

Implementing SPC: Managing your control limits

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The problem of managing the number of out of controls during the implementation phase.

In theory control charts are used in the product and process development phase to analyze processes and when the process is in control for both the average and range chart the process can be released for use in production. In practice however SPC is often introduced in an existing production environment where not all processes are in control and fully capable. During implementation activities and responsibilities should be clearly established.

In the first loop (control loop) the operator will take subgroups and needs to address out of controls of the process following an out of control action plan. When the operator is not capable of handling the out of control in the first loop or preventive action is required the second level should be activated (improvement loop). In this loop responsible production management or engineering takes appropriate actions to avoid reoccurrence of the problem.

In modern production systems there is not much overcapacity of operators and engineers so the time to work on out of control action plans and improvement activities as a result of out of controls is limited. This requires that clear priorities need to be set by management so operators, production management and engineers will address the right problems. This loop is called the planning loop.

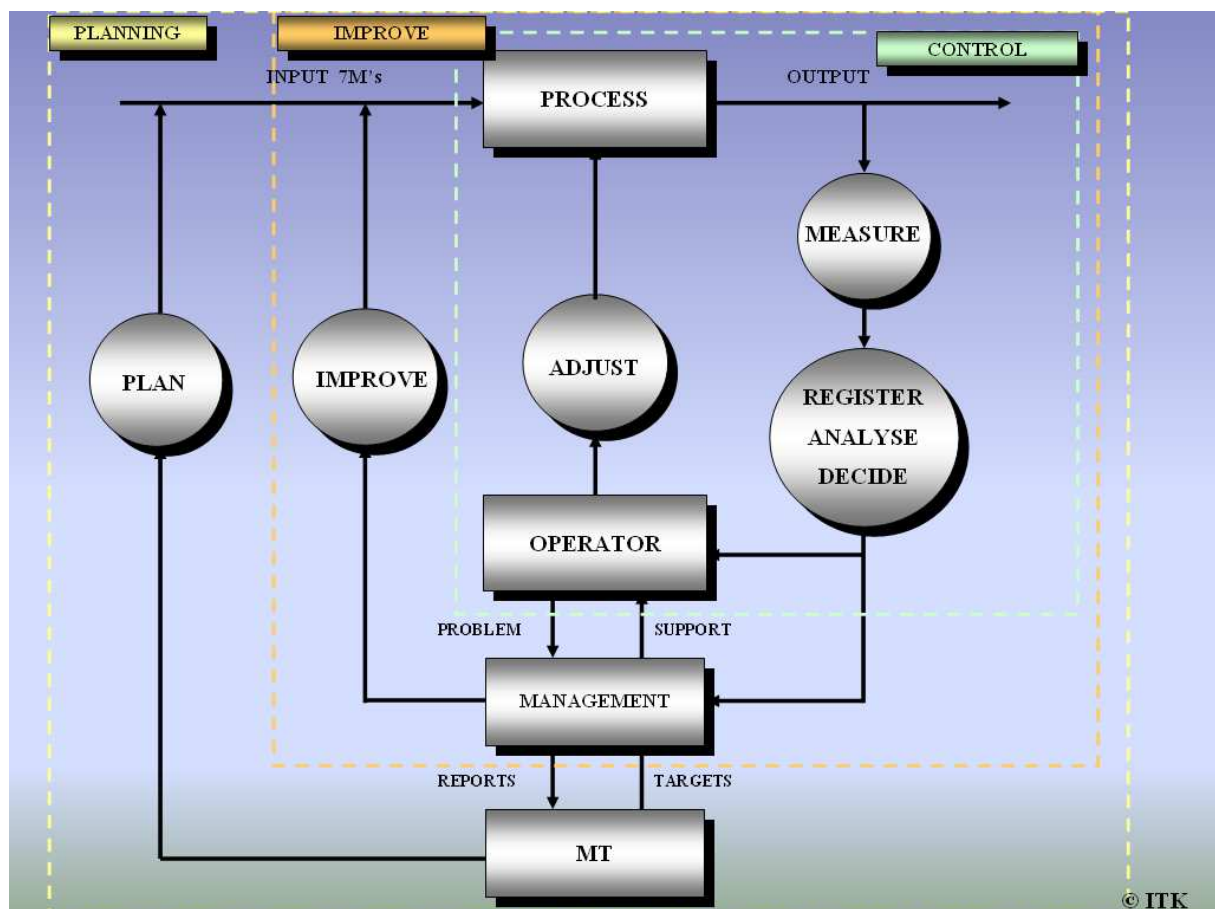


Figure 1: Organization of SPC

During the implementation of SPC or DataLyzer organizations have problems managing the amount of out of controls in the early stages. The large amount of out of controls are caused by several reasons:

- Processes are out of control. In the early stages of a SPC implementation control charts typically show a large percentage of the subgroups out of control. Examples of out of controls in the early stages are incorrect measurements and overadjustment of the process by operators.
- When SPC is introduced and data is entered in DataLyzer you often see a quick growth of the number of control charts. Control limits are calculated automatically and therefore every disturbance in the process will lead to an out of control signal.
- Characteristics are not classified in DataLyzer by the user so all control charts get the same priority while some charts are extremely important and other charts are only used as help for calculations and are of no importance at all. A typical classification in order of priority would be critical, key, major, significant, minor and no priority.
- In a lot of production environments the process average is unstable. Examples are toolware, setup differences, differences in raw material, machine warm-up or differences in a chemical bath over time. All these situations will show out of control points on the average chart and in not all situations it is possible or economically feasible to bring the process average in control. Instability of the process average will be visible by a large difference between C_p and P_p (e.g. $P_p/C_p > 1,25$).

What is even more important with the last cause is that the out of controls on the average chart will place the emphasis on the wrong chart. The most important chart is the dispersion chart and in general this chart should first be in control before attention should be given to the average chart.

There are two ways to address the problem of too many out of controls in the early stages:

1. Reduce the amount of control charts and only use charts for the few really critical quality characteristics.
2. Use control charts for all quality characteristics but widen the control limits of the average chart for non-critical quality characteristics

The advantage of the first option is that SPC will be used as it is intended. The disadvantage is that severe quality problem can appear on quality characteristics which are not monitored and that limited data is available for further analysis of the process and for reporting to customers and management.

The advantage of the second option is that all quality data is monitored and can be used for analysis and reporting. The disadvantage is that more effort and knowledge is required to manage the control charts and the calculation of the control limits.

In this article an approach for the second option will be presented which can be used to manage your control charts during the implementation phase.

Calculation of control limits during the implementation phase

In the start of an SPC implementation all efforts must be aimed at controlling the variation of the dispersion (range or sigma chart). When the dispersion of the process is out of control the

average of the process will likely also go out of control. This is caused because there is a relation between the variation in the dispersion and the variation of the average :

$$\sigma_{\bar{X}} = \frac{\sigma_X}{\sqrt{n}}$$

People should become aware that the dispersion chart is the most important chart and problems on this chart should be addressed first. When control limits on the average chart are calculated in the standard way, out of controls on the dispersion chart will also lead to out of controls on the average chart. These out of controls on the average chart are not an indication of changes in the process average but are a logical result of changes in the dispersion. When operators without proper knowledge of SPC will see out of controls on both average and dispersion chart they will likely start working on the “problem” on the average chart because problems on the average chart are easier to address: just adjust the process.

The way to avoid these problems is to start charting without putting the limits of the average chart at 3 “sigma”. During this phase there are 3 options:

- Don't use control limits for the average at all. Only show the target. This is sometimes called a run chart.
- Fix the limits at a level which will rarely lead to out of controls
- When the process average is unstable use modified control limits to minimize the actions but make sure that process averages which are abnormal are signaled.

When the Cp value is high enough the third method is preferred because the limits are still calculated based on the process variation and it will still give an early warning when a disturbance of the process average will lead to defective products.

How to calculate the modified control limits.

When the process average fluctuates we can allow a certain amount of fluctuation before we start looking for the cause as long as a required Cpk value is still achieved. We can set the control limits at a level that the Cpk is higher than a required value. In other words the distance between USL and the process average should be higher than $((\text{Required Cpk} * 3) \hat{\sigma})$.

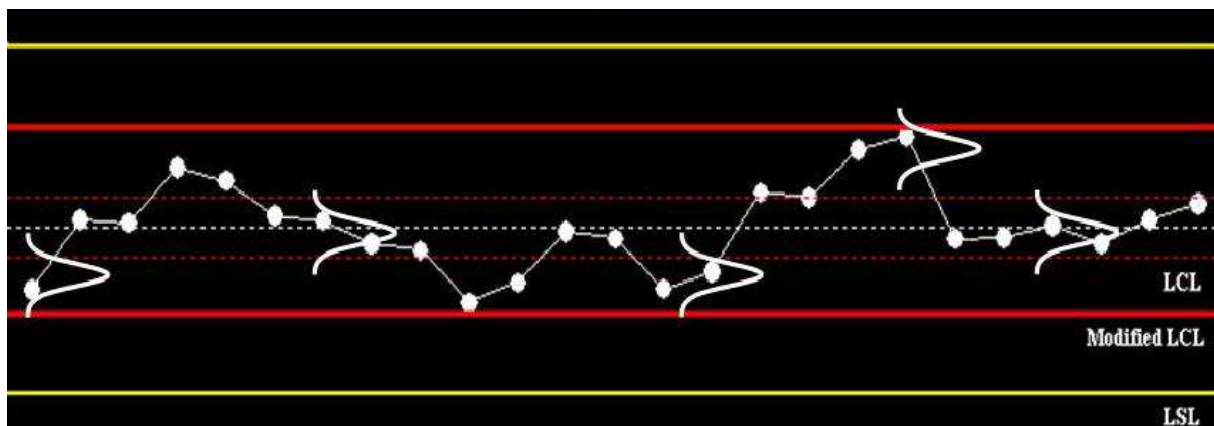


Figure 2: Example of modified control limits for the average chart

In figure 2 the dotted red line are the control limits calculated in the standard way. The red lines are the modified control limits based on a required Cpk value of 1,67. For the example we have shown the (yellow) specification limits. Normally we recommend not to show the specification limits.

The modified control limits can be calculated as follows:

The process average is allowed to shift to a level where the distance between the USL and the process average is (Required Cpk * $3\hat{\sigma}$). The distance between the average and the control

limit is $3 \frac{\hat{\sigma}}{\sqrt{n}}$.

This means the distance between USL and the modified upper control limit is

Required Cpk * $3\hat{\sigma} - 3 \frac{\hat{\sigma}}{\sqrt{n}}$ or $(\text{Required Cpk} * 3 - \frac{3}{\sqrt{n}}) \hat{\sigma}$.

The requirement for using this formula is that the Cp value of the process is higher than the required Cpk. If that is not the case the modified control limits will be too close to the process average resulting in false alarms.

The modified control limits can be calculated using SPC Wizard. When calculating modified control limits in SPC Wizard you can enter a required Cpk value and you will get a warning if the required Cpk value exceeds the Cp value. Based on these values the limits can be set in DataLyzer.

Final remark

The purpose of this document is certainly not to recommend to use modified control limits under all circumstances. If you want to find special causes of variation we recommend to calculate the control limits in the standard way used in DataLyzer. Modified control limits are only recommended as a method to distinguish between priorities of the different characteristics. It can also be used in processes with an unstable average which is not so easy to address.

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