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The Process Performance Metric Ppk

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Below are some highlights of a discussion that I had recently with a young man about using Pp and Ppk for process performance assessment. Please recall that Pp is defined to be (USL - LSL)/6σ, where sigma is based on all the data. Pp^ is assumed to be an estimator of Pp, where the sample standard deviation (s) replaces sigma in the Pp formula. The young man felt that Pp^ might be useful and he offered up some thoughtful arguments that are worth considering.

The Pp^ metric includes both within subgroup (random cause) and between subgroup (special cause) variation in its sigma estimate. I pointed out that, if a process is unstable (i.e., experiences special cause variation), then it is unpredictable. Therefore, computing a metric like Pp^ seems to me to be of no practical value since it does not predict anything about future process performance.

He understood that Pp^ could not be used to predict the future performance of the process. Though, I don't think he knew why. So, I explained this was a very important point -- Pp^ is NOT an estimator of Pp because in order for an estimator (sample value) to predict the parameter (population value) the estimator must be a random variable. This means it has a distribution so we can say the population value lies between certain limits derived from the distribution of the random variable. The problem is that Pp^ is not a random variable. Pp^ has both special and random causes of its variation. Hence, it does not have a fixed random distribution. Therefore, Pp^ is not a random variable and cannot be used to predict Pp.

He argued that Pp could be used as a descriptive statistic for the past performance of the process. I told him that this was certainly true, but if I wanted to know how the process performed I would generate a control chart, frequency distribution with spec limits displayed, and the common measures

such as the mean, standard deviation, skewness, and kurtosis. I might even fit a curve to the observed data and use it to estimate the nonconformance rate and net sensitivity of the process.
One could compare Cp with Pp to get a measure of how unstable the process was. But a better approach, in my opinion, would be to compare the long-term sigma estimate with short-term sigma estimates. The F* test can be used to do this and confidence tables exist for this test [Cruthis, 1993].

He also argued that Pp^ could be used to predict the future performance of a uniformly drifting process. I explained that a process that was drifting uniformly was actually in dynamic control and told him to see Montgomery's example of the tool wear control chart [Montgomery, 2001]. So a uniformly drifting process is really in-control, just not in the classic Shewhart sense. Thus, using the appropriate data transformations Cp^ could be used to predict the performance of this process.

References:

Cruthis, E. N. and Rigdon, S. E. (1993). Comparing Two Estimates of Variance to Determine the Stability of a Process. Quality Engineering, Vol. 5, No. 1.
Montgomery, D. C. (2001). Introduction to Statistical Quality Control. 4 Ed., John Wiley and Sons, New York, NY.

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