Example of *p*- Chart

❖ The following are the figures of defectives in 22 lots each containing 2000 rubber belts:

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Defectives	425	430	216	341	225	322	280	306	337	305	356
Sample No.	12	13	14	15	16	17	18	19	20	21	22
Defectives	402	216	264	126	409	193	326	280	389	451	420

Draw control chart for fraction defective and comment on the state of control of the process.

➢ Here we have seen that the sample size is fixed, which is n= 2000 for each lot. Thus we construct p-chart for fixed sample size, whose control limits are given by,

$$\text{UCL} = \bar{p} + A\sqrt{\bar{p}(1-\bar{p})}$$
$$\text{LCL} = \bar{p} - A\sqrt{\bar{p}(1-\bar{p})}$$
$$\text{CL} = \bar{p}$$

where, $A=\frac{3}{\sqrt{n}}$, $\bar{p} = \frac{1}{k}\sum p_i$ and $p_i = \frac{d_i}{n}$

Calculation:

Sample No.	Defectives (d)	$p_i=\frac{d_i}{n}=\frac{d_i}{2000}$	Sample No.	Defectives (d)	$p_i=\frac{d_i}{n}=\frac{d_i}{2000}$
1	425	0.2125	12	402	0.2010
2	430	0.2150	13	216	0.1080
3	216	0.1080	14	264	0.1320
4	341	0.1705	15	126	0.0630
5	225	0.1125	16	409	0.2045
6	322	0.1610	17	193	0.0965
7	280	0.1400	18	326	0.1630
8	306	0.1530	19	280	0.1400
9	337	0.1685	20	389	0.1945
10	305	0.1525	21	451	0.2255
11	356	0.1780	22	420	0.2100
Total	3543	1.7715		3476	1.7380

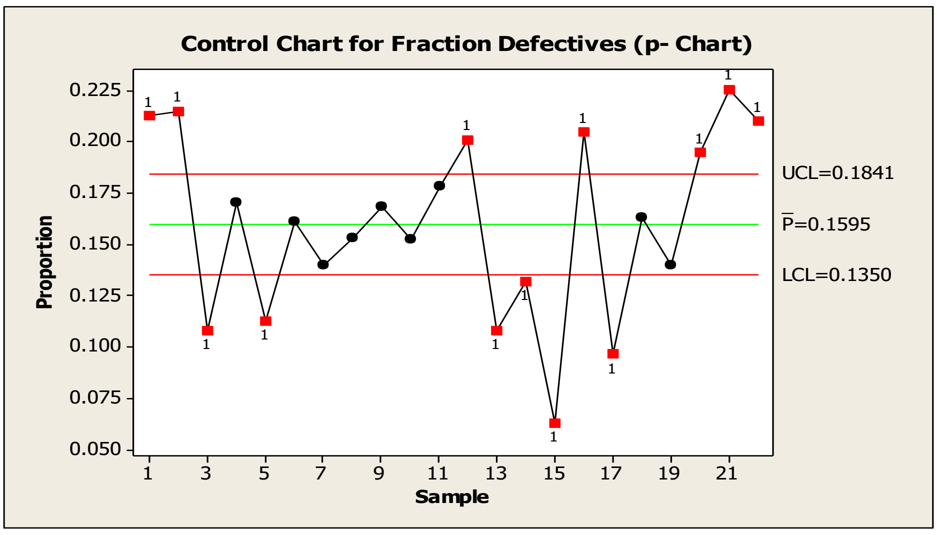
Thus, $\bar{p} = \frac{1}{k}\sum p_i = \frac{1.7715+1.7380}{22} = 0.1595$

which gives, $1-\bar{p} = 1-0.1595 = 0.8405$, and $A = \frac{3}{\sqrt{2000}} = \frac{3}{44.72} = 0.0671$

Hence $\text{UCL} = 0.1595+0.0671\sqrt{0.1595\times 0.8405} = 0.1841$

$\text{LCL} = 0.1595 - 0.0671\sqrt{0.1595\times 0.8405} = 0.1349$

$\text{CL} = 0.1595$



Conclusion: From the above p-chart, we see that the fraction defectives corresponding to the sample numbers 1, 2, 3, 5, 12, 13, 14, 15, 16, 17, 20, 21, 22 fall outside the control limits. So we conclude that the process is out of control.

- Explain the justification for using the 3-σ limits in the construction of control charts irrespective of the probability distribution of the quality characteristic.
  - For non-normal population 3- σ limits are almost universally used as they have been found to be most suitable emperically in the sense that the 3- σ control charts have been found to give excellent protection against probability distribution.

- **<u>Applications of *c*-chart</u>**

Some of the representative types of defects to which c-chart can be applied with advantage are:

- *c* is number of imperfections observed in a bale of cloth.
- *c* is the number of surface defects observed in roll of coated paper or a sheet of photographic film.
- *c* is the number of defects of all types observed in aircraft sub-assemblies or final assembly.
- *c*- chart can be applied to accident statistics, also in epidemiology etc.
- *c*- chart has been applied to sampling acceptance procedures based on number of defects per unit.

- **<u>Comparison of control charts for Variable vs. Attribute</u>**

Control chart for variable	Control chart for attribute
A separate chart is needed for each quality characteristic under consideration.	A single chart is enough to decide for a no. of quality characteristic under consideration.
Small samples serve the purposes very well.	Large samples are needed for correct conclusions.
The cost of inspection of units is large.	Cost of inspection of units is small.
It involves more Computation labour.	The computations are simple.
The control charts are sensitive to assignable causes.	The control charts are less sensitive to assignable causes.
Control charts provide better quality control.	These charts are not very effective in keeping the quality control.
Samples from sub groups should preferably be of equal size.	The need for equal size of samples is not as much as in the case of variable control chart.

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