICAL PROCESS CONTROL

Date: 20 September, 2022 Time: 2 hours Maximum Marks: 50

*Answer as many questions as you can. The maximum you can score is 50*

1. Check whether the following statements are true or false. Justify your answers in not more than 3 sentences.
  - a. For *the individual x* chart, the quality characteristic  $x$  needs to be normally distributed
  - b. If 3-sigma limits in a control chart are replaced with 2-sigma limits then more assignable causes can be detected
  - c. In *the xbar* and  $R$  charts, The factor  $D_4$  is used to calculate the distance between the mean and upper and lower control limits in the  $R$  chart
  - d. A process is in control with  $pbar = 0.10$  and  $n = 100$ . Then the  $LCL$  of the  $np$  chart will be 0
  - e. If the center line of a  $c$  chart is 9, then the upper control limit will be 2 times the center line

[10]

2. A TiW layer is deposited on a substrate using a sputtering tool. The table below contains the averages and standard deviations of layer thickness measurements (in Angstroms) on 20 subgroups of four substrates.

Subgroup	xbar	s	Subgroup	xbar	s
1	448.25	9.91211	11	447	6.976
2	441.75	1.25831	12	451.5	10.344
3	448.5	6.13732	13	448	7.746
4	455.75	13.5493	14	448.5	12.124
5	449.75	6.80074	15	452	9.764
6	453.25	6.18466	16	445.75	8.139
7	447.25	2.62996	17	454.5	4.796
8	450.5	3.87298	18	429.75	6.185
9	448.25	7.67572	19	451.25	10.626
10	450.25	15.3921	20	452	2.309

- a. Set up  $xbar$  and  $s$  charts on this process. Is the process in control? Revise the control limits as necessary and plot the final charts.
- b. Estimate the process mean and standard deviation.
- c. Assume the layer thickness is normally distributed, if the specifications are at  $450 \pm 20$ , estimate the process capability indices.
- d. What fraction of containers produced by this process is likely to be beyond the specification limit?

[12]

3. Control charts for  $\bar{x}$  and  $R$  are maintained for an important quality characteristic. The subgroup size is  $n = 7$ .  $\bar{x}$  and  $R$  values are computed for each sample. After 35 samples we have found that

$$\sum_{i=1}^{35} \bar{x}_i = 7805 \qquad \sum_{i=1}^{35} R_i = 1200$$

- Set up  $\bar{x}$  and  $R$  chart using these data?
- Assume both charts exhibit control, and estimate the process mean and standard deviation.
- If the quality characteristic is normally distributed and if the specification limits are  $220 \pm 35$ , can the process meet the specification? Estimate the fraction nonconforming
- Assuming the variance to remain constant, state where the process mean should be located to minimize the fraction nonconforming. What would be the value of fraction nonconforming under these conditions?

[12]

4. An Eye hospital has compiled the weekly data on an additional visit to the hospital required by the patients who had undergone cataract surgery. Every week the hospital inspected 150 patients undergoing cataract surgery and noted down how many of them had an additional visit to the doctor post-surgery. Twenty weeks of data are given in the table below. Set up a control chart to monitor the process. Plot the point on the control chart

Week	Patients required additional visit	Week	Patients required additional visit
1	6	11	1
2	8	12	0
3	9	13	1
4	7	14	4
5	3	15	5
6	4	16	3
7	2	17	10
8	1	18	4
9	0	19	7
10	2	20	6

[10]

5. Write a short note on **any two** of the following:
- Chance and Assignable causes of variation
  - Central Limit Theorem
  - Rational Subgrouping

[10]