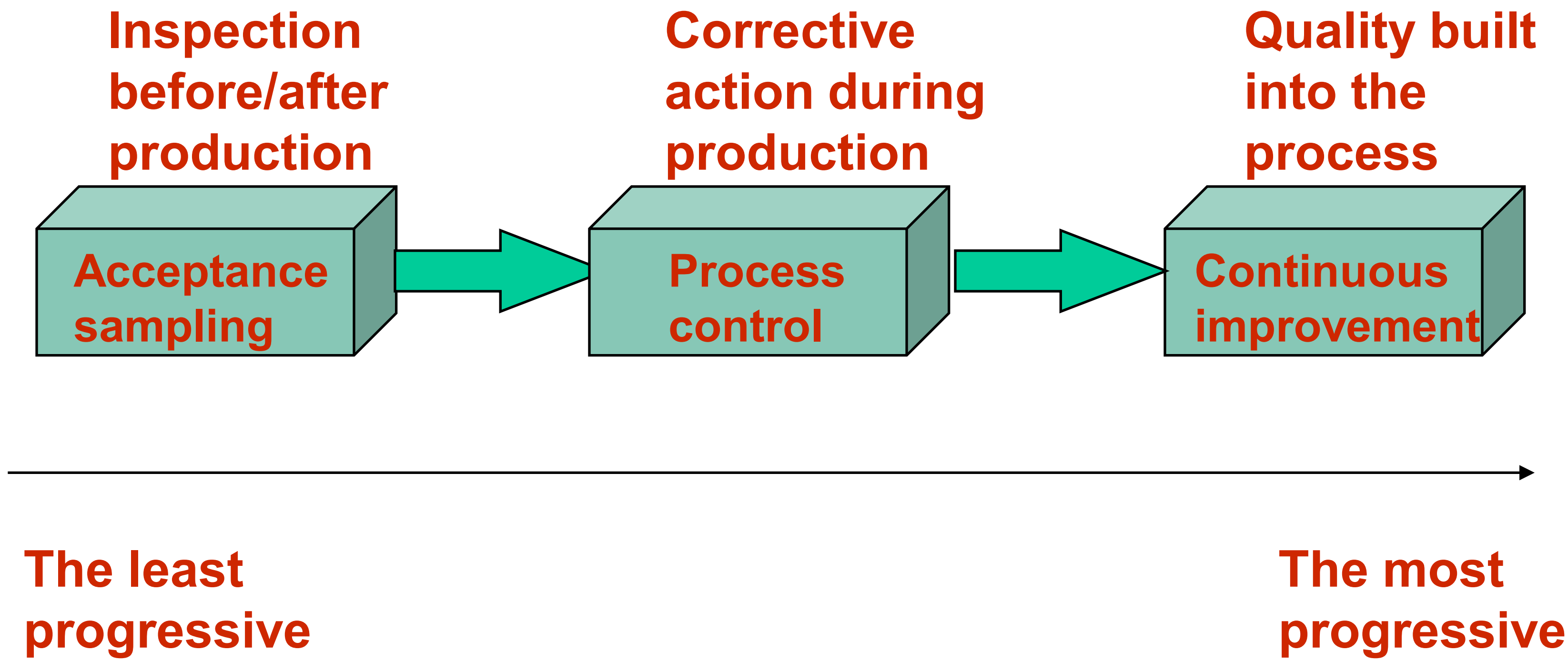
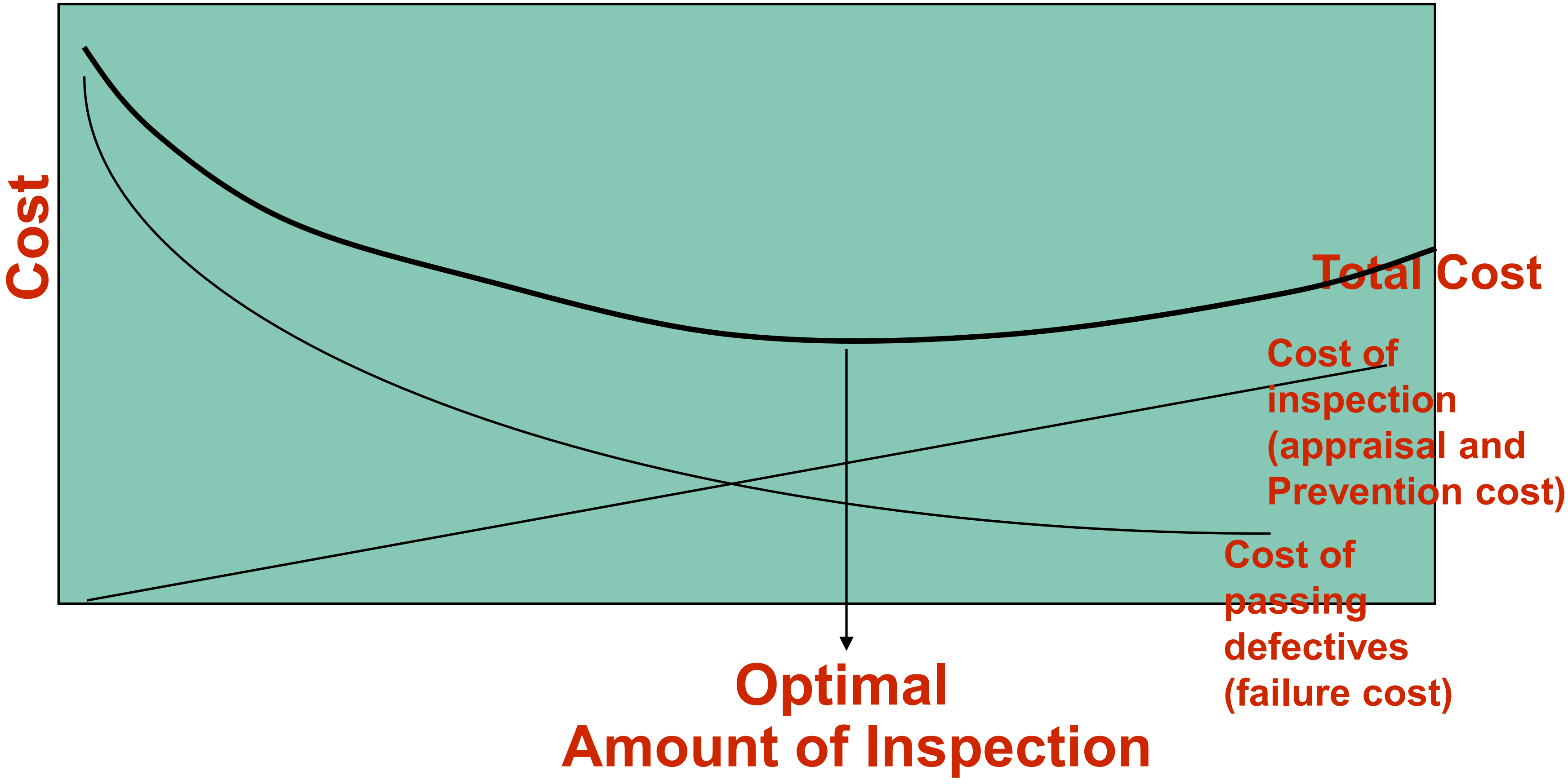
Phases of Quality Assurance



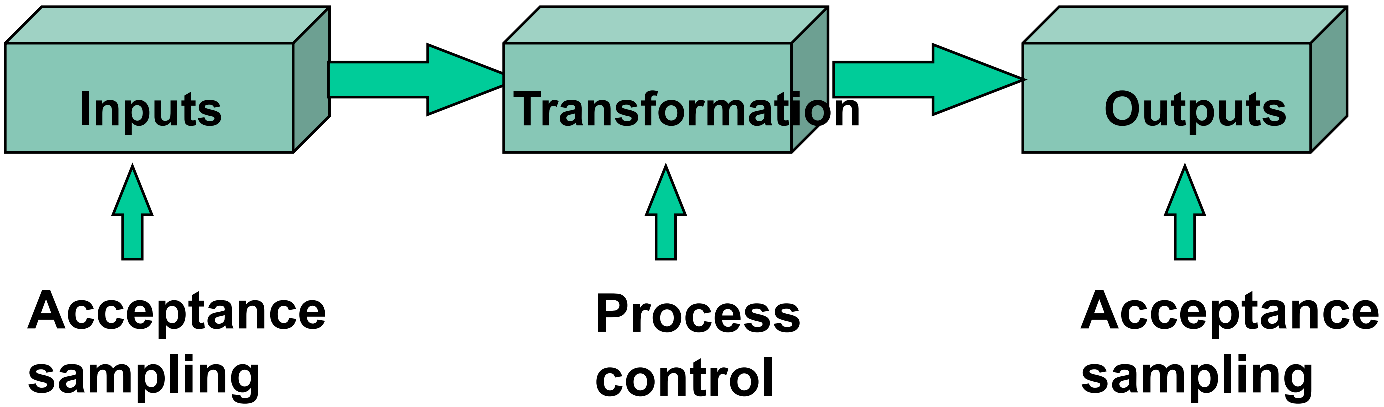
Inspection: Appraisal of good/service quality

- How Much (sample size) /How Often (hourly, daily)



Inspection

- Where/When
  - Raw materials
  - Finished products



  - Before a costly operation, PhD comp. exam before candidacy
  - Before an irreversible process, firing pottery
  - Before a covering process, painting, assembly
- Centralized vs. On-Site, my friend checks quality at cruise lines

Examples of Inspection Points

Type of business	Inspection points	Characteristics
Fast Food	Cashier	Accuracy
	Counter area	Appearance, productivity
	Eating area	Cleanliness
	Building	Appearance
	Kitchen	Health regulations
Hotel/motel	Parking lot	Safe, well lighted
	Accounting	Accuracy, timeliness
	Building	Appearance, safety
	Main desk	Waiting times
Supermarket	Cashiers	Accuracy, courtesy
	Deliveries	Quality, quantity

Statistical Process Control (SPC)

- SPC: Statistical evaluation
  of the output of a process during production

- The Control Process
  - Define
  - Measure
  - Compare to a standard
  - Evaluate
  - Take corrective action
  - Evaluate corrective action

Statistical Process Control

- Shewhart's classification of variability: common cause vs. assignable cause
- Variations and Control
  - Random variation: Natural variations in the output of process, created by countless minor factors, e.g. temperature, humidity variations.
  - Assignable variation: A variation whose source can be identified. This source is generally a major factor, e.g. tool failure.

Mean and Variance

- Given a population of numbers, how to compute the mean and the variance?

$$\text{Population} = \{x_1, x_2, \ldots, x_N\}$$

$$\text{Mean} = \mu = \frac{\sum_{i=1}^{N} x_i}{N}$$

$$\text{Variance} = \sigma^2 = \frac{\sum_{i=1}^{N} (x_i - \mu)^2}{N}$$

$$\text{Standard deviation} = \sigma$$

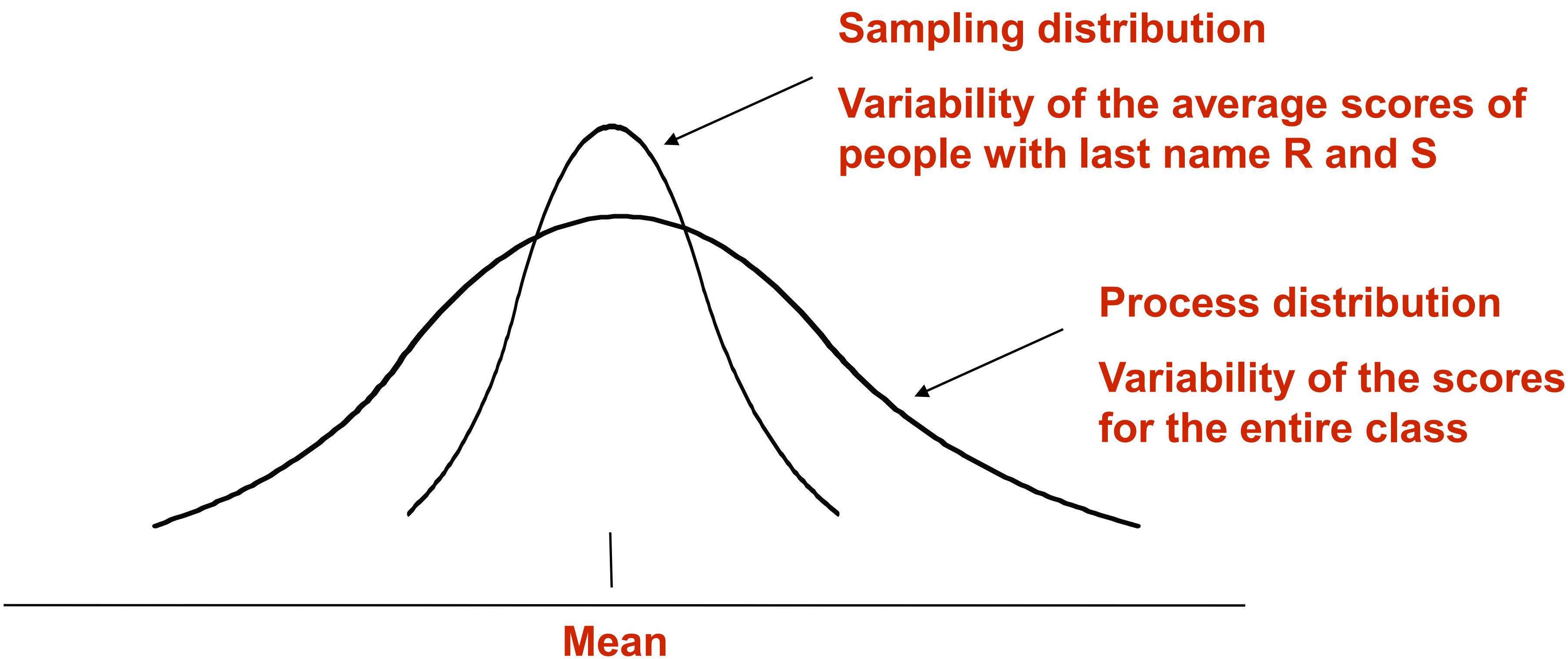
Statistical Process Control

- From a large population of goods or services (random if possible) a sample is drawn.
  - Example sample: Midterm grades of BA3352 students whose last name starts with letter R {60, 64, 72, 86}, with letter S {54, 60}
    - Sample size= n
    - Sample average or sample mean= $\bar{x}$
    - Sample range= R
    - Standard deviation of sample means=

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \quad \text{where } \sigma : \text{Standard deviation of the population}$$

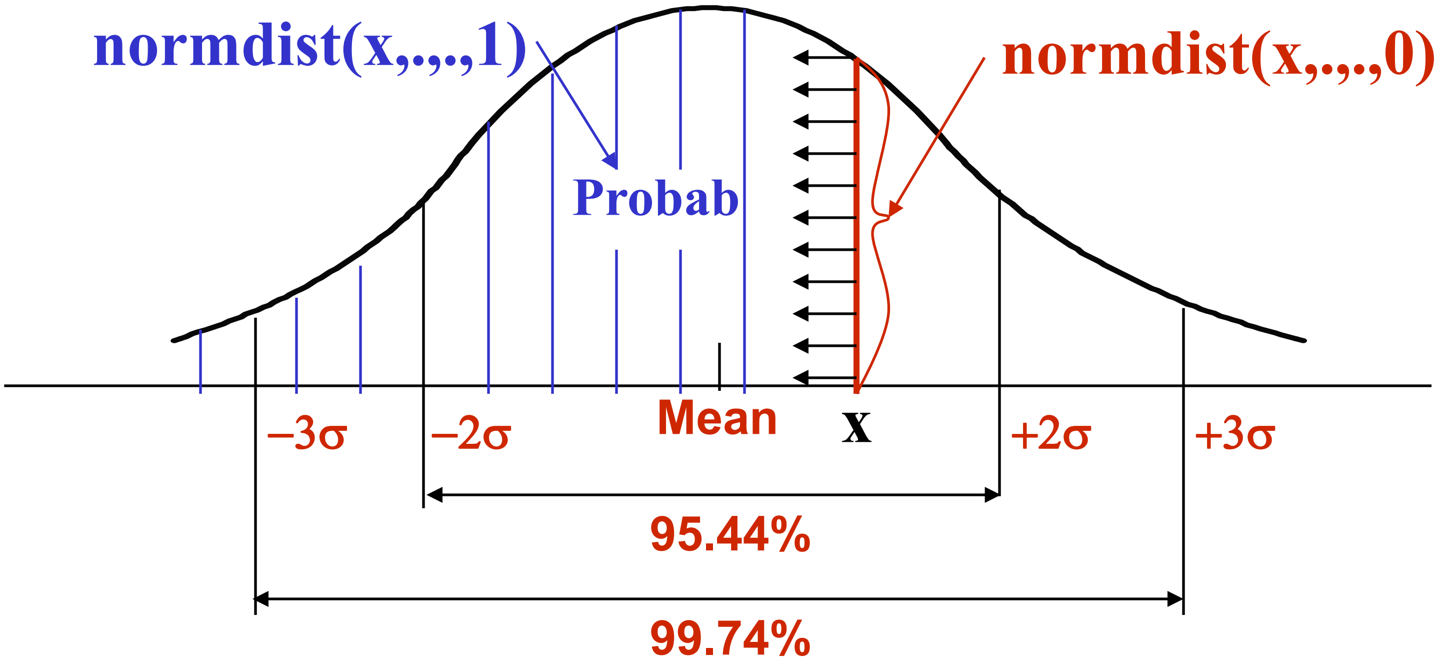
Sampling Distribution

Sampling distribution is the distribution of sample means.



Grouping reduces the variability.

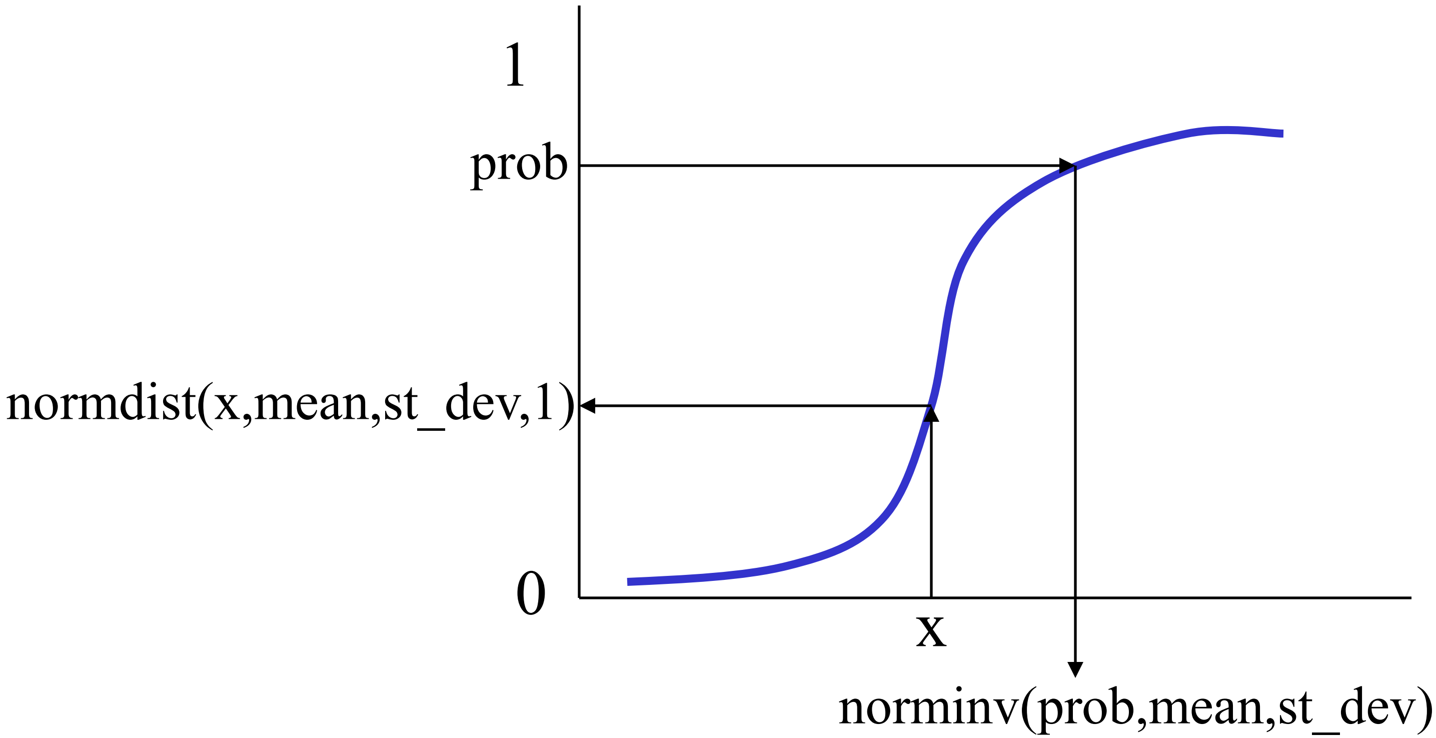
Normal Distribution



Excel statistical functions : normdist($x, mean, st\_dev$,0) normal pdf at x.

Excel statistical functions : normdist($x, mean, st\_dev$,1) normal cdf at x.

Cumulative Normal Density



Excel statistical functions :

Cumulative function (cdf) at x : normdist$(x, mean, st_dev, 1)$

Inverse function of cdf at "prob": norminv$(prob, mean, st_dev)$

Normal Probabilities: Example

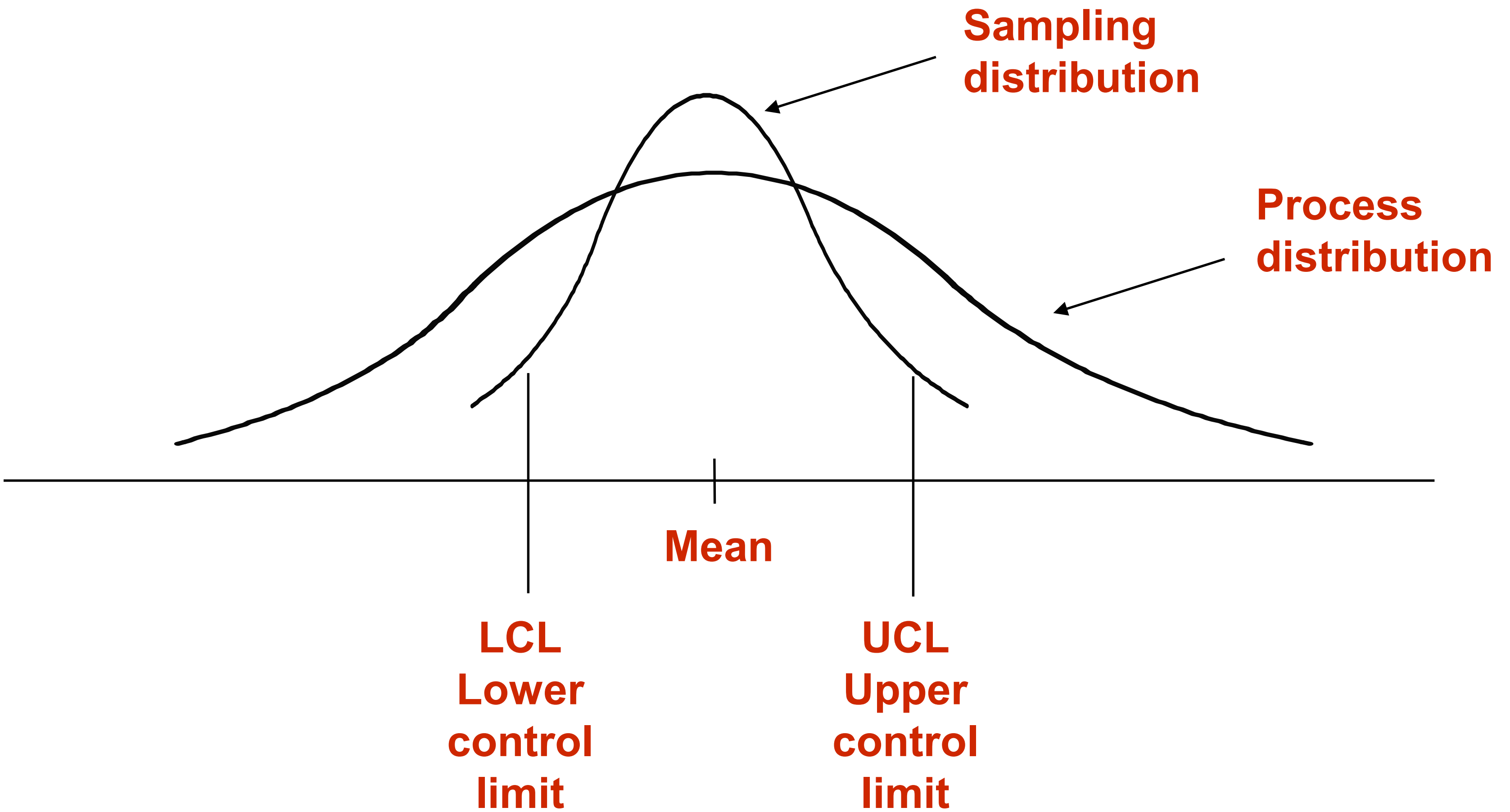
- If temperature inside a firing oven has a normal distribution with mean 200 ^{o}C and standard deviation of 40 ^{o}C, what is the probability that
  - The temperature is lower than 220 ^{o}C

    =normdist(220,200,40,1)
  - The temperature is between 190 ^{o}C and 220^{o}C

    =normdist(220,200,40,1)-normdist(190,200,40,1)

Control Limits

Process is in control if sample mean is between control limits. These limits have nothing to do with product specifications!

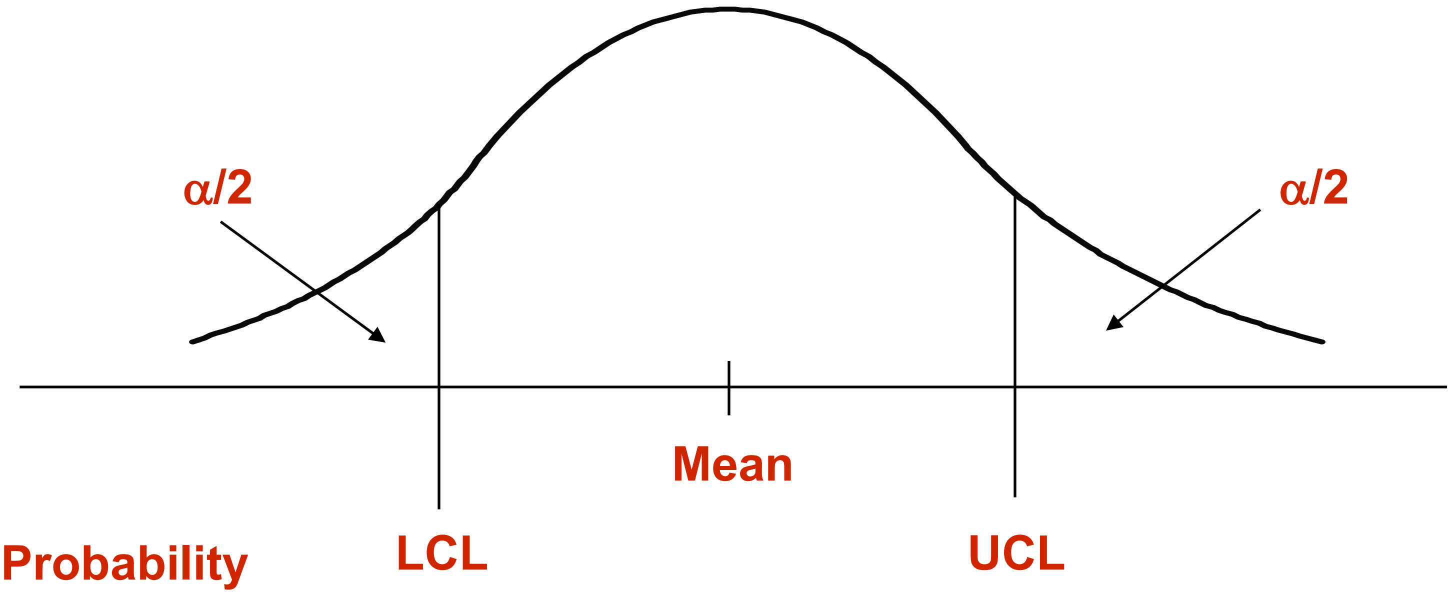


Setting Control Limits: Hypothesis Testing Framework

- Null hypothesis: Process is in control
- Alternative hypothesis: Process is out of control
- Alpha=P(Type I error)=P(reject the null when it is true)= P(out of control when in control)
- Beta=P(Type II error)=P(accept the null when it is false) P(in control when out of control)

- If LCL decreases and UCL increases what happens to
  - Alpha ?
  - Beta?
- Not possible to target alpha and beta simultaneously, control charts target a desired level of **Alpha**.

Type I Error=Alpha

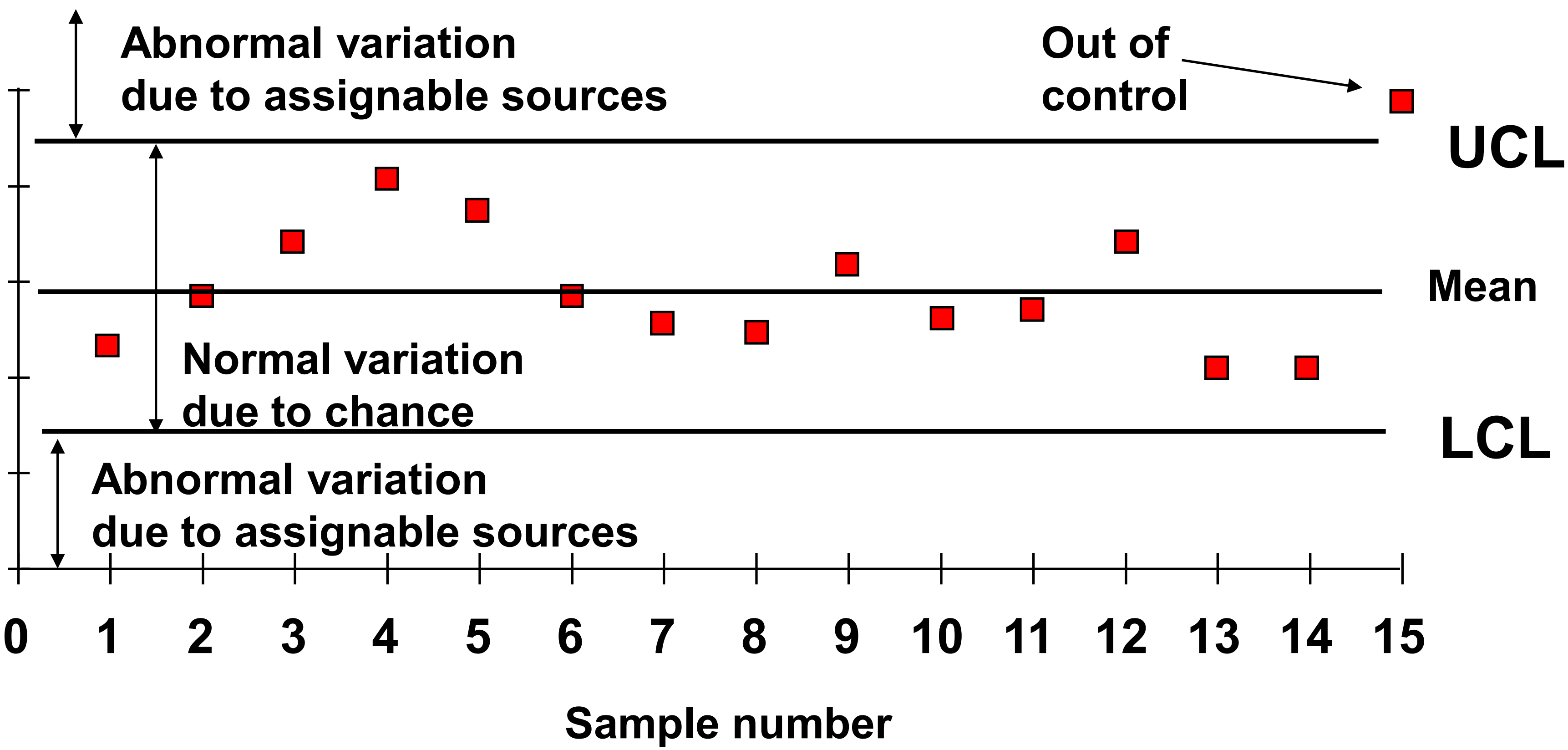


α = Probability of Type I error

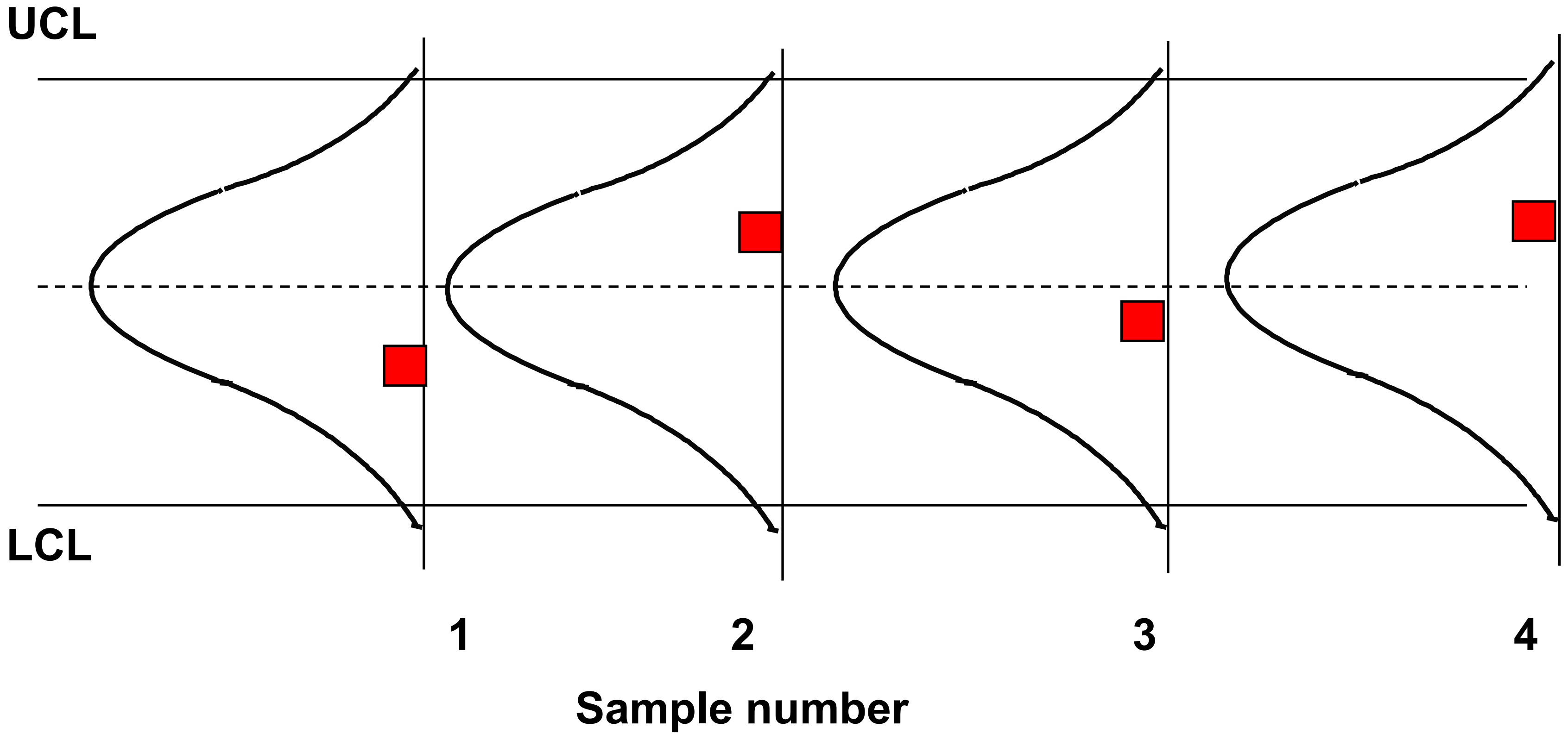
$$\mathrm{LCL} = \mathrm{norminv}(\alpha/2, \mathrm{mean}, \mathrm{st\_dev})$$

$$\mathrm{UCL} = \mathrm{norminv}(1 - \alpha/2, \mathrm{mean}, \mathrm{st\_dev})$$

Control Chart



Observations from Sample Distribution



Control Charts

- Control charts for variables (measurable quantities), e.g. length, temperature
  - Mean control charts
    - To check mean
  - Range control charts
    - To check variability
- Control charts for attributes, e.g. fit, defective
  - p-charts
    - To check proportion of defectives (occurrences)
  - c-charts
    - To check the number of defectives (occurrences)