

Control charts for Variables

$$\text{Upper control limit (UCL)} = \mu + 3 \left[\frac{\sigma}{\sqrt{n}} \right]$$

$$\text{Lower control limit (LCL)} = \mu - 3 \left[\frac{\sigma}{\sqrt{n}} \right]$$

Procedure to draw \bar{X} -R chart

1) Find $\bar{\bar{X}} = \frac{\sum \bar{X}_i}{N}$

2) Find $\bar{R} = \frac{\sum R_i}{N}$

3) Find sample size = n

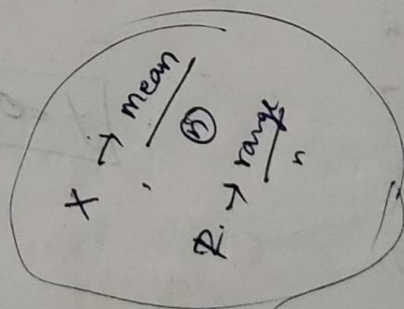
4) Find A_2, D_3, D_4 using table of size n .

5) For \bar{X} :

$$CL = \frac{\sum \bar{X}_i}{N}$$

$$LCL = \bar{\bar{X}} - A_2 \bar{R}$$

$$UCL = \bar{\bar{X}} + A_2 \bar{R}$$



6) For R

$$CL = \bar{R}$$

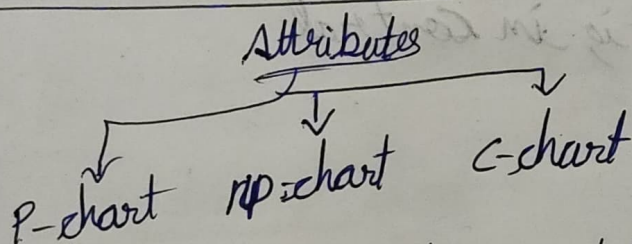
$$LCL = D_3 \bar{R}$$

$$UCL = D_4 \bar{R}$$

7) Draw the graph for \bar{X} & R chart

8) Conclusion

- (or) \rightarrow It is not in control
 \rightarrow It is in control



- i) P-chart for proportion of defectives - for sample of varying size.
- ii) np-chart for number of defectives - for constant sample size.
- iii) C-chart for number of defects per unit.

Procedure to draw C-chart

C-chart

$$\bar{c} = \frac{\text{Number of defects in all units inspected}}{\text{Total number of units inspected}}$$

$$\sigma^2 = \bar{c}$$

$$\sigma = \sqrt{\bar{c}}$$

$$UCL_c = \bar{c} + 3\sqrt{\bar{c}}$$

$$LCL_c = \bar{c} - 3\sqrt{\bar{c}} \text{ where } \bar{c} = \frac{C_1 + C_2 + \dots + C_R}{R}$$

$\therefore C_i$ is the no. of defects in i^{th} unit.

i) Find $\bar{c} = \frac{\sum c_i}{N}$

ii) Find $CL = \bar{c}$

iii) Find $UCL_c = \bar{c} + 3\sigma_c$ (or) $UCL_c = \bar{c} + 3\sqrt{\bar{c}}$

iii) Find $LCL_c = \bar{c} - 3\sigma_c$ (or) $LCL_c = \bar{c} - 3\sqrt{\bar{c}}$

iv) Draw the graph using UCL , CL & LCL

v) Conclusion

→ It is not in control.

→ It is in control.

P-Chart

$$p = \frac{\text{Number of defectives in the sample}}{\text{Sample size}}$$

$$\bar{p} = \frac{\sum p}{\text{Number of samples}}$$

(or)

$$\bar{p} = \frac{\text{Total no. of defectives in all samples}}{\text{Total no. of items inspected in all samples}}$$

$$UCL_p = \bar{p} + 3\sigma_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL_p = \bar{p} - 3\sigma_p = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

∴ n is the sample size (if constant)

p-chart when sample size is varying:-

Method 1:-

$$UCL_p = P + 3\sqrt{\frac{P(1-P)}{n}}$$

$$LCL_p = P - 3\sqrt{\frac{P(1-P)}{n}}$$

Method 2:-

$$UCL_p = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{\bar{n}}}$$

$$LCL_p = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{\bar{n}}}$$

Procedure to draw p-chart

i) Find P

ii) Find \bar{P}

$$\therefore CL_p = \bar{P}$$

iii) Find $UCL_p = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{\bar{n}}}$

iv) Find $LCL_p = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{\bar{n}}}$

v) Draw the graph using UCL_p , CL_p & LCL_p

vi) Conclusion.

→ It is not in control.
(or)

→ It is in control.

np-chart

$$\bar{y} = n\bar{p} = \frac{\text{Total no. of defectives of all samples}}{\text{Total no. of samples inspected.}}$$

$$UCL_{np} = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$LCL_{np} = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$\frac{(n-1)\bar{p}}{n} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

Procedure to draw p-chart

i) Find \bar{p}

ii) Find $n\bar{p}$

iii) Find $UCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

iv) Find $LCL_p = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

v) Draw the graph using UCL_p , LCL_p and \bar{p}

vi) Conclusion.

Process is in control.

(or)

Process is not in control.