Process Capability

Process Capability

Process

- **Consume Resources and Converts Input into Output**

Capability

- **is an ability to produce parts within Specific limit (tolerance) on a consistent basis**

Statistical measurement of a process's ability to produce parts within specified limits on a consistent basis, that is producing good parts.

Specification Limits and Control Limit

Specification Limit

- **Represent process variation and indicate when your process is in control, defined by USL (Upper Specification Limit) and LSL (Lower Specification Limit)**

Control Limit

- **UCL (Upper Control Limit) and LCL (Lower Control Limit) are based on random variation in the process.**

Specification Limit ≠ Control Limit

↓ ↓

Customer Requirement Process Variation

The Basic Concept

When the manufacturing process is being defined, **your goal is to ensure that the parts produced fall within the Upper and Lower Specification Limits** (USL, LSL). Process Capability measures how consistently a manufacturing process can produce parts within specifications.

The basic idea is very simple. You want your manufacturing process to:

(1) be centered over the Nominal desired by the design engineer, and

(2) with a spread narrower than the specification width.

The Basic Calculations

Before we get into the detailed statistical calculations, let's review the high-level steps:

1: **Plot the Data**: Record the measurement data, and plot this data on a run-chart and on a histogram.

2: **Calculate the Spec Width**: Plot the Upper Spec Limit (USL) and Lower Spec Limit (LSL) on the histogram, and calculate the Spec Width as shown below.

Spec Width = USL — LSL

3: **Calculate the Process Width**: Similarly, we will also calculate the Process Width. The simplest way to think about the process width is "the difference between the largest value and the smallest value this process could create".

Process Width = UCL — LCL

4: **Calculate Cp (Capability Index)** : Calculate the capability index as the ratio of the spec width to the process width.

Cp = Spec Width / Process Width

The Basic Calculations

Calculate Cp (Capability Index) : Calculate the capability index as the ratio of the spec width to the process width.

Cp = Spec Width / Process Width

Cp = USL - LSL / 6σ

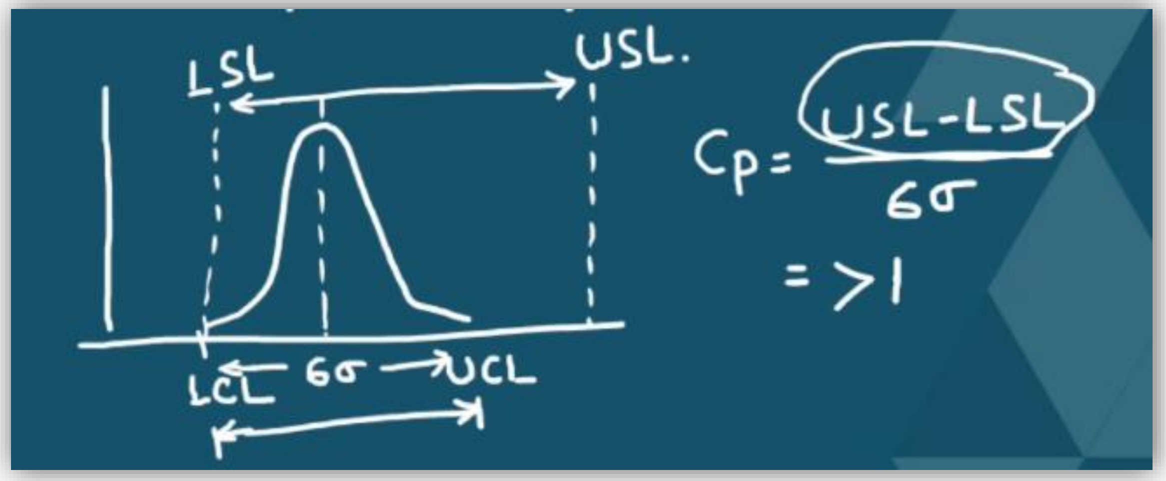
Process Capability, condition should be met:

- Sample to represent the population
- Normal distribution of Data
- The process must be in statistical control
- Sample size must be sufficient

The Basic Calculations

Calculate Cpk (Process performance) : is used to summarize how a process is running relative to it's specification limit.

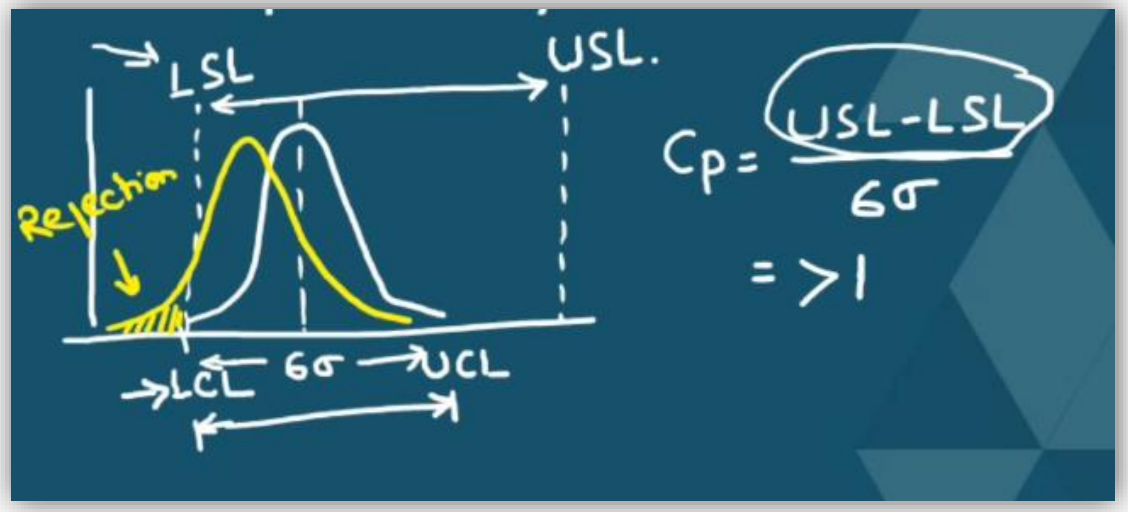
Why we need Cpk ? Let's see the example below:



Here LSL and LCL are just at the same point. Any fluctuation on the lower side would put this product out of Spec.

The Basic Calculations

Why we need Cpk ?

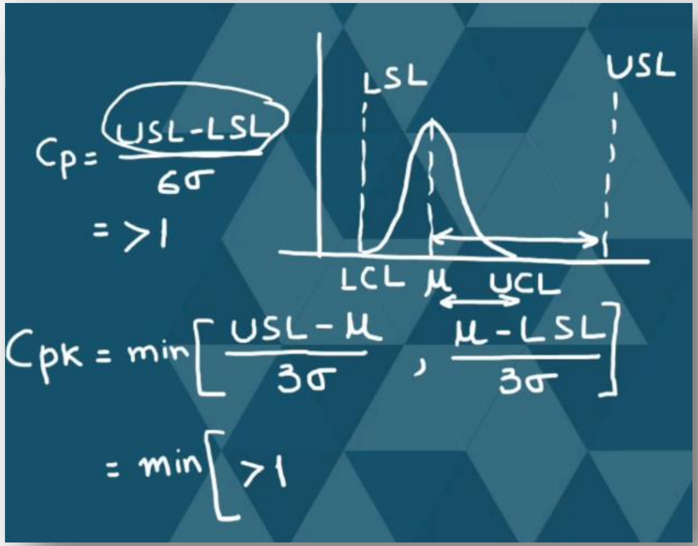


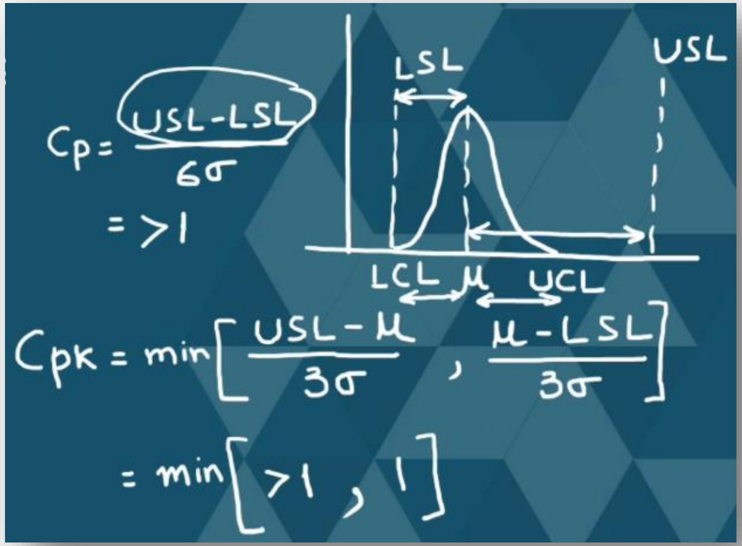
When the curve moves little bit to left over time then we get products rejected. **Cp doesn't tell you that.** So, to take care of that, we have another parameter, which is **Cpk**

The Basic Calculations

How to calculate **Cpk**?

$$Cpk = \min\left[\frac{USL-\mu}{3\sigma}, \frac{\mu-LSL}{3\sigma}\right]$$





$$Cpk = 1$$

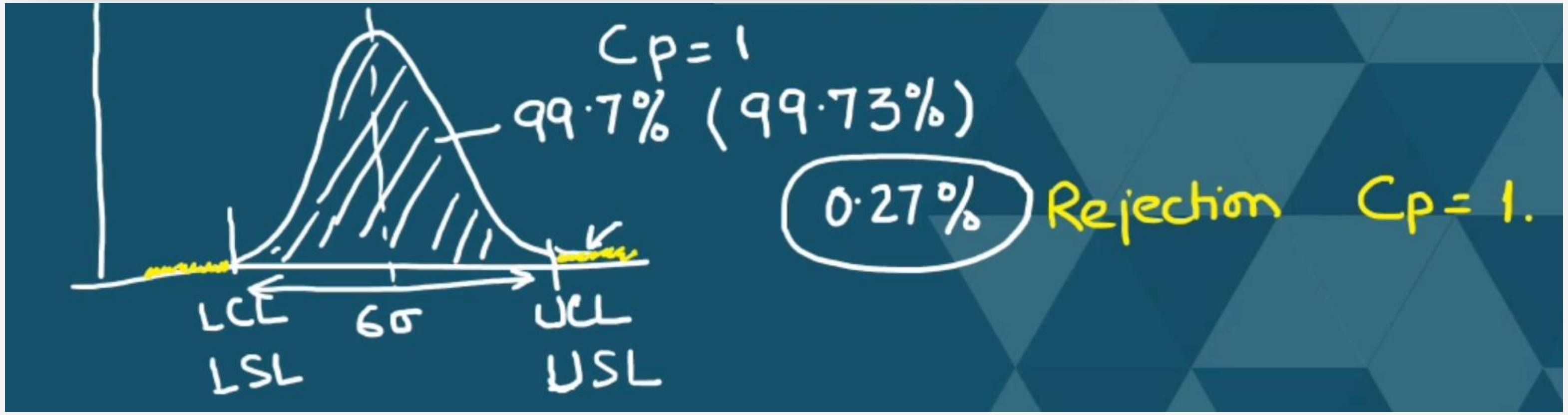
The Basic Calculations

How about in terms of Cpk ?

Cpk <1.00	(Poor, incapable)
1.00< **Cpk** <1.67	(Fair)
Cpk >1.67	(Excellent, Capable)
Cpk = 2 for a 6δ process	(i.e. a 6 sigma process)

Process Capability Vs Rejection

USL–LSL	6σ	8σ	10σ	12σ
Cp	1.00	1.33	1.66	2.00
Rejects	0.27 %	64 ppm	0.6 ppm	2 ppb



Process Capability Vs Rejection

USL–LSL	6σ	8σ	10σ	12σ
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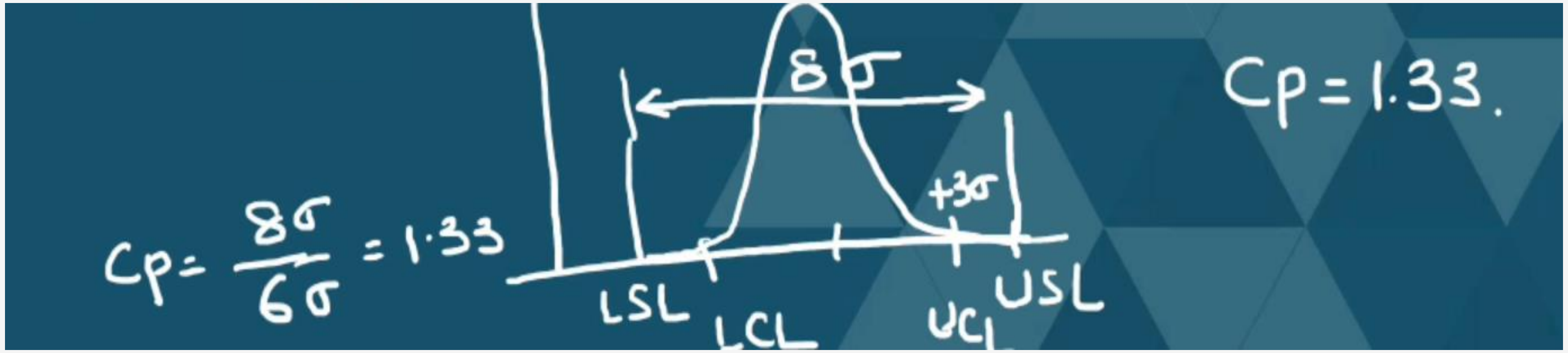

Process Capability Vs Rejection

USL–LSL	6σ	8σ	10σ	12σ
Cp	1.00	1.33	1.66	2.00
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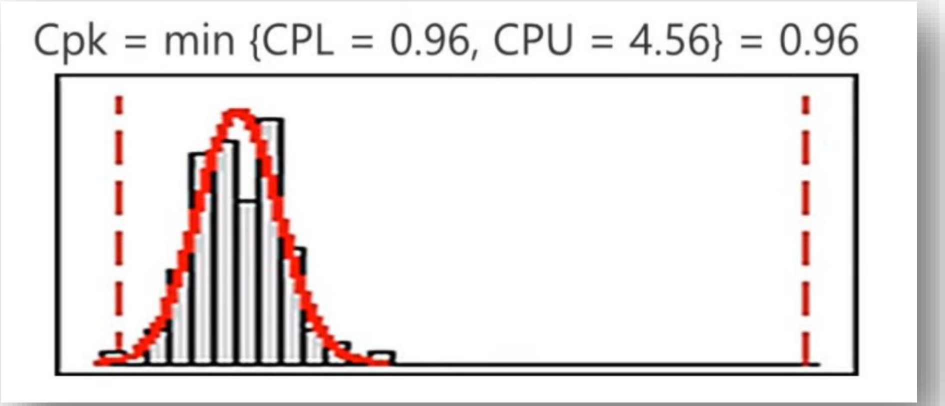
Cp vale increase

Rejection Rate decrease

Process Capability Vs Rejection

Cpk is preferred to Cp because it measure both process location and process standard deviation.



Cpl and Cpu is called One sided Process Potential

Process Capability Analysis Vs Process Performance Analysis

[Potential] Process Capability Analysis (Cp, Cpk):

A process capability study uses data from a sample to PREDICT the ability of a manufacturing process to produce parts conforming to specifications. This prediction enables us to "qualify" a new manufacturing process as being fit for use in production. The index Cp provides a measure of potential process capability i.e. how well a process can perform if there is no change in the underlying process conditions.

Cpk uses "s-short-term" to predict the behavior of the process.

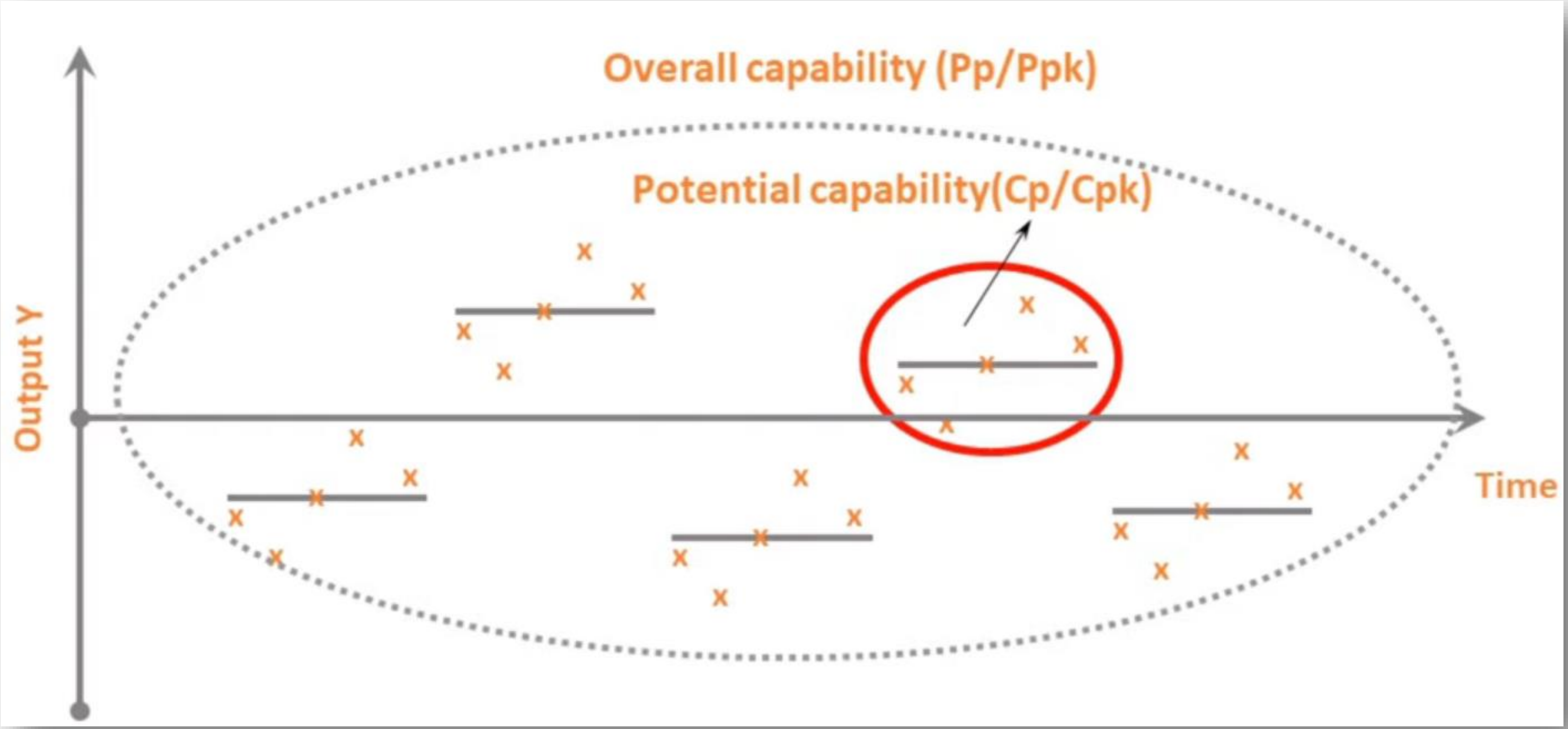
[Actual] Process Performance Analysis (Pp, Ppk):

A process performance study is used to EVALUATE a manufacturing process and answers the question: "how did the process actually perform over a period of time?" This is a historical analysis rather than a predictive analysis, but can still be used to drive process improvements.

Ppk uses "s-long-term" to evaluate the behavior of the process.

If the process is stable, Ppk = Cpk, i.e. the actual performance will match the predicted potential performance. However, if the process is unstable; i.e. if it shifts or drifts over time; you will find Ppk << Cpk.

Process Capability Analysis Vs Process Performance Analysis



Process Capability Analysis Vs Process Performance Analysis

C_p	=	$(USL - LSL) / (6\sigma_{within})$	
C_{PU}	=	$(USL - mean) / (3\sigma_{within})$	Potential Capability
C_{PL}	=	$(mean - LSL) / (3\sigma_{within})$	
C_{pk}	=	min {CPU, CPL}	
P_p	=	$(USL - LSL) / (6\sigma_{overall})$	
P_{PU}	=	$(USL - mean) / (3\sigma_{overall})$	Overall Capability
P_{PL}	=	$(mean - LSL) / (3\sigma_{overall})$	
P_{pk}	=	min {PPU, PPL}	

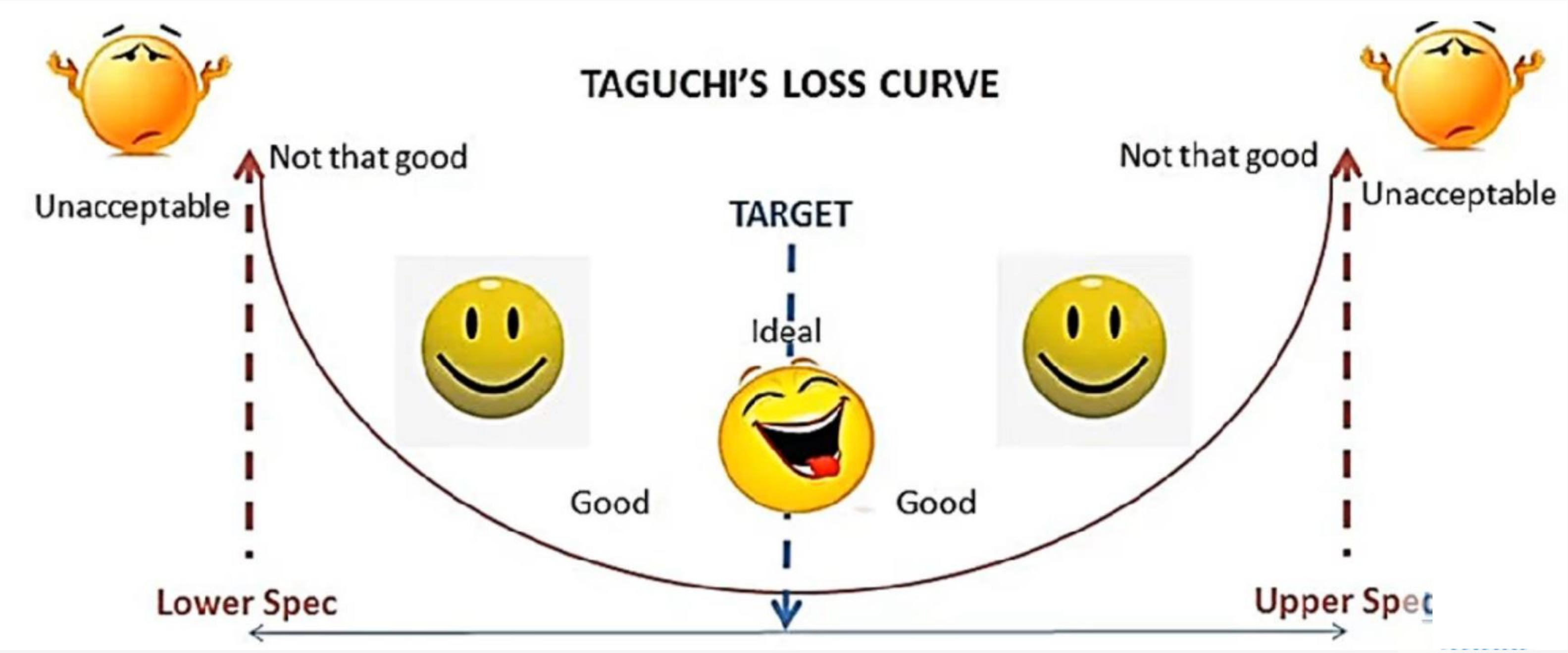
- Calculations for C_p and P_p are similar

Difference between Cpk & Ppk

Cpk is calculated using “within” standard deviation, while **Ppk** is using “overall” standard deviation.

The Basic Calculations

Cpm : focus on how well the process mean correspond to process target, which may or may not be in between spec. limit.



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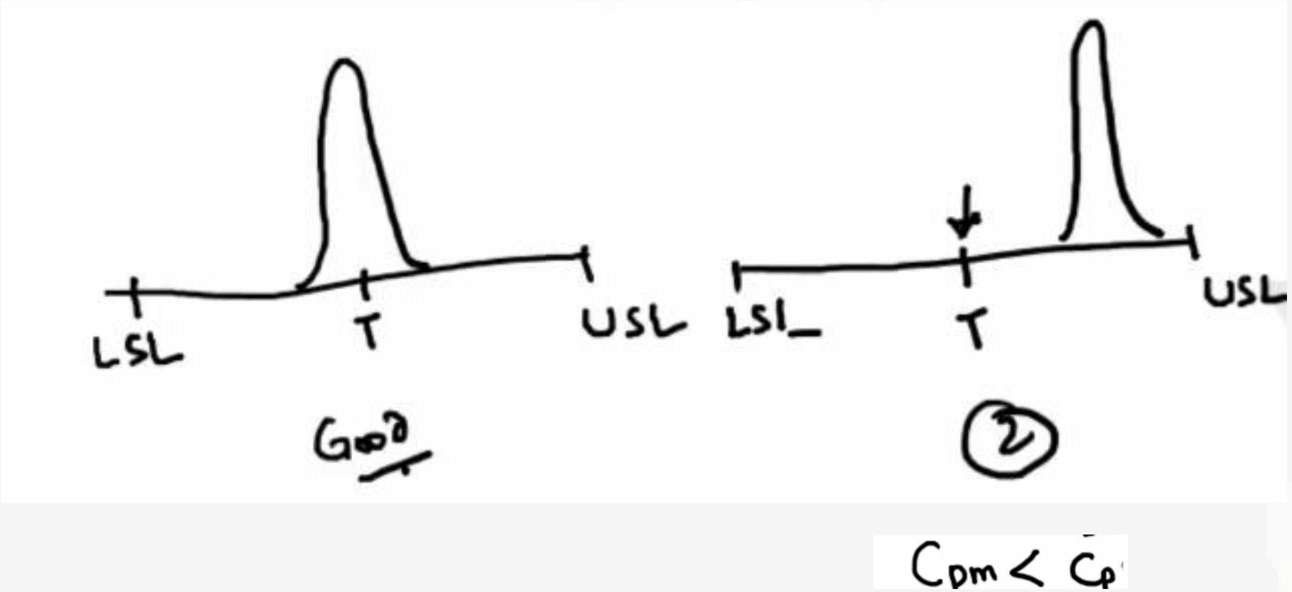
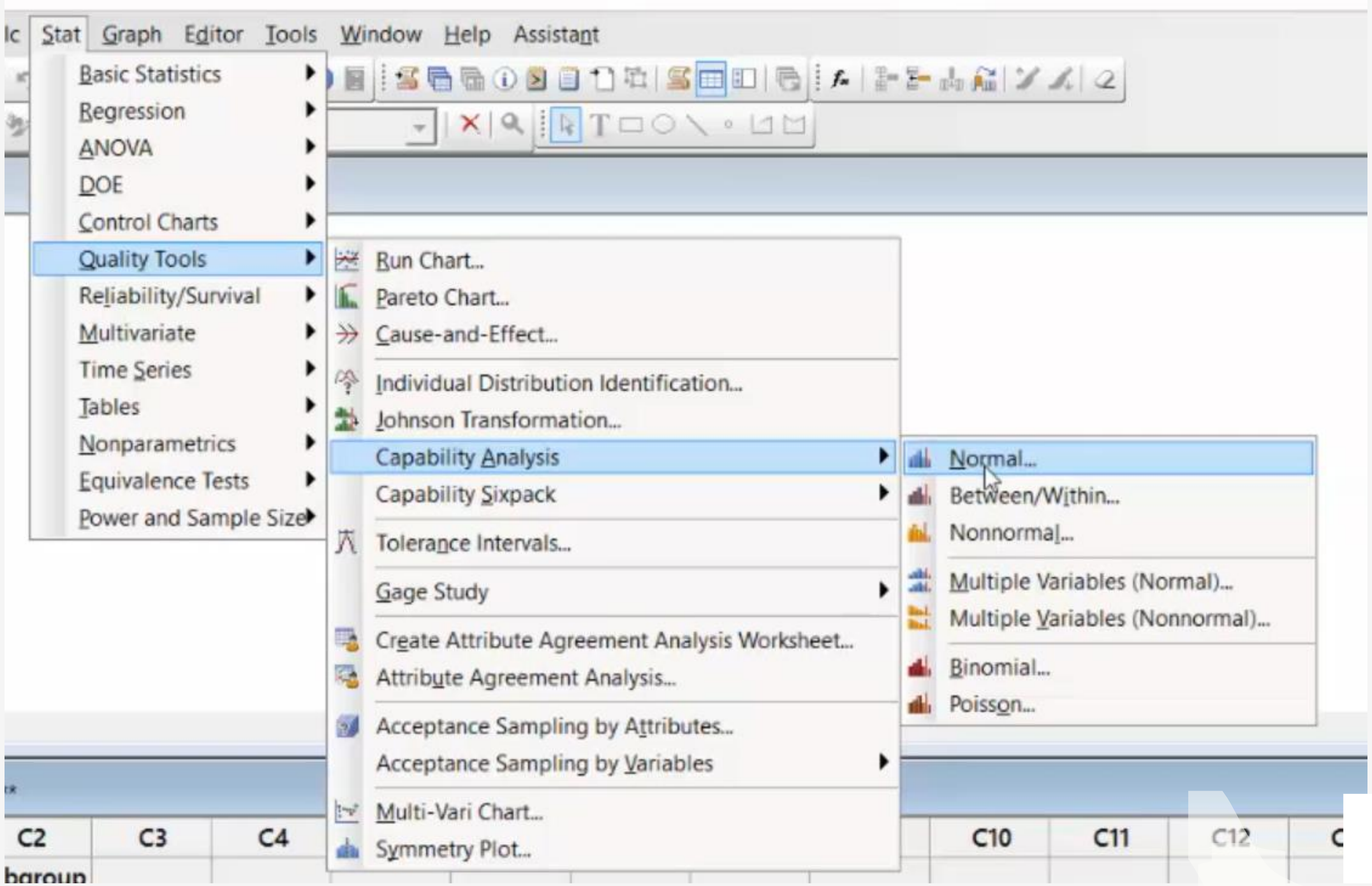


Minitab and Calculating Process Capability



Minitab and Calculating Process Capability