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Partners in Continuous Improvement

SPC 4.0

Why you must deviate from 3 sigma limits

Plea for a new approach

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1 Introduction

Statistical Process Control (SPC) is a very powerful technique and mandatory in a lot of industries. The statistical rules of SPC were established by W.A. Shewhart in his revolutionary book: Economic Control of Quality of Manufactured Product back in 1931.

On page 276 he states: “The limits should be chosen so that the probability of looking for trouble when a subgroup falls outside the limits is economic”.

On page 277 he advises that based upon experience, 3 sigma limits seem to be an acceptable economic value.

Since then, every publication about SPC and every quality requirement manual refers to the use of 3 sigma limits to control quality.

In addition to the 3 sigma limits, additional rules have been defined over the years giving more indications that there is troublein the process. These rules are referred to as Western Electric rules and advanced Western Electric rules.

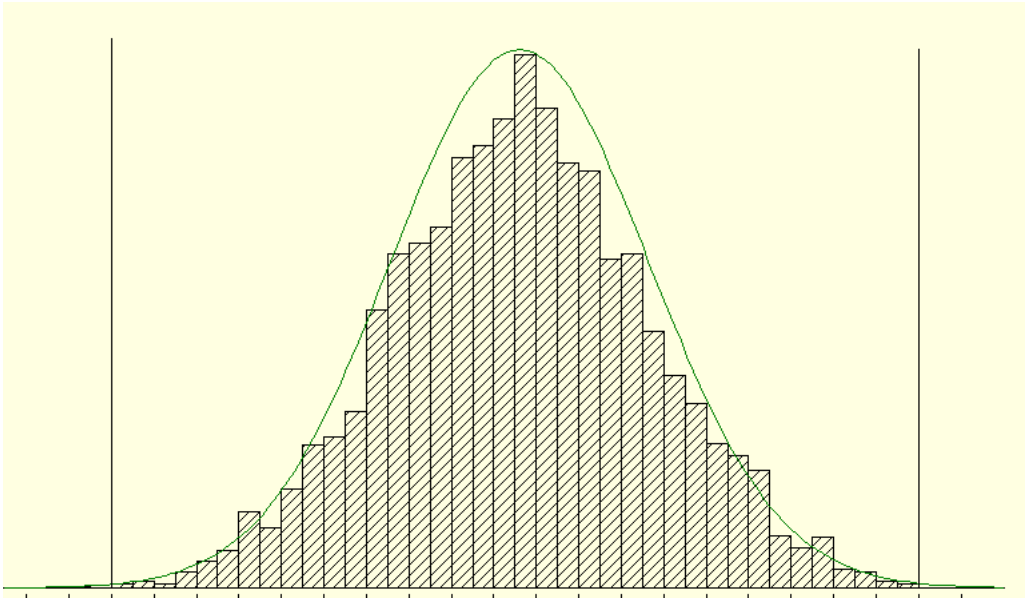
In this article, we will explain why 3 sigma limits and the advanced Western Electric rules should not be used automatically in an SPC application and why you should deviate from these standard rules.

2 Economic limits

The concept of economic limits is related to the distribution of measurements. If a process is perfectly in control and there are no special causes of variation, some values will fall outside the 3 sigma limits. In the figure below, we see data of a process simulation which is perfectly in control and we see that some measurements fall outside the 3 sigma limits. 99.7% will fall inside the 3 sigma limits so on average, 3 out of 1000 will be outside the limits when there is no assignable cause. We call this a false alarm or α-risk. Consequently, people will look for trouble when there is none. Because we have 2 charts in SPC in practice, it means that we will have a false alarm even more than 3 out of 1000. If we would apply all the advanced Western Electric rules, we would get a false alarm on the average chart every 40 subgroups (D. Wheeler).

The other side of the coin is that we might have a special cause of variation which we do not find because a measurement still falls inside the limits. How big this risk is, depends on the size of the disturbance and the subgroup size chosen. This risk is called the β-risk.

Walter Shewhart stated in 1931 that the 3-sigma limit was an acceptable compromise between the α-risk and β-risk.



What we must realize is that at that time, SPC was completely done with pen and paper. Subgroups were taken once per 30 minutes and typically only a few critical characteristics where chosen to apply SPC.

With that low frequency and low number of characteristics it makes a lot of sense to use 3 sigma limits to identify when to look for special causes of variation.

In manufacturing environments nowadays, we can easily monitor thousands of product and process characteristics with a very high frequency. We can even automatically apply SPC on all these characteristics without any effort. But in that case, we need to redefine what the economic limits are exactly, as described by Walter Shewhart.

Let's say we monitor 8 characteristics with a frequency of 1 minute per characteristic. If we only use a subgroup outside the control limits as an out of control and we ignore all other rules, we would get 10 false alarms on an average chart during a shift of 8 hours. That is not economic control of quality anymore.

So how should we approach this in real life?

3 DataLyzer solution

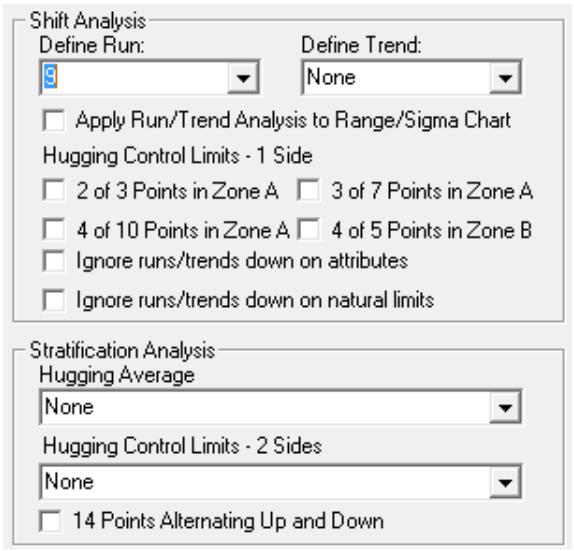
For SPC to be successful the number of out of controls can never be higher than the shop floor organization can handle. If the number of out of controls will be higher, then the out of controls will be ignored and the approach for quality improvement becomes subjective.

If we look at the SPC dashboard in a factory, green colors indicate that there is no problem. Other colors indicate out of controls which require action from somebody on the shop floor.

If a real production situation would show the picture above, it indicates SPC will never work and that you need to make changes to make the number of out of controls manageable.

In the DataLyzer SPC application there are several ways that we can reduce the out of controls:

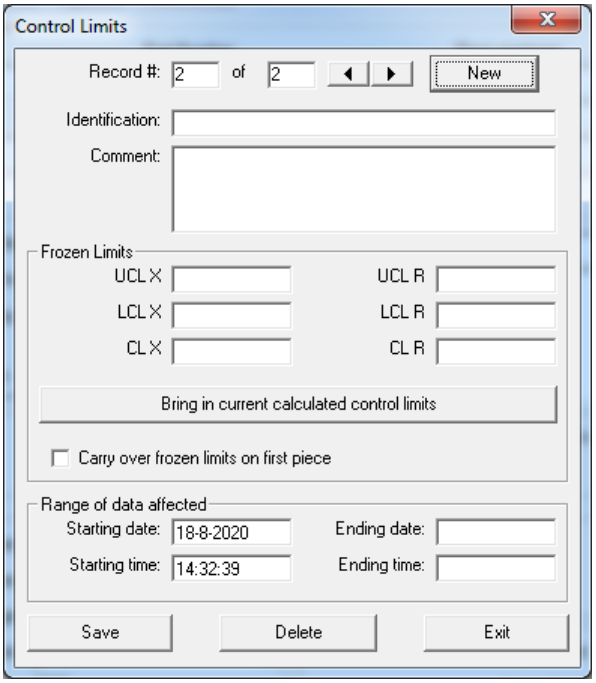
1. Do not apply Advanced Western Electric rules



Advanced Western Electric rules will give more false alarms so only apply these rules in case you have a critical quality characteristic. In all other cases, do not apply these rules. In DataLyzer Spectrum, these rules can be applied per characteristic.

2. Freeze the control limits wider than 3 sigma

If a characteristic is not really critical, you can set the control limits wider than 3 sigma. If you have a one sides specification limit for example a lower natural limit of 0 (flatness, perpendicularity, pollution etc.) then remove that control limit completely.

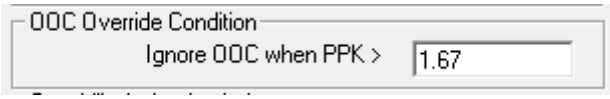


3. Use average moving range to calculate limits for the average chart

The standard rules define that control limits for the average chart will be calculated based on the within subgroup variation Most processes however are not completely stable and this will increase the number of alarms on the average chart. To avoid a large number of alarms, it makes sense to calculate the limits based upon the moving range of averages. That will reduce the number of alarms but still give you enough protection.

4. Ignore alarms incase Ppk is above a benchmark

Freezing the limits is powerful but it will require a lot of work. In many cases it may be easier to ignore an alarm if the Ppk is high.



So, for example, an out of control will not be shown to the operator or an email will not be sent if the Ppk is higher than a threshold value. Just to be clear we are not telling you that you should not apply 3 sigma limits anymore. You definitely should for critical characteristics where it is important to minimize trouble.

What we are emphasizing is that with the current high amount of control charts and the high frequency, we must be aware that we need to configure the system in such a way that the operator does not need to make the choice on which out of controls to work on and which out of controls to ignore. Operators don't always have all of the required information to make that decision and they don't always have the time to make that analysis.

4 Conclusion

For SPC to work in real time on the shop floor we must make sure that the number of out of controls is manageable by the operators and production support people. In this whitepaper we have given some recommendations to make this possible and we have implemented these recommendations in the DataLyzer SPC software.

Everything we recommended is in line with the writings of Walther Shewhart who already set the direction to apply SPC in an economic way.