

Advanced SPC

Power Notes

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Objective of this document :

Our firm is **IMPLEMENTING SPC related Projects** to deploy systematic process control techniques in various organizations. We also support to improve the **skill levels of the middle management** . This document will provide specific inputs towards this ! Best wishes !

Focus
point

Cpk vs Ppk : A close look

RATIONAL SUBGROUPS

A rational subgroup is a group of measurements produced under the same set of conditions. Subgroups are meant to represent a snapshot of your process. Therefore, the measurements that make up a subgroup should be taken from a similar point in time. For example, if you sample 5 items every hour, your subgroup size would be 5.

FORMULAS, DEFINITIONS, ETC.

The goal of capability analysis is to ensure that a process is capable of meeting customer specifications, and we use capability statistics such as Cpk and Ppk to make that assessment. If we look at the formulas for Cpk and Ppk for normal (distribution) process capability, we can see they are nearly identical:

$CPU = \frac{(USL - \mu)}{(3 * \sigma_{Within})}$	$PPU = \frac{(USL - \mu)}{3 * \sigma_{Overall}}$
$CPL = \frac{(\mu - LSL)}{(3 * \sigma_{Within})}$	$PPL = \frac{(\mu - LSL)}{3 * \sigma_{Overall}}$
$Cpk = \text{minimum}\{CPU, CPL\}$	$Ppk = \text{minimum}\{PPU, PPL\}$

The only difference lies in the denominator for the Upper and Lower statistics: Cpk is calculated using the WITHIN standard deviation, while Ppk uses the OVERALL standard deviation. Without boring you with the details surrounding the formulas for the standard deviations, think of the within standard deviation as the average of the subgroup standard deviations, while the overall standard deviation represents the variation of all the data. This means that:

Cpk:

- Only accounts for the variation WITHIN the subgroups
- Does not account for the shift and drift between subgroups
- Is sometimes referred to as the *potential* capability because it represents the potential your process has at producing parts within spec, presuming there is no variation between subgroups (i.e. over time)

Ppk:

- Accounts for the OVERALL variation of all measurements taken
- Theoretically includes both the variation within subgroups and also the shift and drift between them
- Is where you are at the end of the proverbial day

Sri Padhmam's views

- Cpk is about the "*Potentiality*" or "*Capability*" of the manufacturing process, which shall be treated as a Short term study (Cpk – C for Capability)
- Ppk is about the "*Performance*" of the manufacturing process, which shall be treated as a Long term study (Ppk – P for Performance)
- This is the approach of the Statisticians from United States, but there are other school of thoughts also present in the auto industry !



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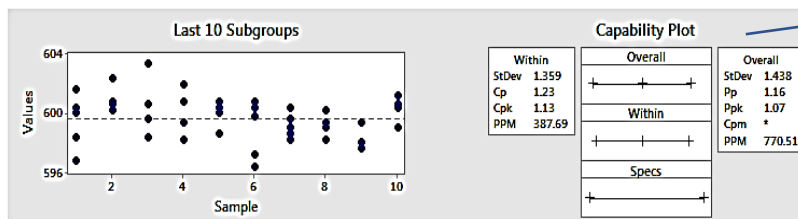
Focus point

Cpk vs Ppk : A close look (Continued...)

EXAMPLES OF THE DIFFERENCE BETWEEN CPK AND PPK

For illustration, let's consider a data set where 5 measurements were taken every day for 10 days.

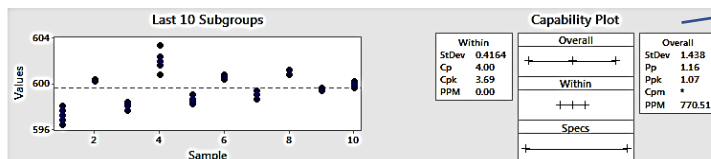
Example 1 - Similar Cpk and Ppk



Here, the Standard deviations & Cpk and Ppk results are closer, with minimal differences

As the graph on the left side shows, there is not a lot of shift and drift between subgroups compared to the variation within the subgroups themselves. Therefore, the within and overall standard deviations are similar, which means Cpk and Ppk are similar, too (at 1.13 and 1.07, respectively).

Example 2 - Different Cpk and Ppk



Here, the Standard deviations & Cpk and Ppk results are having significant differences – compared to the previous case

In this example, I used the same data and subgroup size, but I shifted the data around, moving it into different subgroups. (Of course we would never want to move data into different subgroups in practice – I've just done it here to illustrate a point.)

Since we used the same data, the overall standard deviation and Ppk did not change. But that's where the similarities end.

Look at the Cpk statistic. It's 3.69, which is much better than the 1.13 we got before. Looking at the subgroups plot, can you tell why Cpk increased? The graph shows that the points within each subgroup are much closer together than before. Earlier I mentioned that we can think of the within standard deviation as the average of the subgroup standard deviations. So less variability *within* each subgroup equals a smaller within standard deviation. And that gives us a higher Cpk.

TO PPK OR NOT TO PPK

And here is where the danger lies in only reporting Cpk and forgetting about Ppk like it's George Michael's lesser-known bandmate (no offense to whoever he may be). We can see from the examples above that Cpk only tells us part of the story, so the next time you examine process capability, consider both your Cpk and your Ppk. And if the process is stable with little variation over time, the two statistics should be about the same anyway.

Sri Padhmam's views

Note 1:

“Within” shall be interpreted as SSD is estimated through Range method.

“Overall” shall be interpreted as SSD is estimated through Summation method or Root-mean square method. (The term “Overall” is some times known as “Between” also)

Note 2:

It is worth mentioning here, that Japanese strongly advocate (support) Summation method only, as it considers ALL the observations, unlike the Range method.

Note 3:

The target for Ppk is generally 1.33 and Cpk is mostly 1.67, as per the above approach.

Source : MiniTab