Why is a stable process a prerequisite for calculating the Cpk?

On an American Society for Quality (ASQ) web site, a question was posted by a self-described "LSSBB" (Lean Six Sigma Black Belt) about calculating the process capability index (Cpk). He asked, "Why is a stable process a prerequisite for calculating the Cpk?"

The post led to several responses and most of them noted that if a process is not stable, it is not predictable. Therefore, one cannot predict what its capability might be for comparison to specification limits. I pitched in with the following post:

A stable process is a prerequisite for calculating capability because a process that's out of control is not a process. Deming wrote that "a process has a capability only if it is stable" (Out of the Crisis, p. 314). How can one determine the capability of a process that's not a process? How can one calculate a process capability index (Cpk) for a process that has no capability? Well, I suppose one can calculate a Cpk for an out-of-control process – but it won't be valid.

The LSSBB who started the discussion replied with some mighty convoluted reasoning. He made me question yet again the quality of six sigma training and ASQ's standards for awarding black belts.

> Fine, you are saying that processes must be stable before doing capability calculation. That means to start any improvement activity, one has to 1.) Make a run chart to see if the process is stable or not 2.) If stable, check data distribution - Normal / Non-normal to calculate process capability. If not stable, start identifying the causes of instability and eliminate the root causes.
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> If that is the case, then in DMAIC methodology, in measure phase, you do MSA and measure existing process capability. But to calculate the process capability one is making the process stable by eliminating special causes, thus doing improvement and hence one is starting working on "I - Improve" phase directly without "Analyze" phase in-between.

Where does one begin?...

Run charts are not used to determine if a process is stable, nor is a "Normal / Non-normal" check of the distribution. After all, the process may naturally produce a skewed, non-normal distribution, in which case the X-bar and R Charts will be the appropriate tools to see if the process is stable. The LSSBB was correct, however, to suggest that if the process is not stable one would have to apply root cause analysis to find, remove and prevent the reoccurrence of the special cause, thereby achieving stability.

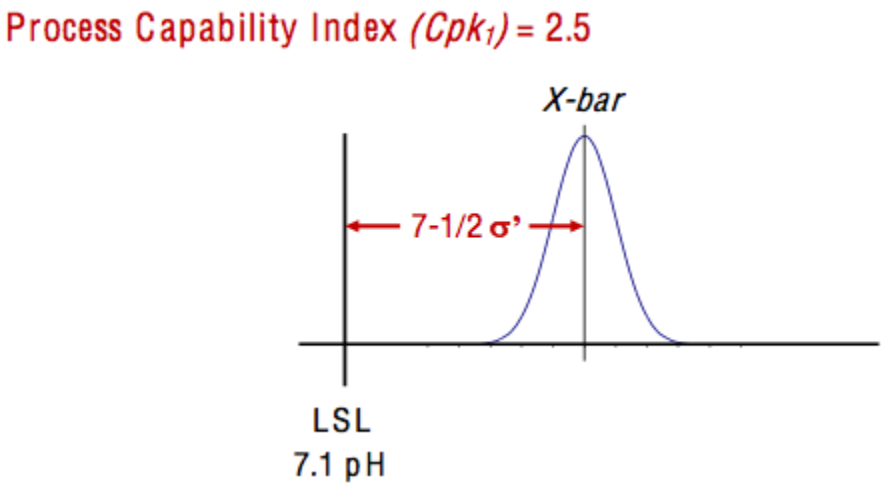
In the DMAIC (Define-Measure-Analyze-Improve-Control) methodology, however, you do not "do MSA" (measurement system analysis) to "measure existing process capability." You do it to determine if your measurement system is trustworthy. The LSSBB compounded his many errors by suggesting that the elimination of special causes is "doing improvement" without the "Analyze" phase.

The elimination of special cause variation does not improve a process. All it does is get the process back to where it should have been all along. Dr. Deming used to use a very simple analogy in his seminars. Deming noted, “If this building catches on fire, we must put out the fire. Putting out the fire does not improve the building. All it does is get the building back to where it should have been all along – no fires!”

In defense of the person who raised the original inquiry, he is not the first LSSBB to demonstrate a disturbing lack of knowledge about statistical methods, theory of variation and even the simple DMAIC rubric. I've encountered them all over the world. On one occasion, I had another LSSBB interrupt one of my seminars by declaring, “If you have a high Cpk the process doesn’t have to be stable because you won’t produce any defects.”

I tried to inform him that you calculate the Cpk based on the assumption of stability, but he kept declaring, “It doesn’t matter! It doesn’t matter!” Later I learned that he had led a Black Belt project and claimed to have brought a chemical batch process to a highly-capable state with a Cpk of 2.5. When I plotted the pH data from the batches, however, I discovered that the process was nowhere near in control; it was in a state of chaos!

The LSSBB had entered his measurements into his computer and it indicated that the Cpk was equal to 2.5. To provide this Cpk value, the software merely plucked the central line off the X-bar chart – completely ignoring that the chart was in a state of chaos. Next, the software plucked the central line off of the out-of-control R Chart and used both values in the calculation of the Cpk. The LSSBB’s Cpk of 2.5 translates into a situation where one would find seven-and-a-half standard deviations between the process average and the nearest spec limit.



How can that be, when 11 individual measurements fell right at the lower spec limit for pH? As Dr. Deming was fond of saying, there is no substitute for knowledge!

Histogram of the Original pH Measurements

$Cpk_l = 2.5?$ How Can That Be?