

# What is Process Capability?

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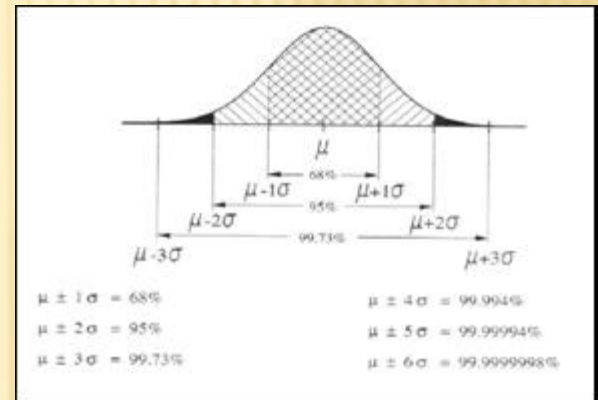
Process capability analysis is conducted to compare the tolerance of a given characteristic to its process spread of six standard deviations ( $\pm 3\sigma$  from the average). Consider the following numbers, which are based on 99% conformance of daily activities:

- 500 wrong drug prescription
- Unsafe drinking water for 15 minutes
- 2 plane crashes at each major airport
- 714 incorrect surgical procedure
- 480,000 lost articles (US Mail)
- 5,280,000 checks deducted from the wrong bank accounts

As can be seen, 99% conformance is unacceptable in such situations. Based on industry standard, capability indices CP and CPk must be at least 1.33, meaning that a normally distributed process must be centered on target (the nominal value) and not taking more than three quarters of the tolerance.

Customer requirements for critical characteristics can even extend to CP and CPk of 1.67 or even 2.0.

Six-Sigma programs are based on CP and CPk of 1.5 resulting in 3.4 failures per million (Six Sigma programs are actually based on  $\pm 4.5$  standard deviations).



Once the process is stable (in statistical control), process capability can be determined by calculating CP and CPk as follows:

$$CP = \frac{USL - LSL}{6\sigma}$$
$$CPk = \text{Min}\left(\frac{USL - \bar{X}}{3\sigma}, \frac{\bar{X} - LSL}{3\sigma}\right)$$

where  $\bar{X}$  is the process average,  $F$  is the standard deviation, USL is the upper specification limit, and LSL is the lower specification limit. From a control chart ( $\bar{X}$  & R), where  $\bar{R}$  is the average of the ranges from the control chart and  $d_2$  is a constant based on the sample size.

CPk takes into account the centering of the process. In other words, the process is exactly on target if CPk is equal to CP.

Example: A control chart based on sample sizes of  $n=5$  ( $d_2=2.326$ ) reveals that the process is stable over time. The process average  $=20.5$ , its standard deviation  $F=0.3$  and the specifications are  $20.0 \pm 1.0$ . Is the process capable and on target? Since the process is stable, capability analysis can be conducted. The tolerance (USL - LSL) = 2.0 and the process spread ( $6F$ ) = 2.4 so  $CP=1.11$  and  $CPk=0.55$ . This means that based on the standard of 1.33 the process is not capable and it is also off-target. If the process average can be adjusted to be on-target, the CPk would improve to 1.11 (CPk cannot be greater than CP).

Proportion out-of-specifications can also be estimated based on the normal distribution. For the above example, it can be predicted that, on the average, 4.75% will fall beyond the specification limits of 19.0 and 21.0, mostly above the upper side.