

Process Capability

Definitions

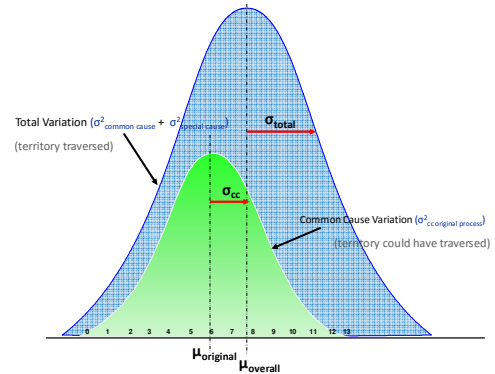
- **Process Capability** – What can it do?
- **Control Chart** – Is the process stable / predictable?
- **DOE** – (Design of Experiments) What is the full potential?
- C_p – Potential to meet tolerances w/ inherent variation?
- C_{pk} – Ability to meet tolerances accounting for location and inherent variation?
- C_{pm} – Relative COPQ for deviations from target with only inherent variation?

Recommendations

1. C_p – A first step / doesn't apply for one-sided specification
2. C_{pk} – OK indicator/ include confidence intervals
3. C_{pk} - Doesn't guarantee low defect rates
4. Increasing C_{pk} – Value depends on how
5. Stability - Accomplishing capability is meaningless without it
6. P_{pk} – Indicator of performance Ok but can be misleading
7. C_{pm} - Consider its use to maintain focus on true COPQ
8. Priority – Stability / Analysis & reduction of variation / CI

When to Use What

Application	DOE	Control Chart	C _p	C _{pk}	C _{pm}	P _{pk}	σ _{cc}	σ _{total}
Determine Stability		●					●	
Optimize Process	●						●	●
Determine Potential Capability			●				●	
Determine Capability				●			●	
Indicate Relative COPQ					●		●	
Indicate Performance to Tolerance						●		●



Formulas

- Potential Capability** $\hat{C}_p = \frac{USL - LSL}{6\hat{\sigma}_{cc}}$
- (Actual) Capability** $\hat{C}_{pk} = \min \left[\frac{USL - \hat{\mu}}{3\hat{\sigma}_{cc}}, \frac{\hat{\mu} - LSL}{3\hat{\sigma}_{cc}} \right]$

($\hat{\sigma}_{cc}$ = estimated standard deviation due to **common cause** variation = \bar{R} / d_2 or $\sigma = \hat{s}_{cc} / c_4$)

- Taguchi Capability** $C_{pm} = \frac{(USL - LSL)}{6 * \hat{\sigma}_{Cpm}}$

$$(\hat{\sigma}_{Cpm} = \sqrt{\frac{\sum_{i=1}^n (x_i - T)^2}{n - 1}} \quad T = \text{target})$$

Alternative formulas

$$C_{pm} = \frac{USL - LSL}{6 \sqrt{\sigma^2 + (\mu - \text{Target})^2}}$$

$$\hat{C}_{pm} = \frac{\hat{C}_p}{\sqrt{1 + \left(\frac{\hat{\mu} - T}{\hat{\sigma}}\right)^2}}$$

- Process Performance** $\hat{P}_{pk} = \min \left[\frac{USL - \hat{\mu}}{3 * \hat{\sigma}_{total}}, \frac{\hat{\mu} - LSL}{3 * \hat{\sigma}_{total}} \right]$

($\hat{\sigma}_{total}$ = estimated standard deviation due to **common + special cause** variation = $\sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \mu)^2}$)