LEANOhio

Transforming the Public Sector

Green Belt

Process Capability

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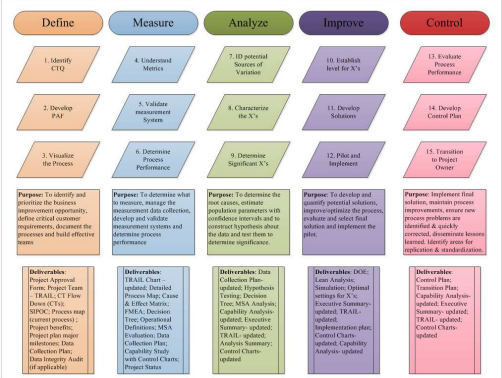
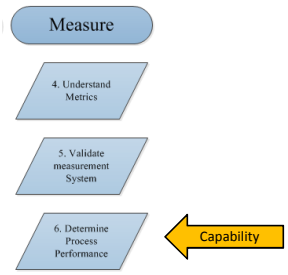


DMAIC Flow

- Measure:
  - Understand Metrics
  - Validate Measurement System
  - Determine Process Performance



Why Care About Process Capability?

- How capable is the process?
- How close are we to meeting the desired state?
- Allows comparison from baseline to after process improvement
- Demonstrate Success!

Process Capability Study: Set-Up

- Process capability study assumes that you have a **stable process**
- Identify Specification Limits
- Capability improvements can be in terms of *decreased variation* or *improved centering*, but are **always relative to the spec limits**

Control Limits vs. Spec Limits

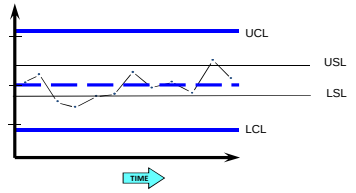
- Where do Control Limits come from?
  - The DATA: +/- 3σ (99.73% of the process variation is expected to fall between these limits)
- Where do Specification Limits come from?
  - The customer: spec limits are not found on control charts

Control Limits vs. Spec Limits

Upper Control Limits = UCL
Lower Control Limits = LCL

Upper Specification Limits = USL
Lower Specification Limits = LSL

Is The Process Below Making Defects ?



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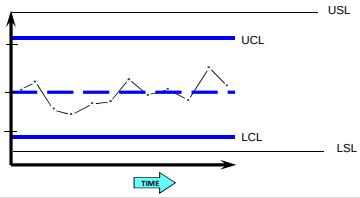

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Process Capability Study Steps

- **Four Basic Steps**
  1. Verify that the process is stable
  2. Verify that the distribution of the data is normal
  3. **Calculate capability indices and determine the level of quality**
  4. Recommend process improvements that increase process capability

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Before We Get Too Far Ahead

- Refresher on process stability
  - How do you know if you have a stable process?
- Refresher on data normality
  - How do you know if you have normal data?

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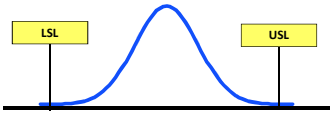
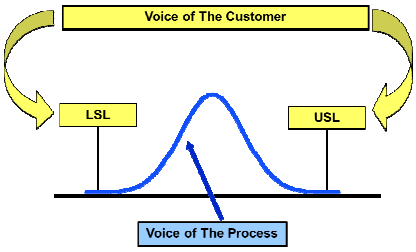
Process Capability Vs. Control

- Remember…
  - Process capability is relative to spec limits
  - Process control is relative to the outputs

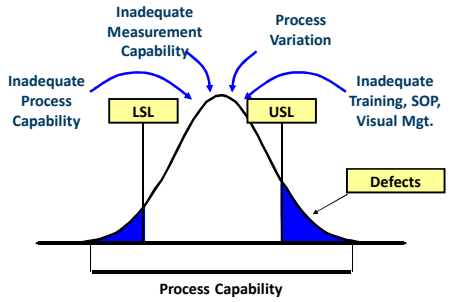
Spec limits are not the same as control limits



Process Capability Vs. Control



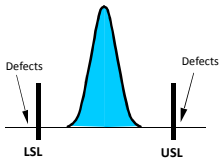
Dissecting Process Capability



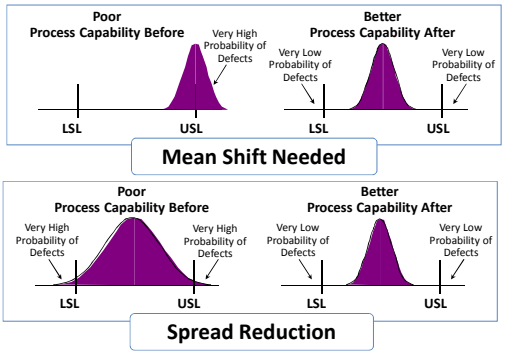
Process Capability - The Strategy

Centering – Put The Process On Target

Spread – Reduce The Variation



The Focus of Improvement



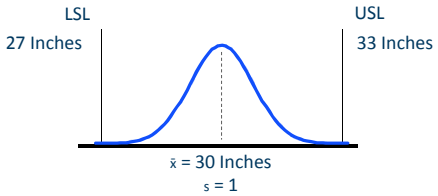
Process Capability Ratios

- **There are two key measures for short-term capability**
  - **Cp and Cpk**

$$C_p = \frac{|USL - LSL|}{6s} = \frac{\text{Total Tolerance}}{\text{Process Spread}}$$

$$C_{pk} = \text{Min}\left(\frac{\overline{X} - LSL}{3s}, \frac{USL - \overline{X}}{3s} \right)$$

Let's Calculate Cp!



Cp Answer

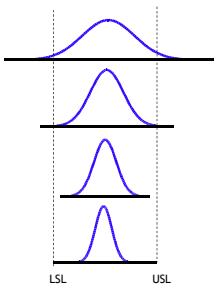
- Cp = (|33 - 27| / (6 x 1))
- Cp = 6 / 6
- **Cp = 1.0**

$$C_p = \frac{|USL - LSL|}{6s} = \frac{\text{Total Tolerance}}{\text{Process Spread}}$$

$$C_{pk} = \text{Min}\left(\frac{\overline{X} - LSL}{3s}, \frac{USL - \overline{X}}{3s} \right)$$

Interpretation of Cp

Cp	Interpretation
<1.0	Poor capability
1.0 – 1.5	Marginal capability
>1.5	Good capability
>2.0	6 Sigma capability



We've calculated Cp

- Q: So if Cp > 2 we are good to go?
- A: Not necessarily!... Remember the third mantra???

$$C_p = \frac{|USL - LSL|}{6s} = \frac{\text{Total Tolerance}}{\text{Process Spread}}$$

$$C_{pk} = \text{Min}\left(\frac{\overline{X} - LSL}{3s}, \frac{USL - \overline{X}}{3s} \right)$$

Shift Happens

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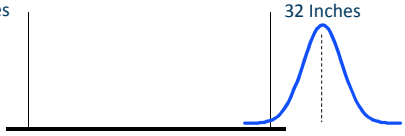
Let's Calculate Cpk!

LSL
28 Inches

USL
32 Inches



$\bar{x}$ = 33 Inches
s = .333

Cp = |USL – LSL|/6s
= 4/2
=2

Cpk Answer

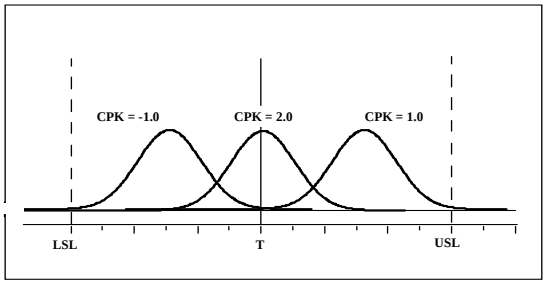
- Cpk = Min CpL or CpU

CpL = ((33 – 28) / 3 x .333)
CpL = (5 / .999)
CpL = 5

CpU = ((32 – 33) / 3 x .333)
CpU = (-1 / .999)
CpU = -1 so Cpk = -1

$$C_{pk} = \text{Min}\left(\frac{\bar{X} - LSL}{3s}, \frac{USL - \bar{X}}{3s}\right)$$

Three Processes with Cp = 2.0

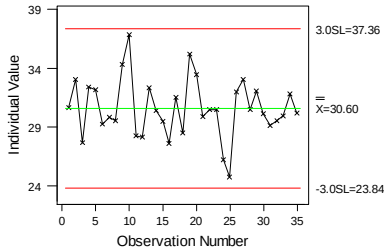


Short Term Capability

- A Short-term Capability study covers a relatively short period of time (Days, Weeks) generally consisting of 30 to 50 data points. The actual number depends on the subject under study.

Is The Process In Control ?

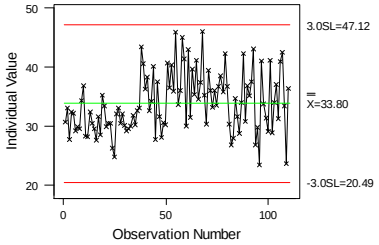
Is It Producing Defects ?



Long Term Capability: Pp and Ppk

Is The Process In Control ?

Is It Producing Defects ?



A Long-term capability study covers a relatively long period of time (Weeks, Months) generally consisting of 100-200 data points. Again, the actual amount depends on the subject under study.

A Further Look at Capability

- Compare the estimates of the process deviations from the short-term and long-term data

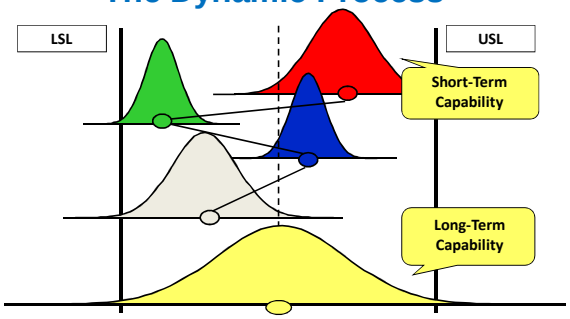
Descriptive Statistics

Variable	N	**Mean**	Median	**St Dev**
short term	35	**30.6**	30.4	**2.253**
long term	110	**33.8**	33.5	**4.438**

What is the difference between the Short-term and the Long-term Data?

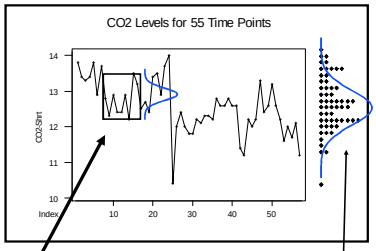
What Implication does this have in doing capability studies?

The Dynamic Process



Over time, a process tends to shift by approximately 1.5σ

Capability vs. Performance



Capability: Only random or short term variability

(Cp & Cpk)

Process Performance: Total Variation including shifts and drifts

(Pp & Ppk)

Calculating Pp and Ppk

- Minitab →
- Quality Tools →
- **Capability Analysis**

Minitab gives you Cp, Cpk, Pp, and Ppk all in one analysis

Interpret Pp the same way you would Cp

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Goal Setting

- Generic sequence of process improvement:
  - **Near-Term Goal:** Center the process
  - **Mid-Term Goal:** Reduce Variation
  - **Long-Term Goal:** Eliminate Random Variation

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Reminder!

- Capability studies require a stable process and normal data
- Without these two factors the results will be misleading
- What do you do if you don't have a stable process or normal data?

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Recap… What did we learn?

- Process Capability Vs. Process Control
- Calculating Cp and Cpk
- Long-term process performance matters
  - Shift Happens!

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Questions?

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