# Implementing SPC: Importance of Range chart

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When starting with SPC or six sigma, companies and especially operators tend to put too much emphasis on the average chart. In this article we will discuss 2 reasons why too much emphasis is put on the average chart and show how to increase emphasis on the range chart.

### *Relation between average and range chart*
One of the questions we often ask in our SPC class is :

If the chart shows out of controls on both charts like in the highlighted area where should the operator start in the out of control action plan. Look for the problem which is causing the out of controls on the range chart or look for the cause of the out of controls on the average chart ?
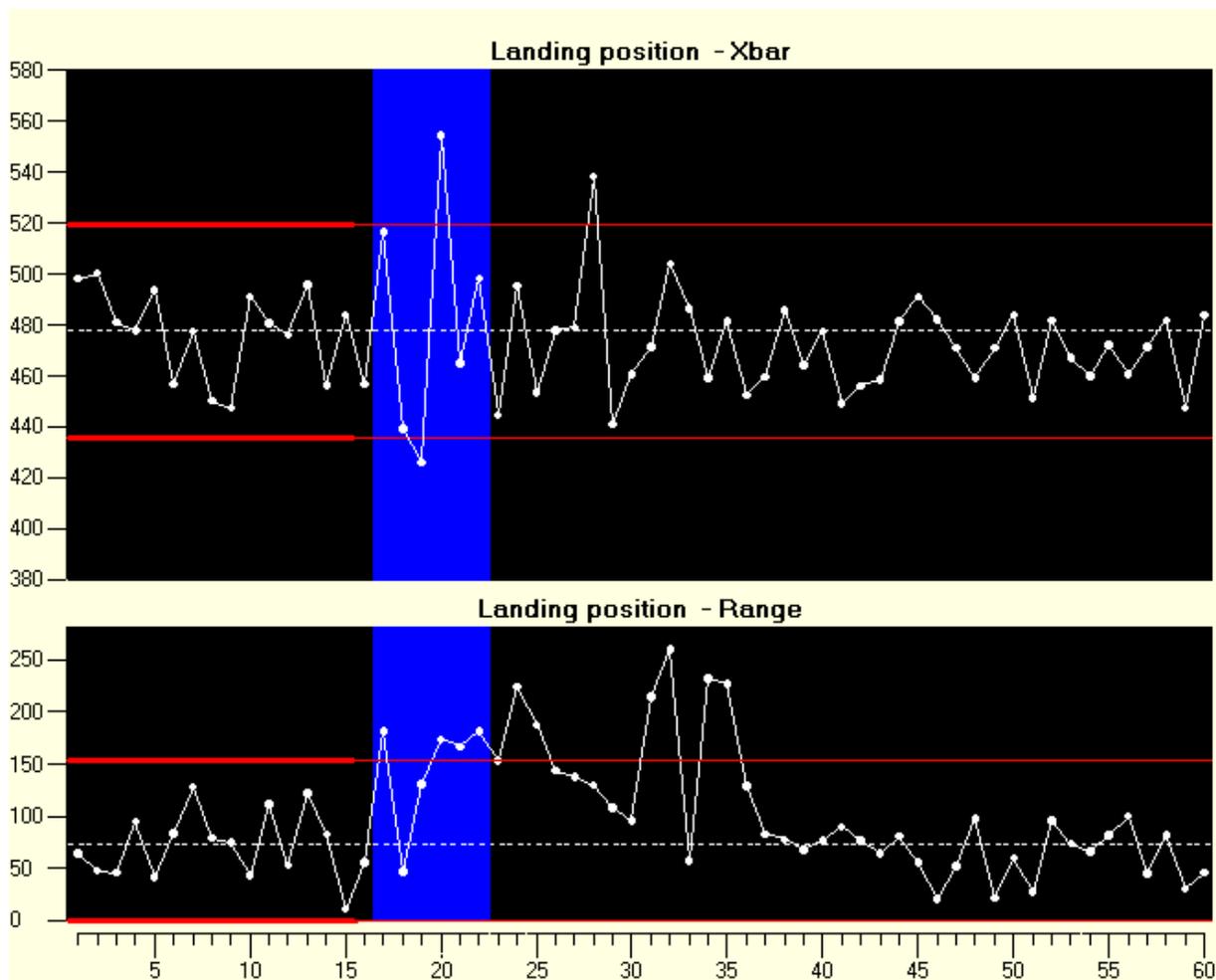


*Figure 1: Simulation from SPC Wizard*

Before we answer this question let us look at typical causes of out of controls on the average chart and typical causes of out of controls on the range chart. In these examples we assume that we have rational subgrouping of a process and that we are not combining multiple

parallel processes in one chart.

An out of control of the average chart is happening when the average of the process is shifting and the range of the process is the same. Typical causes are:

- Change of process settings (Eg rise of temperature)
- Change in setup of process (eg operator influence)
- Tool wear (for example drilling process)
- Wrong calibration of the gage
- Change of material

An out of control of the range chart is happening when some but not all of the measurements are different from what is normal for that process. Typical examples are:

- Incorrect measurement
- Contamination in the process
- Malfunctioning of the process

Erratic behavior of the average chart is always caused by variation in the process. This means that if the variation of the process increases – visible by out of controls on the range chart - then the variation of process average will automatically increase and will show as out of controls on the average chart. You will often see out of controls above the UCL and below the LCL in that case clearly indicating an increase in variation. So an important cause of out of controls on the average chart is an increase in variation of the process.

Note: In practice you likely will respond on the first out of controls subgroup so the control chart will not show the large number of out of controls like presented in the simulation in figure 1.

When improving processes the first step is to remove special causes of out of controls which affect the variation of the process. If the variation of the process is in control then the average chart can be interpreted easier and we can work on removing special causes of variation influencing the average. So in general we can say the range chart is the most important chart and if we are able to reduce the number of out of controls on the range chart we have clearly improved our processes.

During training it should be clearly explained that if both average and range chart show signs of out of control the operator should only react on the out of control of the range chart .

### *Relation between within subgroup variation and between subgroup variation*

The better SPC literature for example Advanced topics in Statistical Process Control of Donald Wheeler put much emphasis on rational subgrouping. This means products should be taken from a process with a minimum amount of variation within the subgroup. In practice that is not always possible (see whitepaper parallel processes and SPC).

Based on the within subgroup variation, control limits are calculated for both the range chart and the average chart. If the between subgroup variation is higher than the within subgroup variation that will clearly be visible as out of controls on the average chart.

In many cases the cause of the higher variation between subgroups is clear and it is

economically not feasible to remove these special causes of variation. For example if the outside temperature is influencing the average of our process it is economically not always possible to remove that factor.

Another example is that we take 2 consecutive measurements of a chemical concentration of a batch. In theory the measurements should be the same and we take 2 measurements to reduce the measurement variation. In this case the variation within the subgroup is measurement variation and the variation between subgroups is process variation.

If the variation between subgroups is higher than within subgroups it is recommended to calculate the control limits for the average chart not in the standard way but to calculate the limits based on the moving range of subgroup averages. This is also referred to in literature as the 3 way control chart. An average chart, a moving range of averages and a range chart.

In practice it often means the control limits on the average chart will be wider than with the standard calculation automatically putting more emphasis on the range chart. We strongly recommend to use this as the standard setting in DataLyzer to calculate control limits for the average chart.
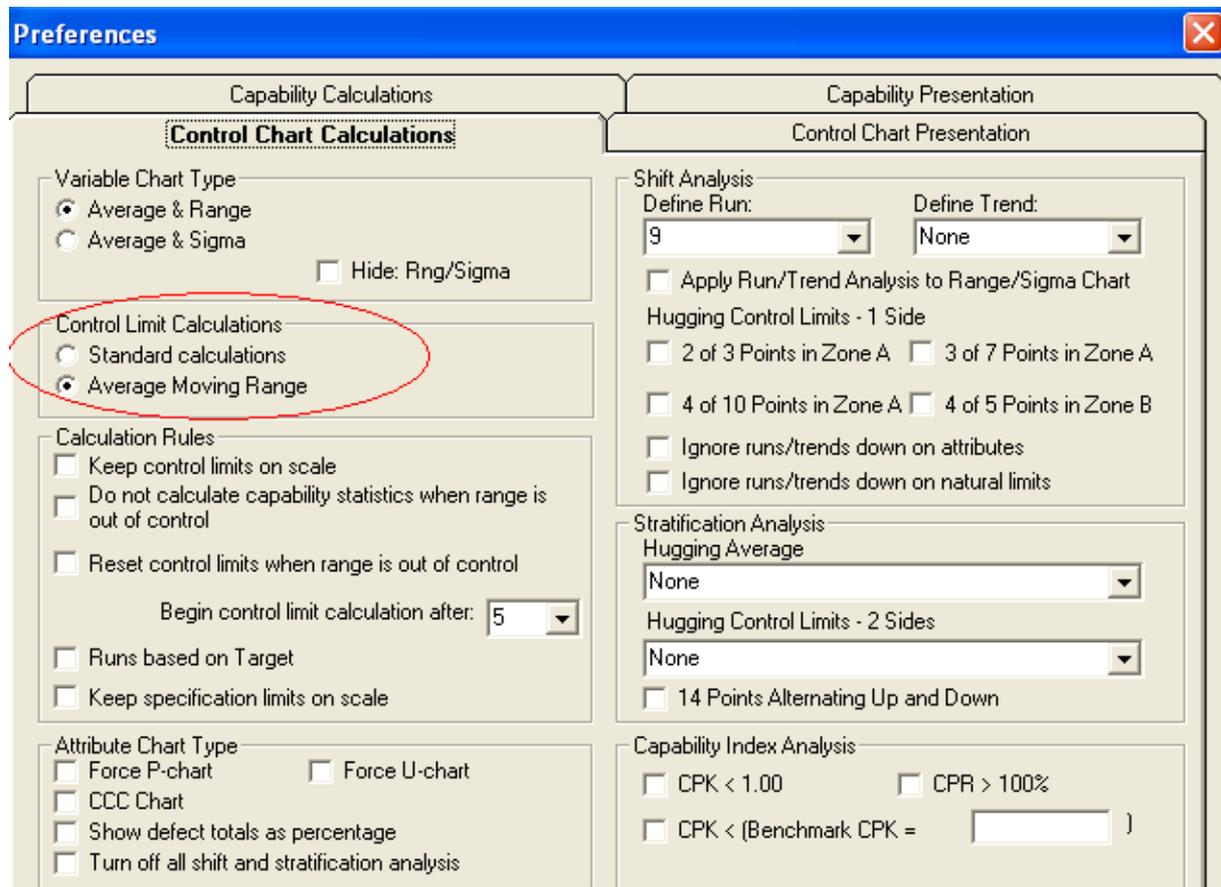


*Figure 2: Setup control limit calculation of the average chart*

*Manage the implementation process*

When starting with SPC we recommend to put more emphasis on the range chart than on the average chart. A way of doing that apart from the way the control limits are calculated or fixed (see also article about managing control limits) is by creating user defined reports where you report the percentage of out of controls of the range chart and focus the improvements in the early stages at reducing the out of controls of the range
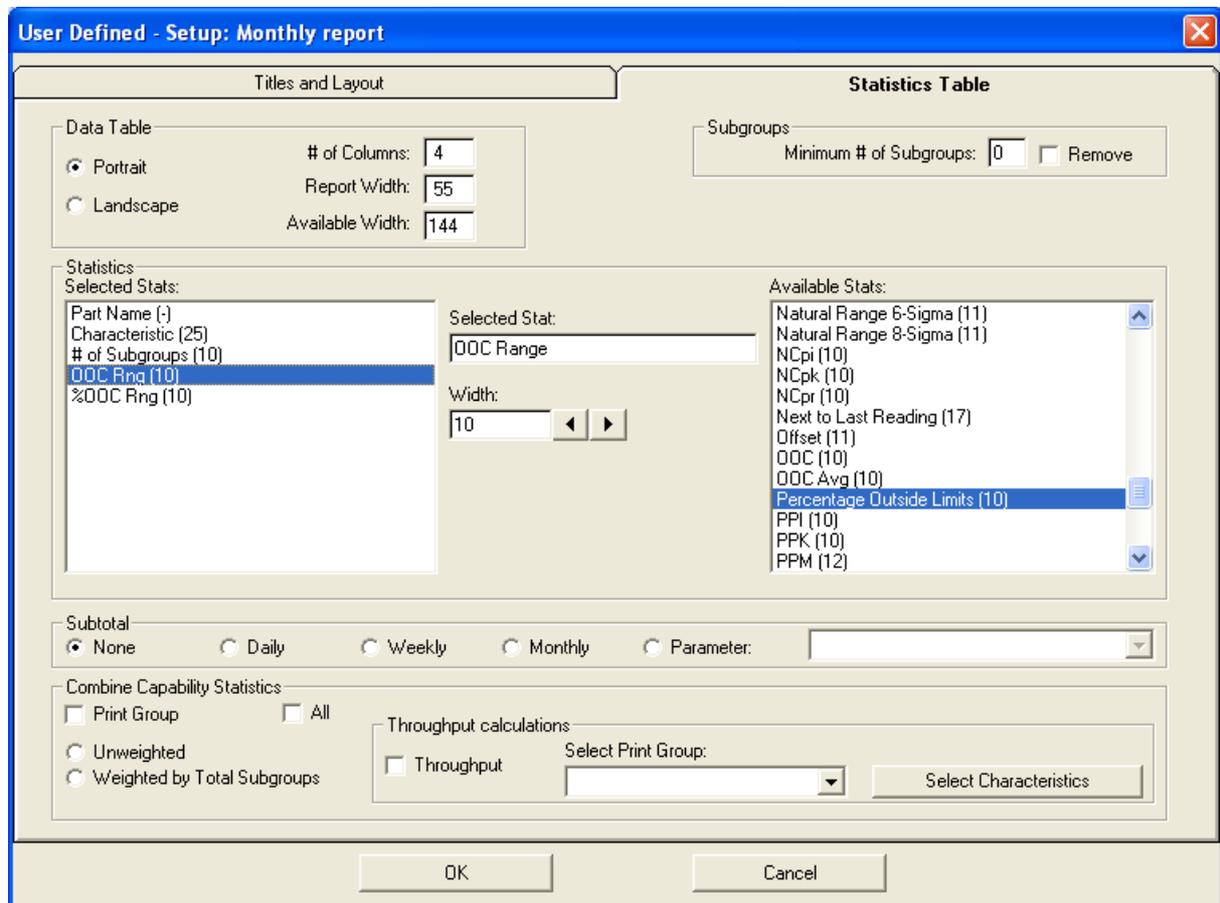


*Figure 3: Setup of out of control management report of the range charts*

**Final remark**

When starting with SPC or with automated SPC we often see companies start with a large number of control charts because it is not always clear what is really important to control and creating control chart is fairly easy with real-time SPC software. A big problem in that situation is how you can manage the large number of out of controls.

The recommendations in this article give the user some guidelines for this situation and the reader should be critical when and how to apply the recommendations.

For further information:

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