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STATISTICAL PROCESS CONTROL. x-bar Chart: Standard Deviation Known

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ABSTRACT
Individuals control charts are statistical tools used to evaluate the central tendency of a process over time. They are also called X charts or moving range charts. Individuals control charts are used when it is not feasible to use averages for process control. Some common reasons why averages control charts may not be feasible are that: observations may be expensive to get output may be too homogeneous over short time intervals , and the production rate may be slow and the interval between successive observations long. The X-bar and sigma chart is a pair of control charts for variables data.
Keywords: x-bar, control charts, control limits

1. INTRODUCTION
The chart is advantageous in the some situations: The sample size is relatively large (say, n > 10), because R-charts are typically used for smaller sample sizes. The sample size is the variable. Computers can be used to ease the burden of calculation

Control charts for individuals are often used to monitor batch processes, such as chemical processes, where the within-batch variation is so small relative to between-batch variation that the control limits on a standard X chart would be too close together. Range charts are used in conjunction with individuals charts to help monitor dispersion. As with averages and ranges charts, the range R is the difference between the largest and the smallest in a subgroup.

Using x- bar Process average and process variability must be in control. It is possible for samples to have very narrow ranges, but their averages might be beyond control limits. It is possible for sample averages to be in control, but ranges might be very large. It is possible for an R-chart to exhibit a distinct downward trend, suggesting some nonrandom cause is reducing variation.

2. X-bar AND SIGMA CHARTS
The X-bar and sigma chart is a pair of control charts for variables data. The chart should be used with subgroup size of 11 or more the chart shows the stability and predictability of the system. Also it enables to monitor the effect of process improvements. This gives a more effective measure of process spread, as each individual reading of the parameter is used for variability calculation. The chart, actually, consists of two separate charts: X-bar (process location over time, based on average of series of observations) and Sigma chart (variation between observations of series over time).

2.1. X-bar AND RANGES CONTROL CHARTS

X-bar control limits could be based on either range or sigma, depending on which chart it is paired with. When the X-bar chart is paired with a sigma chart, the most common (and recommended) method of computing control limits based on 3 standard deviations.
Averages and standard deviation control charts are conceptually analogue to averages and ranges control charts. The difference is that the subgroup standard deviation is used to measure dispersion rather than the subgroup range.

The subgroup standard deviation is statistically more efficient than the subgroup range for subgroup sizes greater than two. This efficiency advantage increases as the subgroup size increases.
However, the range is easier to compute and easier for most people to understand. In general, it is recommended to use subgroup ranges unless the subgroup size is 10 or more. If the analyses are to be interpreted by knowledgeable personnel and calculations are not a problem, the standard deviation chart may be preferred for all subgroup sizes. Individuals control charts are statistical tools used to evaluate the central tendency of a process over time.

They are also called X charts or moving range charts. Individuals control charts are used when it is not feasible to use averages for process control. Some common reasons why averages control charts may not be feasible are that: observations may be expensive to get, output may be too homogeneous over short time intervals, and the production rate may be slow and the interval between successive observations long.

Control charts for individuals are often used to monitor batch processes, such as chemical processes, where the within-batch variation is so small relative to between-batch variation that the control limits on a standard X chart would be too close together. Range charts are used in conjunction with individuals charts to help monitor dispersion. As with averages and ranges charts, the range R is the difference between the largest and the smallest in a subgroup.

3. X-bar AND S CHARTS

X-bar and s charts are used to monitor the mean and variation of a process based on samples taken from the process at given times. They are generally recommended over the X-bar and R charts when the subgroup sample size is moderately large (n> 10), or when the sample size is variable from subgroup to subgroup.

The measure of process variability, either the subgroup standard deviation or the subgroup range, is the basis of the control limits for averages. These control limits are used to monitor variation over time.

This approach also forms the basis of establishing control limits for individual measurements, as far as possible

$$\overline{X} = \frac{sum\ of\ gropup\ measurements}{subgropup\ \text{size}} \qquad \overline{s} = \frac{sum\ of\ subgropup\ sigmas}{number\ of\ subgropups}$$

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \overline{X}\right)^2}{n-1}}$$ - center line

Table 1. Example of averages and standard deviation control charts

Samples	1	2	3	4	5	Average	Range
1	110	93	99	98	109	101.8	17
2	103	95	109	995	98	100	14
3	97	110	90	97	100	98.8	20
4	96	102	105	90	96	97.8	15
5	105	110	109	93	98	10399.4	17
6	110	91	104	91	101	99.4	19
7	100	96	104	93	96	97.8	11
8	93	90	110	109	105	101.4	20
9	90	105	109	90	108	100.4	19
10	103	93	93	99	96	96.8	10
11	97	97	104	103	92	98.6	12
12	103	100	91	103	105	100.4	14
13	90	101	96	104	108	99.8	18
14	97	106	97	105	96	100.2	10
15	99	94	96	98	90	95.4	9
16	106	93	104	993	99	99	13
17	90	95	98	109	110	100.4	20
18	96	96	108	97	103	100	12
19	109	96	91	98	109	100.6	18
20	90	95	94	107	99	97	17
21	91	101	96	96	109	98.6	18
22	108	97	101	103	94	100.6	14
23	96	97	106	96	98	98.6	10
24	101	107	104	109	104	105	8
25	96	91	96	91	105	95.8	14

The table contains 25 subgroups of five observations each. N=5, K=25

The $\overline{x}$ chart is only valid **if the within-sample variability is constant and the** $\overline{x}$ chart **is examined to determine if the sample mean is also in statistical control.**

On the other hand, If the sample variability is *not* in statistical control, then the entire process is judged to be not in statistical control regardless of what the $\overline{x}$ chart indicates.

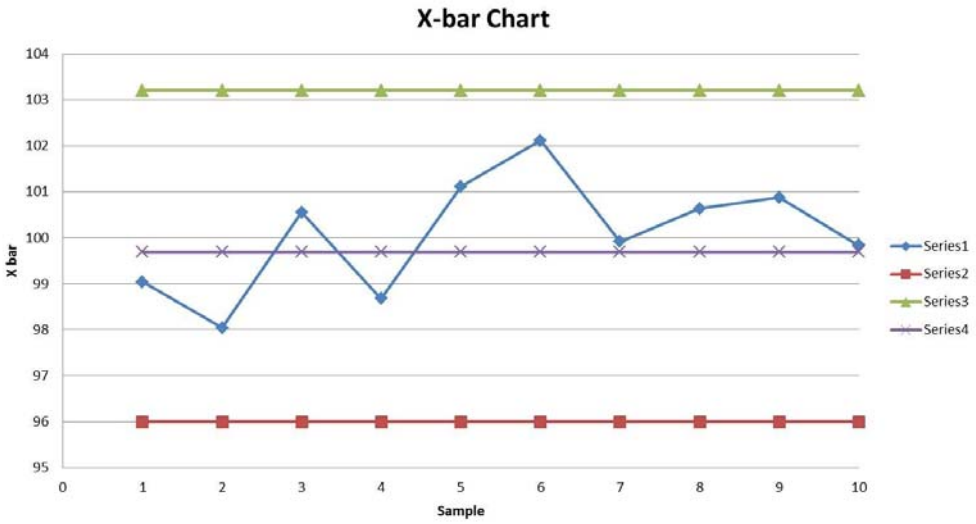

Figure 1. X-bar chart for 4 series

4. CONCLUSION

In the X-bar chart, the sample means are plotted in order to control the mean value of a variable (size of piston rings). Control limits for both the averages and the ranges charts should enable that a subgroup average or range from a stable process would not fall outside of the limits.

All control limits are set at plus and minus three standard deviations from the centre line of the chart. The control limits for subgroup averages and ranges are plus and minus three standard deviations of the mean from the grand average, and three standard deviations of the range from the average range, respectively.
It is used in conjunction with the X-bar chart when the process characteristic is a variable.

5. REFERENCES

[1] S. Kirin., "Statistical process control", Belgrade, 2014.
[2] J. A. Patterson, „Tools of Statistical Process Control", October, 2004
[3] ISO 9001*:2015 – Quality management system*