

Measurement of Process Capability: Cp, Cpk, Pp, Ppk, Probability Plotting, and Six Sigma *

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Process capability and process performance index studies are to assess a process relative to specification criteria. Quantification of this measurement is often reported using units Cp, Cpk, Pp, and/or Ppk. Statisticians often challenge how well commonly used capability indices do this; however, the fact remains customers often request these indices when communicating with their suppliers. A customer might set process capability/performance targets then ask their suppliers for their level of conformance to these targets.

The equations for process capability/performance indices are basically very simple; however, they are very sensitive to the input value for standard deviation (s). Unfortunately there can be differences of opinion on how to determine standard deviation for a given situation. Some organizations consider Cp and Cpk are a measure of "short-term" capability, while Pp and Ppk are a measure of long-term capability; however, all organizations don't agree with this procedure. Motorola considers Cp and Cpk to be long-term. An internal or external process is considered to be Six Sigma if Cp is equal to or greater than 2.0 and Cpk is equal to or greater than 1.5. A process with these indices has a calculated defect rate of 3.4 parts per million. In addition, it should be noted that the traditional equations are for normally distributed data. Computer programs can often address situations where data are not from a normal distribution.

When using process indices to describe the quality of a process, we need keep in mind that this calculation quantifies the tails of a distribution and the uncertainty of the result from this calculation is typically very large. To illustrate how this can impact an organization, consider using reported process capability number(s) to choose the best supplier. Differences between reported numbers are not all attributable to process quality. Issues often not considered when comparing reported process indices is sample size, data normality, data outliers, and samples not being representative of future product. One supplier might report a very good process capability value using only five samples produced on one day, while another supplier of the same commodity might report a somewhat lesser process capability number using data from a longer period of time that more closely represents the process. If we were to only compare these two process index numbers when choosing a supplier, the best supplier might not be chosen.

It can sometimes be more meaningful when comparing and quantifying process capability to rely on a slightly different approach. With this approach, there is no need for specifications; hence, management can use this approach to describe their important business processes. In addition, this measurement approach can be an integral part of a process quantification and improvement program. This process measurement approach consists of two steps. First, a control chart identifies special cause problems for resolution. Secondly, a normal or Weibull probability plot of the common cause variability from the control chart describes the capability of the process as a picture.

Consider how difficult it is to physically picture the capability of a process that, for example, has reported Process Capability Index (Cp) = 1.6 and Process Capability Index (Cpk) = 1.1. A probability plot overcomes this confusion by describing the process in terms that are easy to understand (e.g. 80% of the time it takes 2 to 40 days to fill an order or it is estimated that specification limits are exceeded 2% of the time). With this tool, you can make definitive statements and pictorially describe the capability of a process. Specifications and normality are not required. Also, this analyses can detect outliers, address bimodal distributions, and consider more than one distribution for a process.

It often appears that organizations get so involved in trying to determine the capability of their process that they lose sight of an important issue -- identifying and implementing improvement opportunities. Measurements are useful to help baseline current processes; however, measurements alone don't improve anything.

Additional information and a roadmap for integrating measurements with process improvement activities can be found within *Implementing Six Sigma: Smarter Solutions using Statistical Methods*, Forrest W. Breyfogle III, John Wiley and Sons, New York, NY, 1999. The wise integration of process capability measurements and other Six Sigma tools is described within our training. Focus during the training is given to building effective implementation procedures that have bottom line results for the application situations described by attendees.

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