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# Process Capability

## Key Learning Points

1. Identify when to perform a process capability study.
2. Calculate the process capability of continuous data.
3. Explain the difference between long-term and short-term capability.

## What is Process Capability?

Process Capability is the performance of a process relative to customer specification limits. This measure is used to identify if a process is or is not meeting customer requirements.

Process Capability is usually expressed using the following measurements:

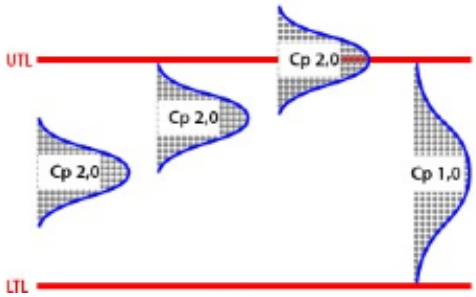
- Pp: Process Performance
- Ppk: Process Performance Index
- Cp: Process Capability
- Cpk: Process Capability Index
- Process yields and Sigma Level are related metrics.

### Cp (Capability Process)

The Cp index describes process capability if the process was centered. It is the number of times the spread of the process fits into the tolerance width. The higher the value of Cp, the better the process.

Example: if Cp = 2.5, the spread of the process fits 2½ times into the tolerance width, while Cp = 1 means that the spread is equal to the tolerance width.

Note that even if the spread is off-center, it is still the same size (Cp index). The figure takes no account of where the spread is positioned in relation to the upper and lower tolerance limits, but simply expresses the relationship between the width of the spread and the tolerance width.



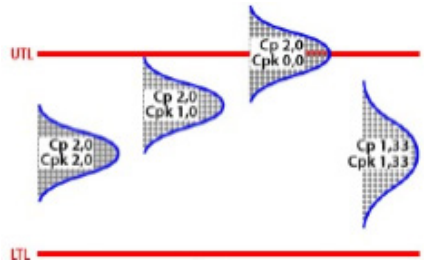

Source: http://www.statisticalprocesscontrol.info/glossary.html

## Cpk (Capability Process Index)

The ultimate process capability measure also considers the position of the process in relation to the tolerance limits. The Cpk index describes the process capability corrected for position. It is not much use having a high Cp index if the process setting is way off center in relation to the middle of the tolerance range.

A high Cpk index means, then, that you have a good process with a small spread in relation to the tolerance width, and also that it is well centered within that width. If Cpk is equal to Cp, the process is set to produce exactly in the middle of the tolerance range.

A normal requirement is that Cpk should be at least 1.33.

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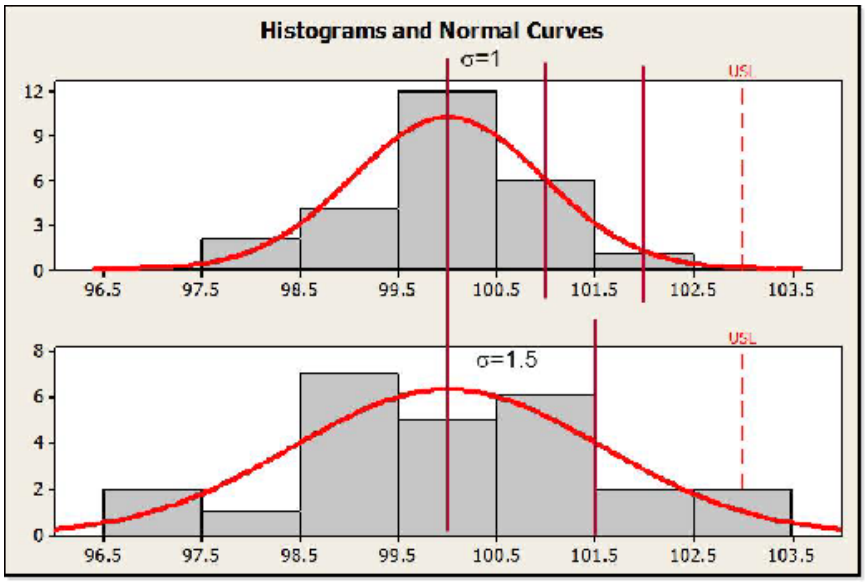
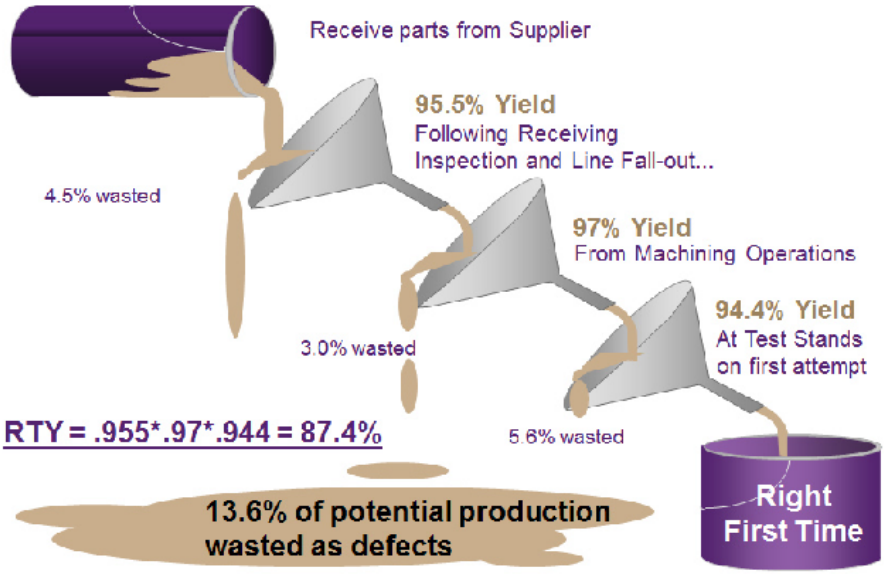
## Sigma Level and Standard Deviation




## Rolled Throughput Yield




## Why Study Process Capability?

Process Capability is the ability of a process to meet customer requirements or specifications.

Sigma level is the distance of the mean of a data distribution to a specification limit measured in Standard Deviations.

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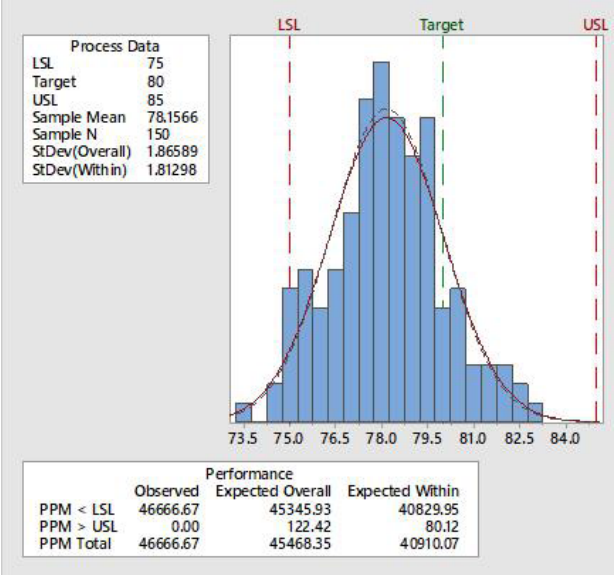
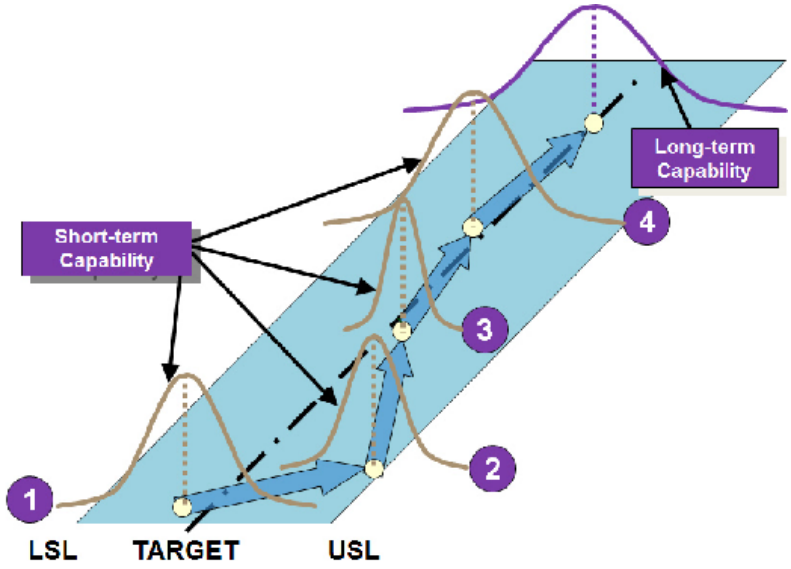



## When to Perform a Process Capability Study

A process capability study is performed in the Measure Phase of a DMAIC project to determine process performance after the data for your Y have been gathered.

The study will be repeated when you are improving the process, and finally again when the process is in statistical control.

## Long-Term vs. Short Term Capability



## Capability Indices and Sigma

**Short-term Capability Indices**

$$C_p = \frac{(USL - LSL)}{6 * s_{short-term}}$$

$$C_{pk} = \frac{Min\,(USL - \bar{x}, \bar{x} - LSL)}{3 * s_{short-term}}$$

**Long-term Capability Indices**

$$P_p = \frac{(USL - LSL)}{6 * s_{long-term}}$$

$$P_{pk} = \frac{Min\,(USL - \bar{x}, \bar{x} - LSL)}{3 * s_{long-term}}$$

| $C_{pk}$ | Adjusted Sigma level (σ) | Process yield | DPMO |
|---|---|---|---|
| 0.33 | 1 | 30.85% | 691462 |
| 0.67 | 2 | 69.15% | 308538 |
| 1 | 3 | 93.32% | 66807 |
| 1.33 | 4 | 99.38% | 6209 |
| 1.67 | 5 | 99.98% | 232.6 |
| 2 | 6 | 100.00% | 3.4 |

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**Long-term Capability Indices**

$$P_p = \frac{(USL - LSL)}{6 * s_{long-term}}$$

$$P_{pk} = \frac{Min\,(USL - \bar{x}, \bar{x} - LSL)}{3 * s_{long-term}}$$

$C_p$ and $P_p$ are Potential Process Capability measures that estimate what the process is capable of producing if the process mean were centered

$C_{pk}$ and $P_{pk}$ are Performance Process Capability measures given the process mean is not centered

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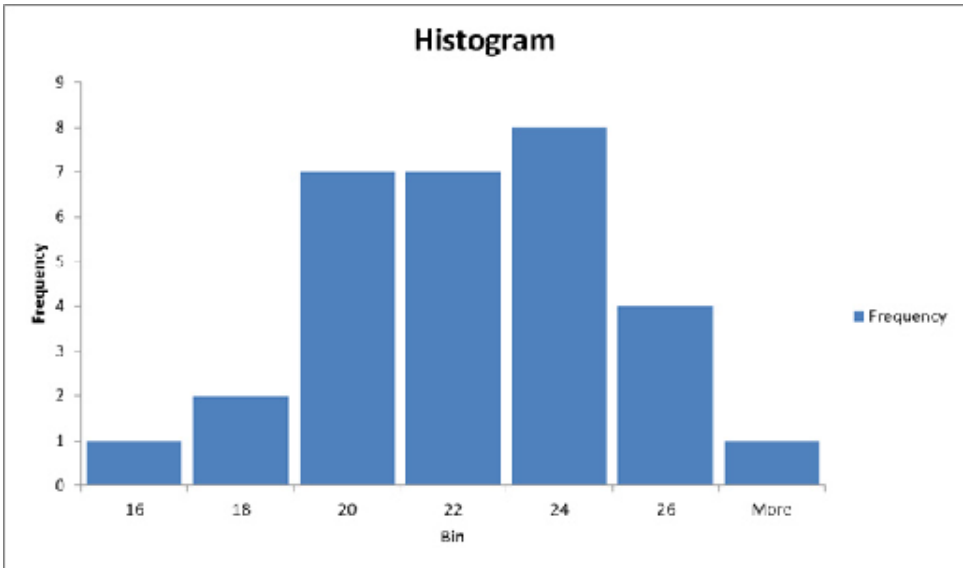
## How to Perform A Process Capability Study

1. Generate a histogram of the data to assess normality.
2. If data appear approximately normal, calculate the mean and standard deviation.
3. Determine the specification limit(s). This can be lower specification limit (LSL), upper specification limit (USL), or both.
4. Input the mean, standard deviation, and specification limits into the Sigma Calculation Tool.

## Example Process Capability Study

### Step 1: Generate a Histogram of the Data to Assess Normality

This example uses the sample data file Capability.xls.




### Step 2: If Data Appear Approximately Normal, Calculate the Mean and Standard Deviation

This example uses the sample data file Capability.xls.

**In the sample file:**

- mean = 21.128
- standard deviation = 2.723

**Formulas In Microsoft Excel:**

- mean: =average(range)
- st. dev: =stdev(range)

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### Step 3: Determine the Specification Limit(s). This Can Be LSL, USL, or Both

This example uses the sample data file Capability.xls.

In the sample file:

- LSL = 14.00
- USL = 30.00

### Step 4: Input the Mean, Standard Deviation, and Specification Limits into the Sigma Calculation Tool

This example uses the sample data file Capability.xls.

| | Enter Short-term Parameters |
|---|---|
| Xbar | 21.128 |
| S | 2.723 |
| USL | 30 |
| LSL | 14 |

| | |
|---|---|
| $Sigma_{st}$ | 2.58 |
| $C_{pk}$ | 0.87 |
| $C_U$ | 1.09 |
| $C_L$ | 0.87 |

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