C-Chart

02 April 2021 09:40 PM

Construction of *c*-chart

- *c*-chart is used when it is required to control (minimize) the ***number of defects per unit***.
- There are situations where it is necessary to control the number of defects in a unit of product, rather than the fraction defective or the number of defectives.
- For example, controlling the number of defects per hundred meters of cloth, number of air bubbles in a piece of glass, etc.
- Such situations are described by the Poisson distribution.

Control limits of *c*-chart

Let c represents the number of defects counted per unit and

$\bar{c}$ represent the mean of the defects counted in several such units.

Then

- Central line $= \bar{c}$
- Lower control limit, LCL$= \bar{c} - 3\sqrt{\bar{c}}$
- Upper control limit, UCL$= \bar{c} + 3\sqrt{\bar{c}}$

Problem 1

15 tape-recorders were examined for quality control test. The number of defects in each tape-recorder is recorded below. Draw the appropriate control chart and comment on the state of control.

Unit number (i)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of defects (c)	2	4	3	1	1	2	5	3	6	7	3	1	4	2	1

Solution.

Here each sample has only one item and the number of defects in each sample is given, we have to apply c-chart to steady the state of control.

Number of samples, $N = 15$

Mean of the defectives, $\bar{c} = \frac{\Sigma c}{N} = \frac{2+4+3+\cdots+1}{15} = \frac{45}{15} = 3$

<u>Control limits for c-chart</u>

Central line, $\bar{c} = 3$

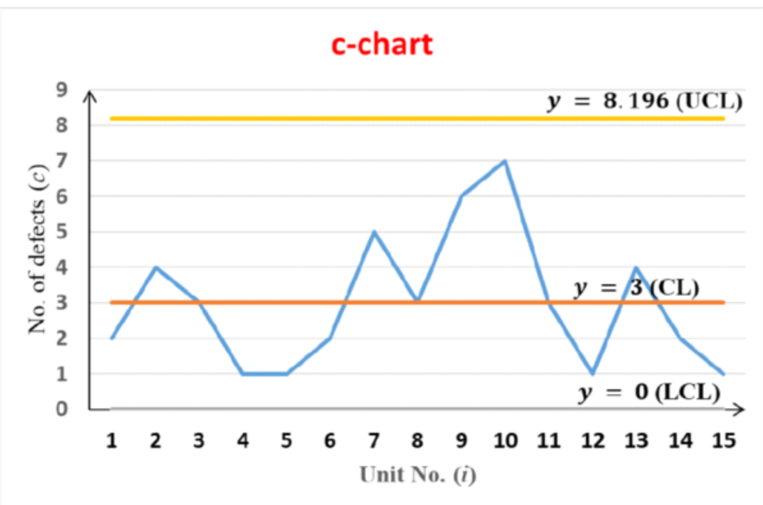
Lower control limit, LCL $= \bar{c} - 3\sqrt{\bar{c}} = 3 - 3 \times \sqrt{3}$

$= 3 - 5.196 = -2.196$

LCL cannot be negative, so take LCL $= 0$

Upper control limit, UCL $= \bar{c} + 3\sqrt{\bar{c}}$

$= 3 + 5.196 = 8.196$



i	c
1	2
2	4
3	3
4	1
5	1
6	2
7	5
8	3
9	6
10	7
11	3
12	1
13	4
14	2
15	1

State of control

Since all the sample points lie within LCL line and UCL line, the process is under control.

Problem 2

A plant produces paper for newsprint and rolls of paper are inspected for defects. The results of inspection of 20 rolls of papers are given below. Draw the c-chart and comment on the state of control.

Roll No. (i)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of defects (c)	19	10	8	12	15	22	7	13	18	13	16	14	8	7	6	4	5	6	8	9

Number of samples, $N = 20$

Mean of the defectives, $\bar{c} = \frac{\Sigma c}{N} = \frac{19+10+\cdots+9}{20} = \frac{220}{20} = 11$

<u>Control limits for c-chart</u>

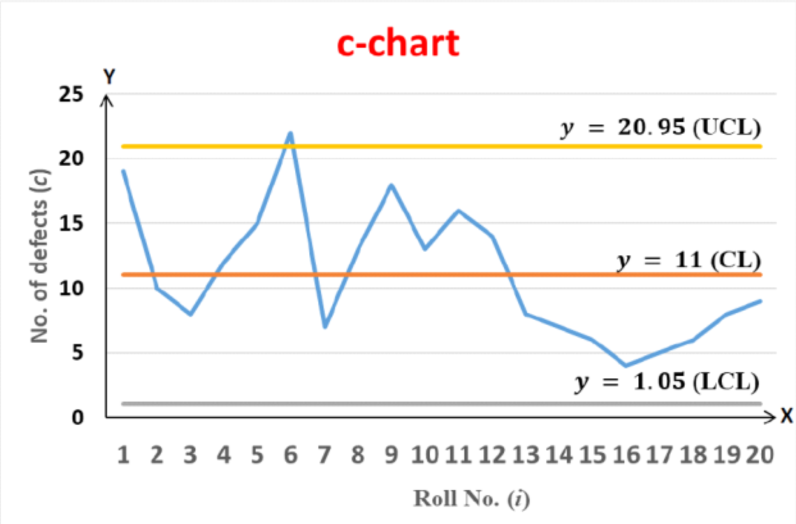
Central line, $\bar{c} = 11$

Lower control limit, LCL $= \bar{c} - 3\sqrt{\bar{c}} = 11 - 3 \times \sqrt{11}$

$= 11 - 9.95 = 1.05$

Upper control limit, UCL $= \bar{c} + 3\sqrt{\bar{c}}$

$= 11 + 9.95 = 20.95$



i	c
1	19
2	10
3	8
4	12
5	15
6	22
7	7
8	13
9	18
10	13
11	16
12	14
13	8
14	7
15	6
16	4
17	5
18	6
19	8
20	9

State of control

Since one sample point falls outside the control lines, the process is out of control.

Test yourself

1. The following data relate to the number of defects in each of 15 units drawn randomly from a production process.
   6, 4, 9, 10, 11, 12, 20, 10, 9, 10, 15, 10, 20, 15, 10.
   Draw the control chart for the number of defects and comment on the state of control.
   ANS: LCL = 1.27, UCL = 21.13. The process is under control.
2. At a certain point in the assembly process, radios were subjected to a critical inspection. Twenty radio sets were selected at random and inspected and the number of defects per set found are given below:
   4, 5, 7, 6, 8, 9, 10, 4, 6, 11, 12, 13, 14, 15, 10, 11, 12, 10, 6, 7
   Draw the control chart for defects.
   ANS: LCL = 0, UCL = 18. The process is under control.

Specification limits

Specification limits are the values between which products or services should operate. These limits are usually set by customer requirements.

Example:

- To print labels for a shipping process, the size will be specified by the customer. If the labels are too big or too small, it will not be accepted by the customer. It has both lower specification limit and upper specification limit. Otherwise labels will not be acceptable.
- Photos for visas has both upper and lower specification limit.
- A chemical company requires an inert gas to be at least 80% pure. The quality analysts set a lower specification limit but do not set an upper specification limit because purer is better.
- Consider a call center where calls must be answered within 30 seconds. In this case, only an upper specification is relevant because the quicker a call is answered, the better.

Difference between Control limits and Specification limits

- Specification limits and control limits are used for different purposes.
- Control limits are calculated from process data. They represent how a manufacture's process actually performs. Specification limits are defined by the customer and represent the desired performance of manufacture's process.
- Control limits help to assess whether a process is stable. Specification limits allow to assess how capable a process is of meeting customer requirements.

Tolerance limits

- In quality control, the limiting values between which measurements must lie if a product is to be accepted is defined as tolerance limits. It gives a specific proportion of the population at a given confidence level. In the context of process control, they are used to make sure that production will not be outside specifications.
- If the process is under control then the tolerance limits are computed as

$$\hat{\mu} = \bar{\bar{x}} \pm \frac{3\bar{R}}{d_2}$$

NOTE

If the tolerance limits are within the specification limits then the process is assumed to operate at an acceptable level. That is, the tolerance limits are used to determine whether individual manufactured components are acceptable, whereas the control limits are used to control the manufacturing process.