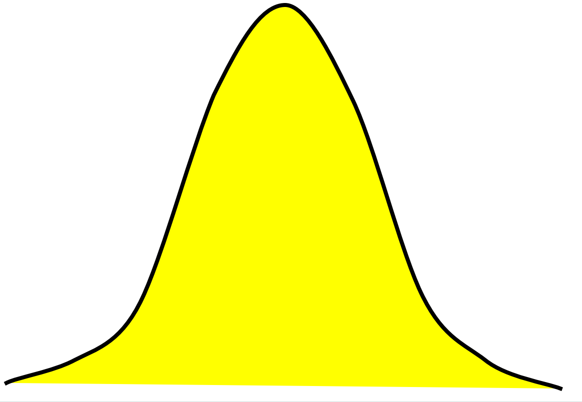
# Process capability



# OBIECTIVES

- Understanding the principle of process capability
- Providing an understanding meaning of capability indices Cp,Cpl, Cpu and Cpk
- Use of capability indicies in specofications.

# INTRODUCTION

- Bad news first

No two products, process, machines, operations or individuals are exactly alike

- Good news

Variation when measured overtime producepattern

→ Gausss curve

Understanding thr pattern of variations allowes us to predict future performance, and to manage the process.

# CONSEQUENCES of VARIATIONS

## High process variability compared to specification

- Process difficoult to manage.
- Non conforming productis produced randomly.
- Cost of rework, repair and scrap are high.
- No prdictions can be made.

## Low process variability compared to specification

- Non conforming product may be produced, but amount of that product is predictable.
- Production in specification is not by chance.
- Adjustment of process are minimized.

# WHY PROCESS VARIATIONS

INPUT → PROCESS → OUTPUT

| Influence criteria | | Influence criteria | | Succes criteria |
|---|---|---|---|---|
| **starting material** | **+** | **process parameter** | **=** | **CONSEQUENCE** |
| **Raw materials** | | **Procedures** | | **Product** |
| **Energie** | | **Adjustment** | | **Quality** |
| **Equipment** | | **Operation** | | **Cost** |
| **etc.** | | **etc.** | | **etc.** |

# Causes of variations ?

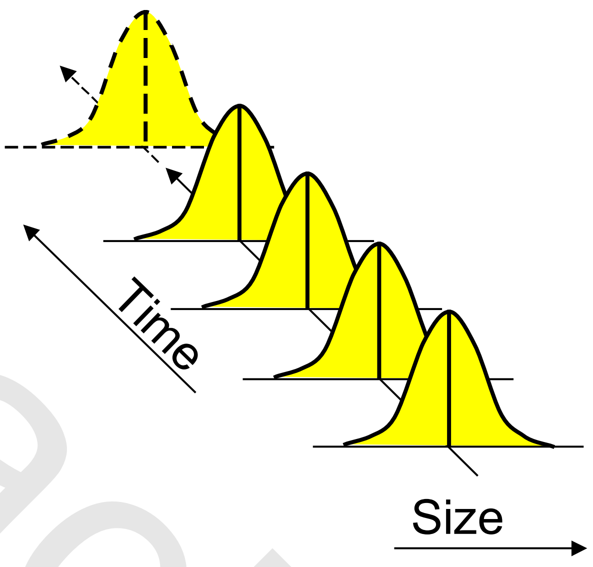
- Variation due only to the machine = Machine Variability .
- Machine variability can be measured by analysing about 30 products taken in a raw or during a short period.

- Variation due to Common causes . Sources of variation within process that behave in a reasonably constant manner over time. Sources are various and difficult to identify separately.
  - Process variability can be estimated by analysing at least 100 pieces not taken in a raw, during a period of time not too short and too long (one shift for example).

- Variation due to Special causes (or assignable causes) : shift change, Raw Material lot change, breakdown, …...

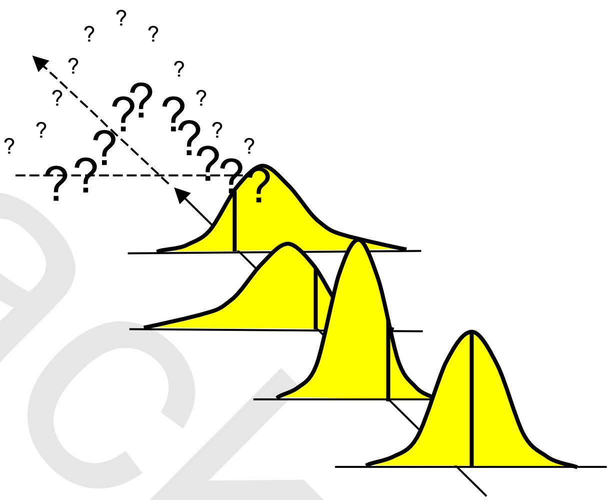
# CAUSES of VARIATION ?

If only common couses
of variations are present,
the output of a process
forms a distribution that is stable
over time and is prdictable



# Causes of Variation

- If special causes of variation are present, the process output is not stable over time and is not predictable

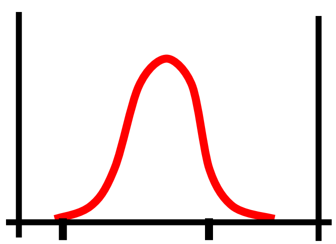


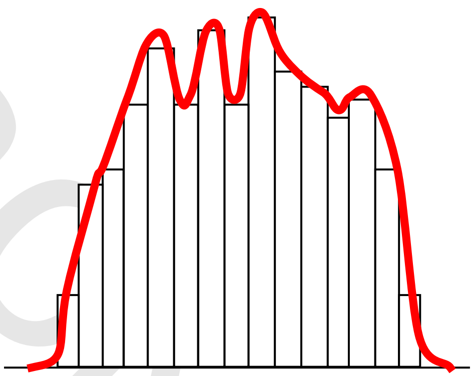
# Capability study

## **Requirements :**

- Parameter measurable
- Normally distribution

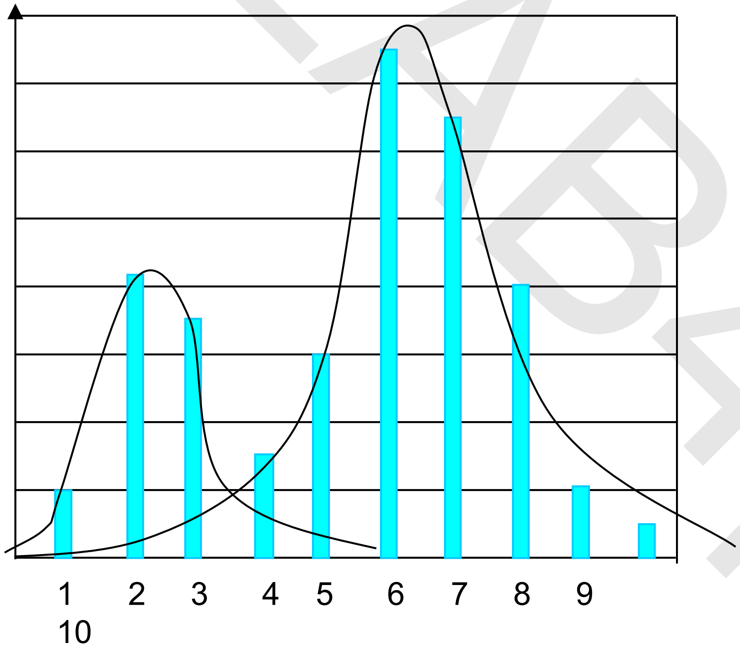
(Check if parameter is **ND**, if not Cpk will not apply)

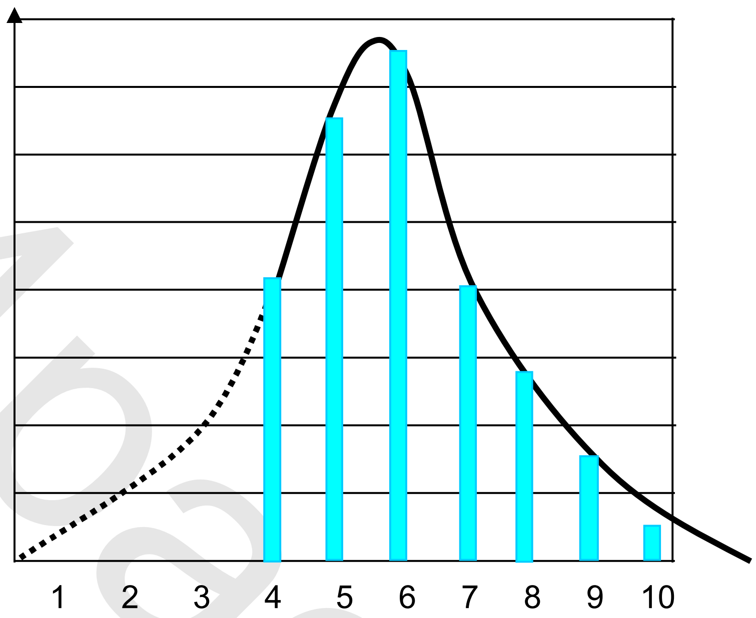




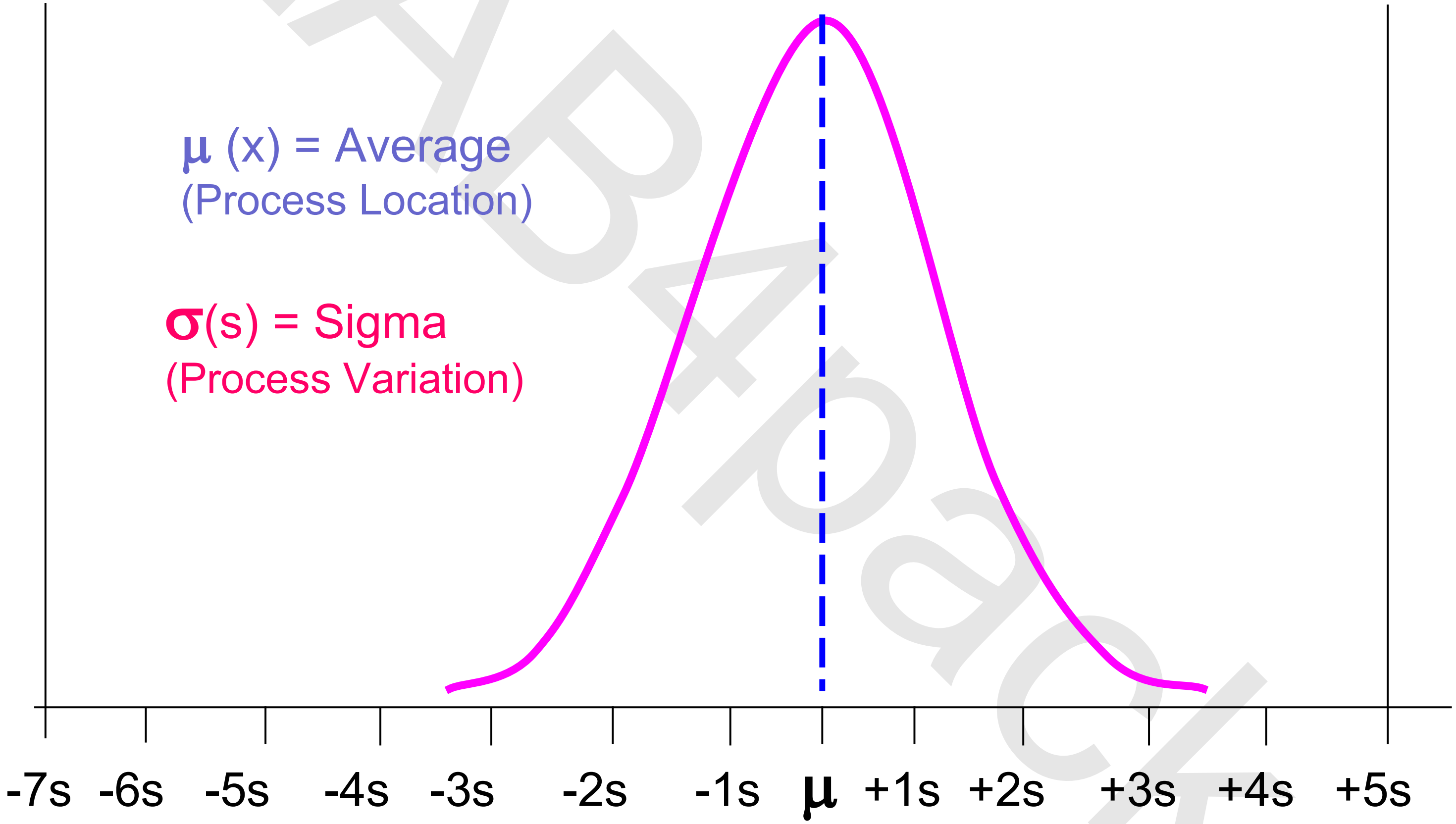
- Tolerances defined

# Examples of different situations

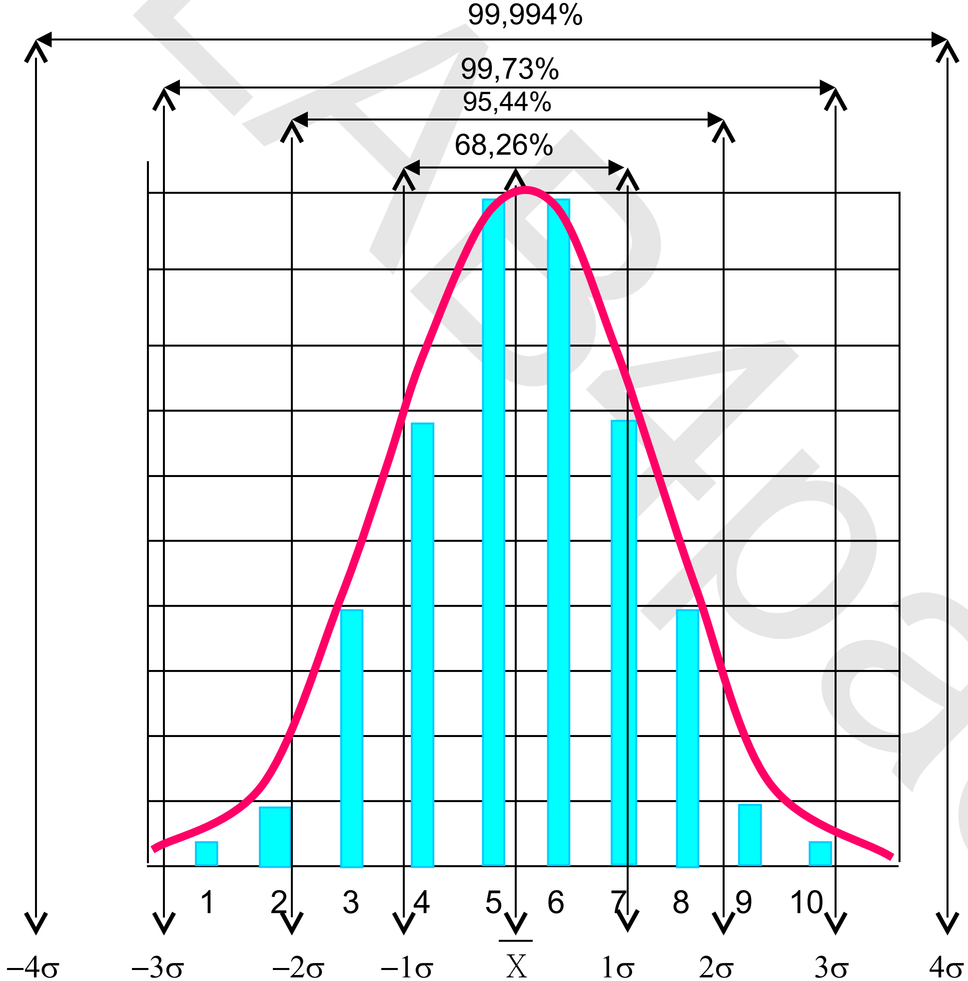


# Process Characteristic



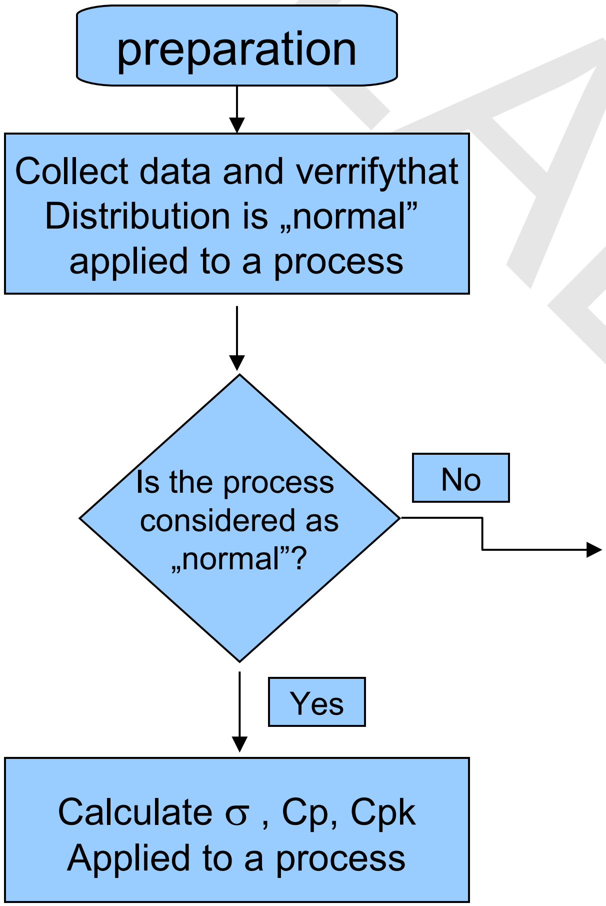
# Normal distribution shape



# Capability and defect level

| Spec Width | Process Width | Cpk | Defect level | % of Data Covered |
|---|---|---|---|---|
| 1 sigma | 3 sigma | 0,33 | 37 % | 66 % |
| 2 sigma | 3 sigma | 0,67 | 4,6 % | 95 % |
| 3 sigma | 3 sigma | 1,00 | 0,27 % | 99,73 % |
| 4 sigma | 3 sigma | 1,33 | 64 ppm | 99,9936 % |
| 5 sigma | 3 sigma | 1,67 | 0,6 ppm | 99,99995 % |

# Overview of capability study proocess




- What process/machine? Measurements? Which methods and tools? Who?
- Sampling size must be 50min to 200
- Samples must be collected subsequently when the machine is considered as stable and adjusted.
- Determine the total range (max – min )
- Collected the data.
- Check the data
- Check the process is following a normal distribution

- Correct the process until the distribution is „normal"
  if not, capability index and control limits are not relevant.

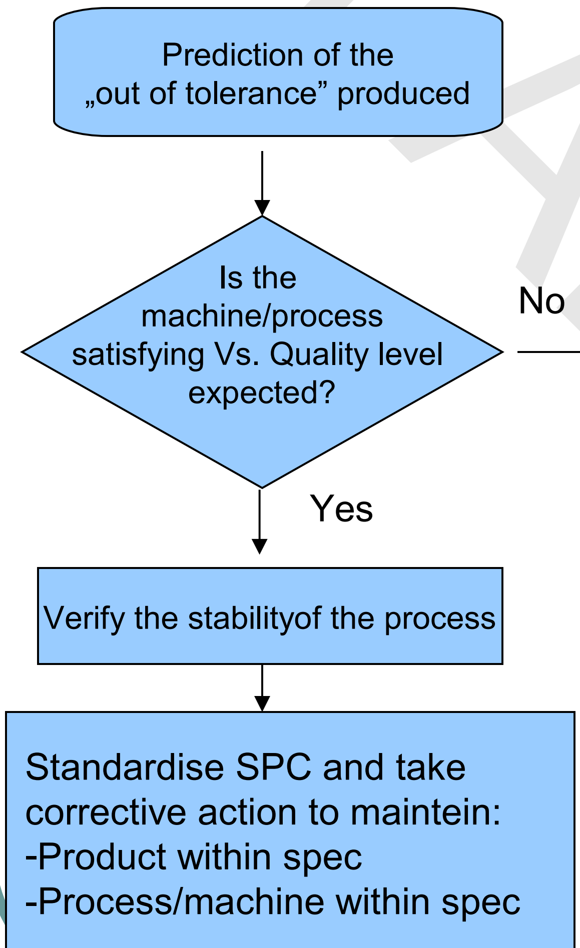
**σ** = standard deviation of the values

**Cp** (process capabillity index) = USL – LSL / 6σ

**Cpk** (process centring capabillity index) – the lovest value between :

**USL-X/3σ & X-LSL/3σ**

# Overview of capability study proocess




| Cp or Cpk | 0,5 | 0,7 | 1,0 | 1,2 | 1,8 | 1,5 | 1,7 |
|---|---|---|---|---|---|---|---|
| Out of tolerance | 13,4 % | 3,6 % | 0,3 % | 318 ppm | 96 ppm | 7 ppm | 0,34 ppm |

- Set up corrective action to improve or modify the machine or the process or change the specification

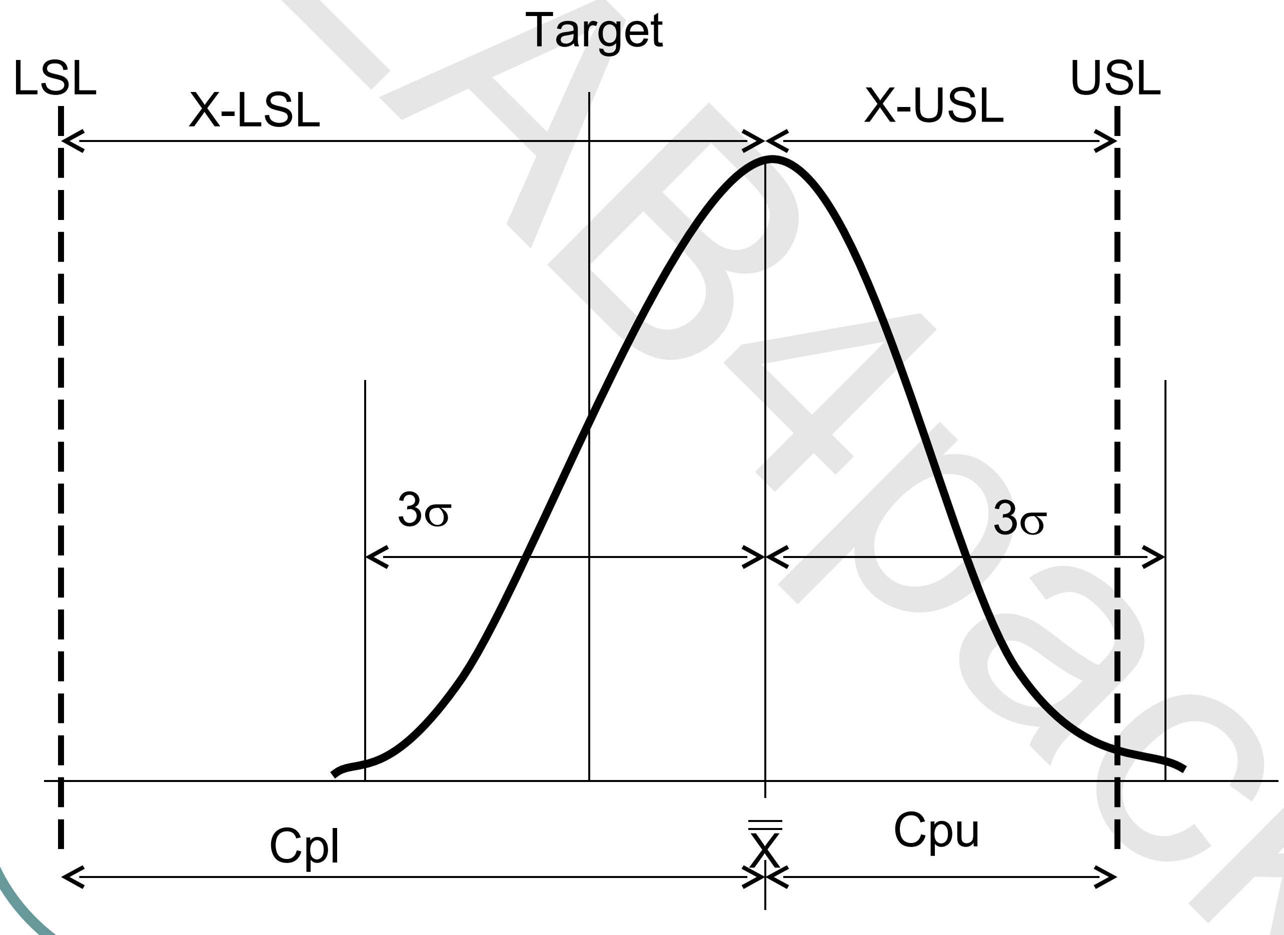
- Set up SPC on regular basis including capability index measurements at scheduled period

- Controle the product vs. specification and performance is posible.
- Capability index measurement enable us to controle andmaintain the ability of the machine/process to deliver good quality all the time

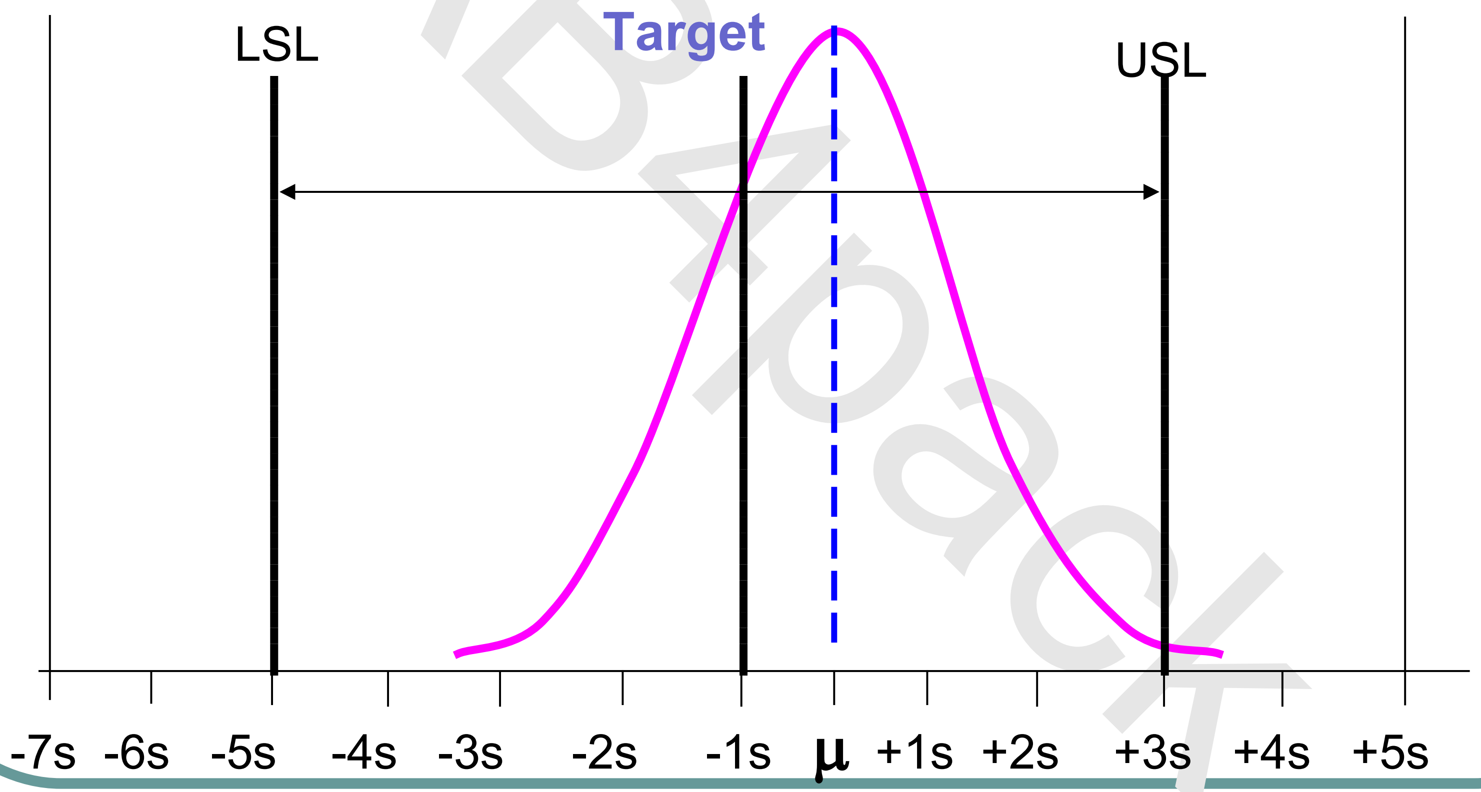
# Some definitions

| | | | |
|---|---|---|---|
| $\sigma$ | Standard deviation ( the whole population) | Distance to average of distribution | $\sqrt{\frac{\sigma(X_i - X)^2}{n_i}}$ |
| $C_m$ | Machine capability | Variability capability<br>How good could we be ? | $\frac{USL-LSL}{6\sigma}$ |
| $C_{mk}$ | Centring machine capability | Variability capability<br>How good are we? | Minimum of:<br>$\frac{USL - X}{3\sigma}$ & $\frac{X-LSL}{3\sigma}$ |
| $C_p$ | Process capability | Variability capability<br>How good could we be ? | $\frac{USL-LSL}{6\sigma}$ |
| $C_{pk}$ | Centring process capability | Variability capability<br>How good are we? | Minimum of:<br>$\frac{USL - X}{3\sigma}$ & $\frac{X-LSL}{3\sigma}$ |

| | | |
|---|---|---|
| USL | Upper specification limit | Distance to average of distribution |
| LSL | Lower specification limit | Distance to average of distribution |
| CpU | Process capability USL | Process capability relative to upper specification |
| CpL | Process capability LSL | Process capability relative to lower specification |

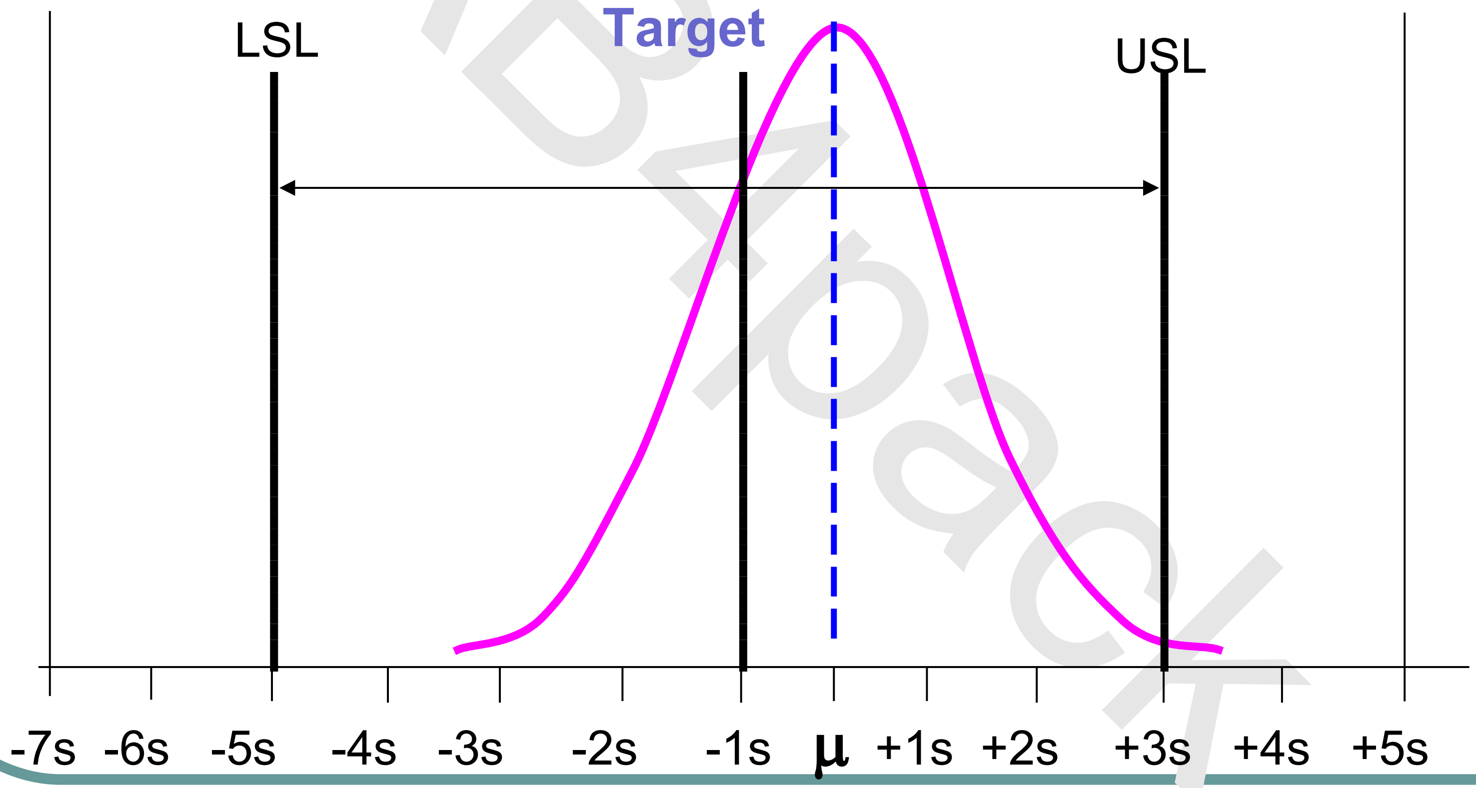

Target
LSL
USL
X-LSL
X-USL
3σ
3σ
Cpl
$\bar{\bar{X}}$
Cpu

# Specification



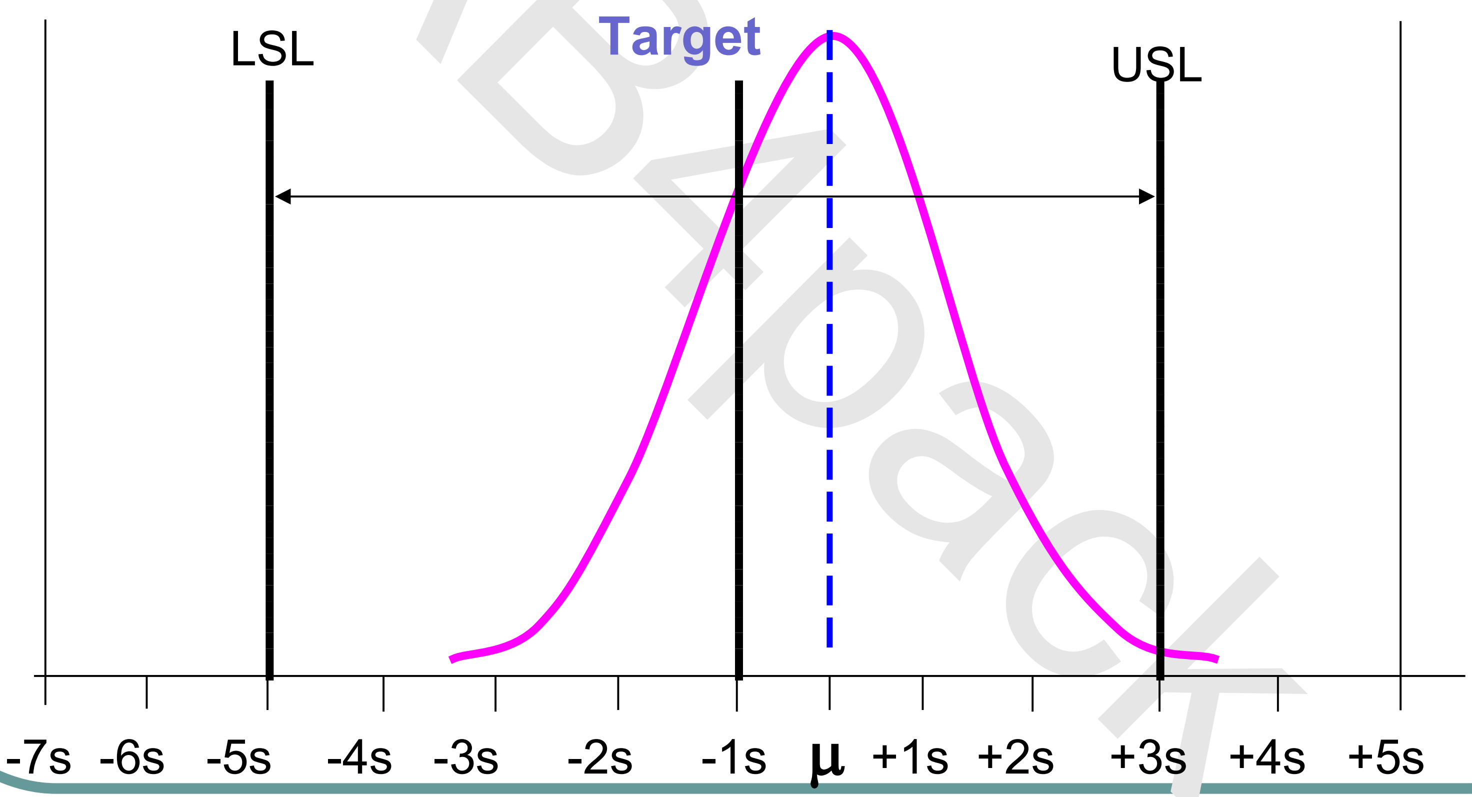
# How good could we be ?

$$C_p = \frac{\text{Spec Width}}{\text{Process Width}} = \frac{USL - LSL}{6\sigma}$$



# How good we are ?

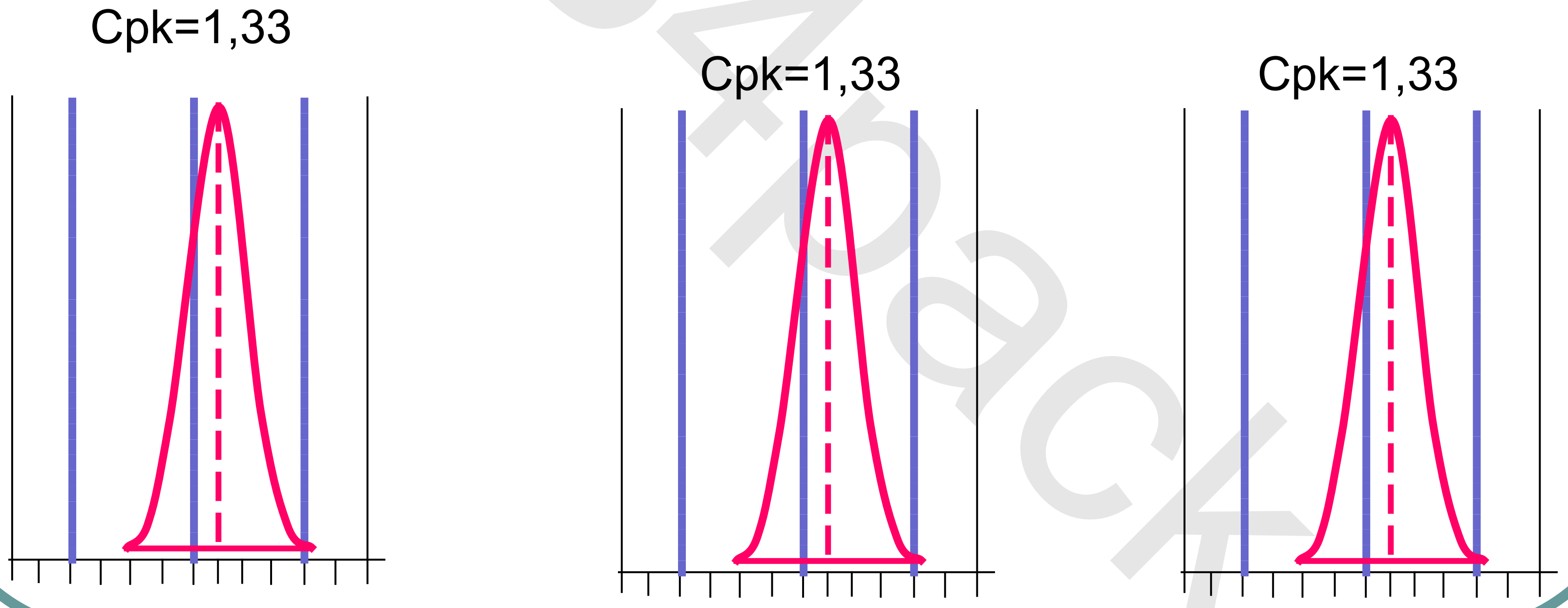
$$C_p = \frac{\text{Nearest spec limit} - \mu}{\text{1/2Process Width}} = \frac{USL - \mu}{3\sigma} \text{ or } \frac{\mu - LSL}{3\sigma}$$



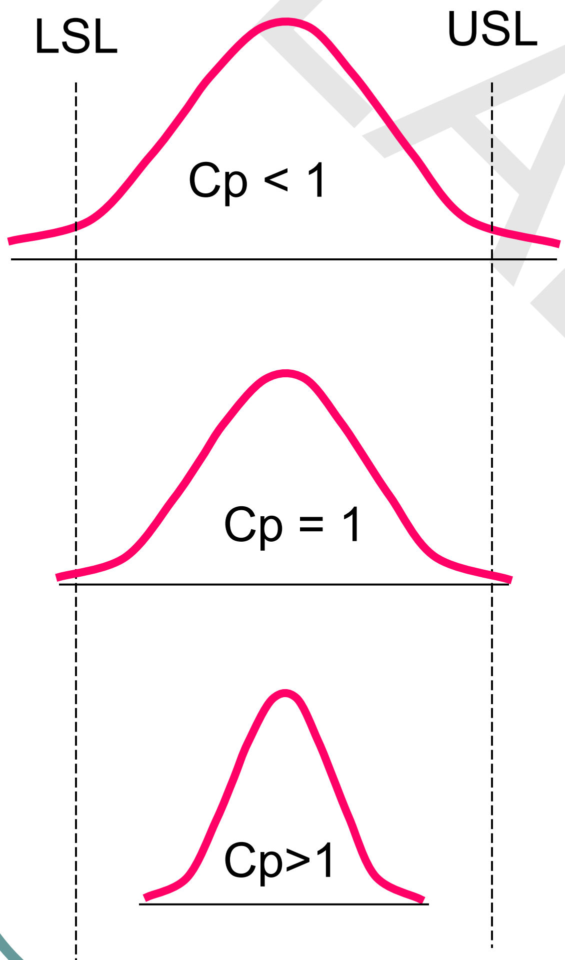

In this case, Cpk= $\frac{\mu - LSL}{3\sigma}$

# From Cpk=1......to Cpk=1,33

$$C_{pk} = \frac{USL - \mu}{3\sigma} = \frac{3\ \sigma}{3\ \sigma} = 1$$

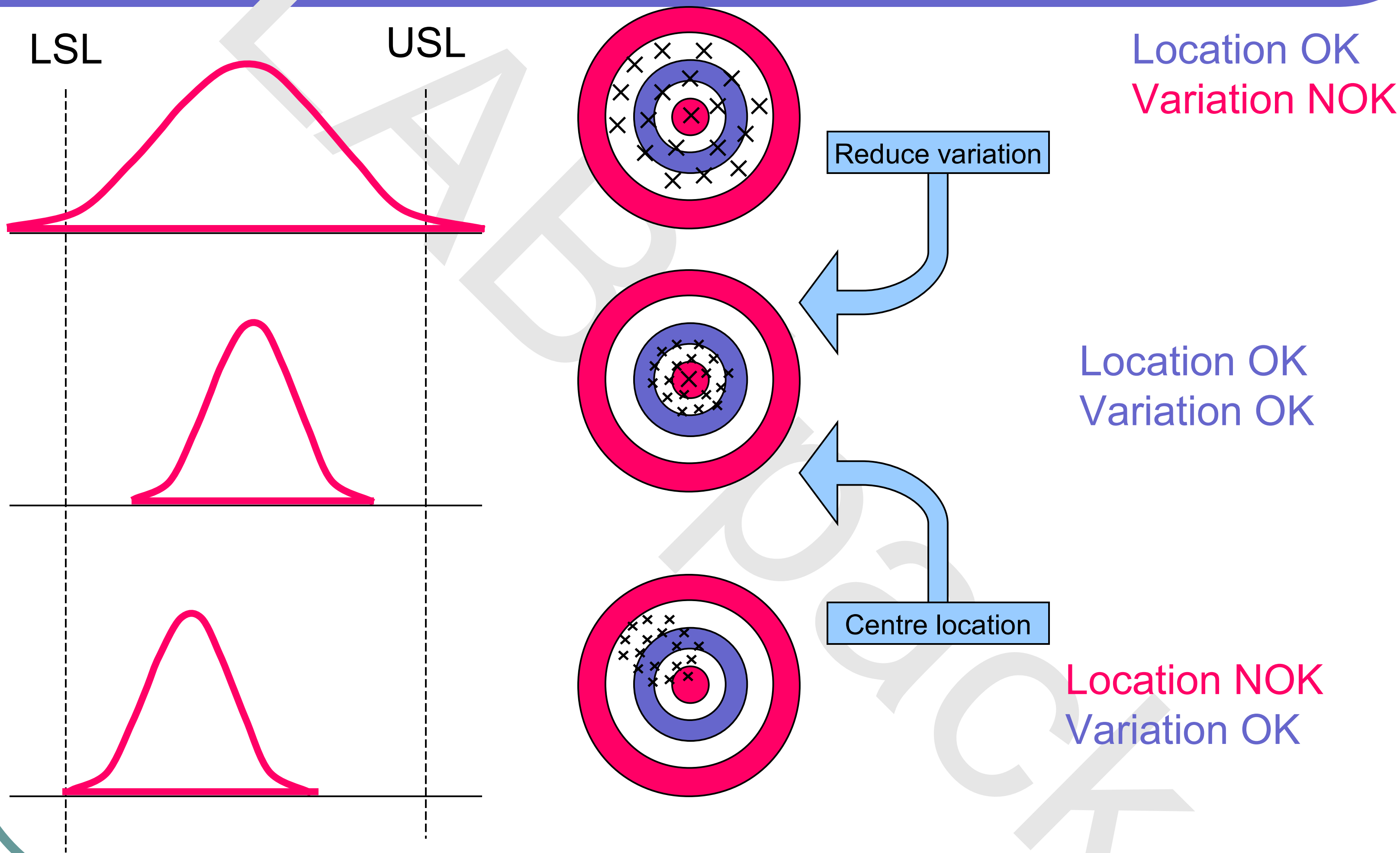


# Overview of capability study proocess




- Variation of the process extend the standard
  Out of specification products to be produced
- Variation of the process is placed just in the standard. No less than 0,3% of product will come out of specification, especially when process is not centered.
- Variation of the process is lower then standard.
  Faults will appear when process will be not centered.

# REMINDER


LSL
USL
Location OK
Variation NOK
Reduce variation
Location OK
Variation OK
Centre location
Location NOK
Variation OK

Thank you for your attention