Lecture # 23

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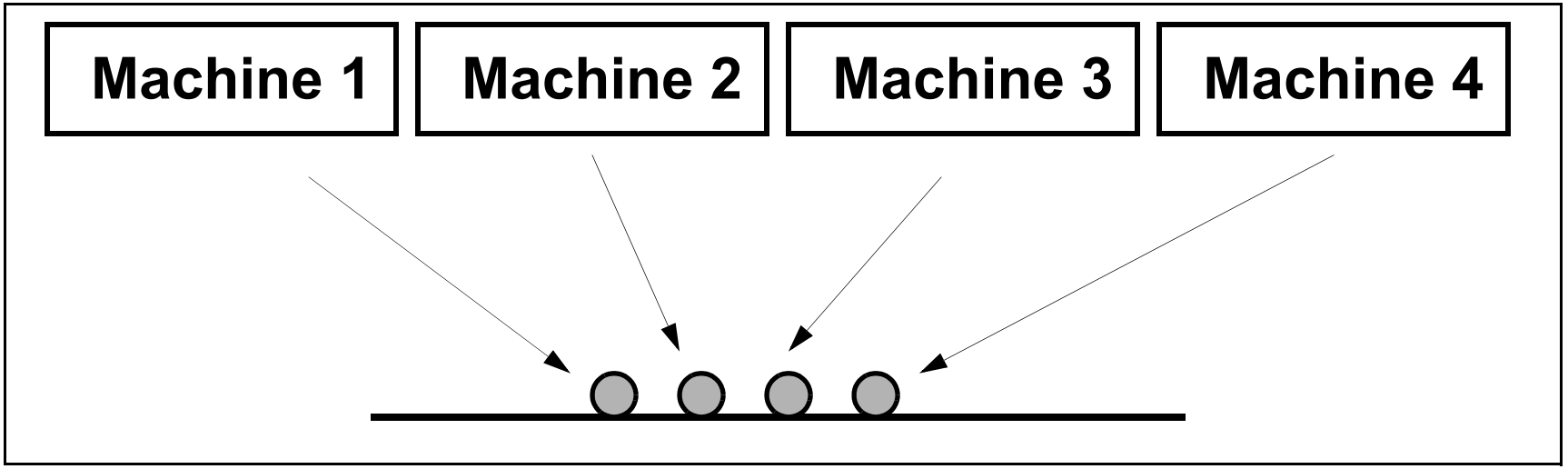
Pitfalls in Subgroup Selection

- **Stratification**
- **Mixing**

What is Stratification??



Stratification

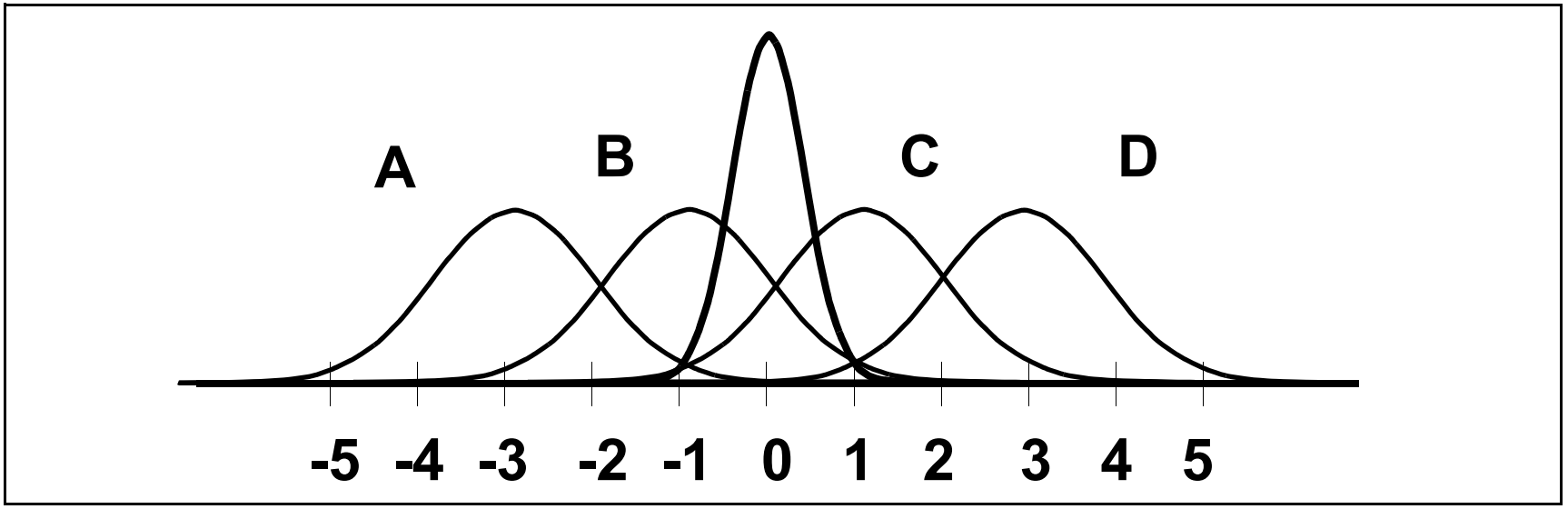
How can it occur??

1. **Process produces a characteristic - natural multiple occurrence of an item, e.g., mold cavities, multihead filling maching, turret**

2. **Conscious effort to distribute "sampling points" in an orderly fashion, e.g., measure a sheet, shaft dimensions, dimension of a cast part as it cools**

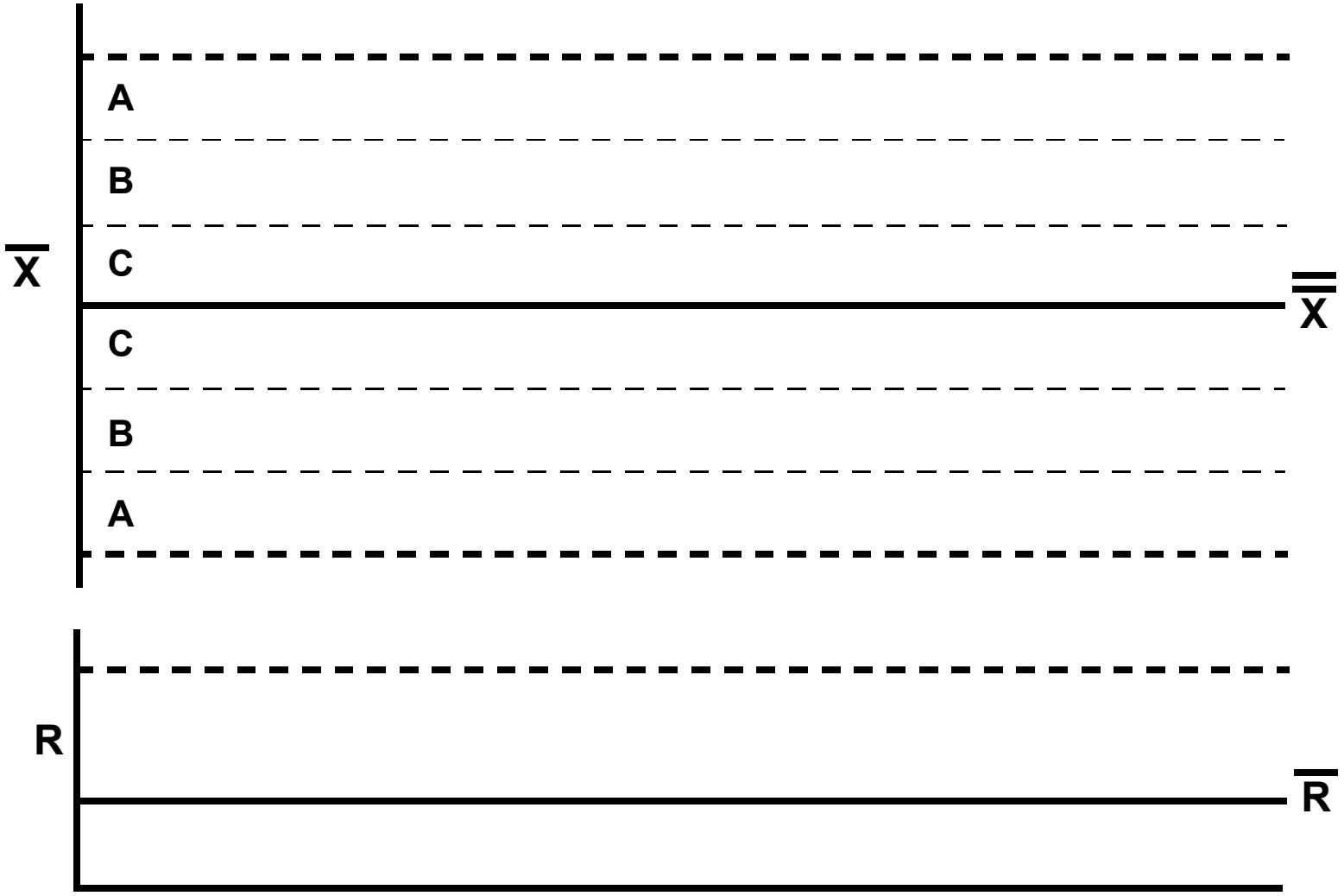
3. **Shortcut SPC application by taking representative sample across several machines**

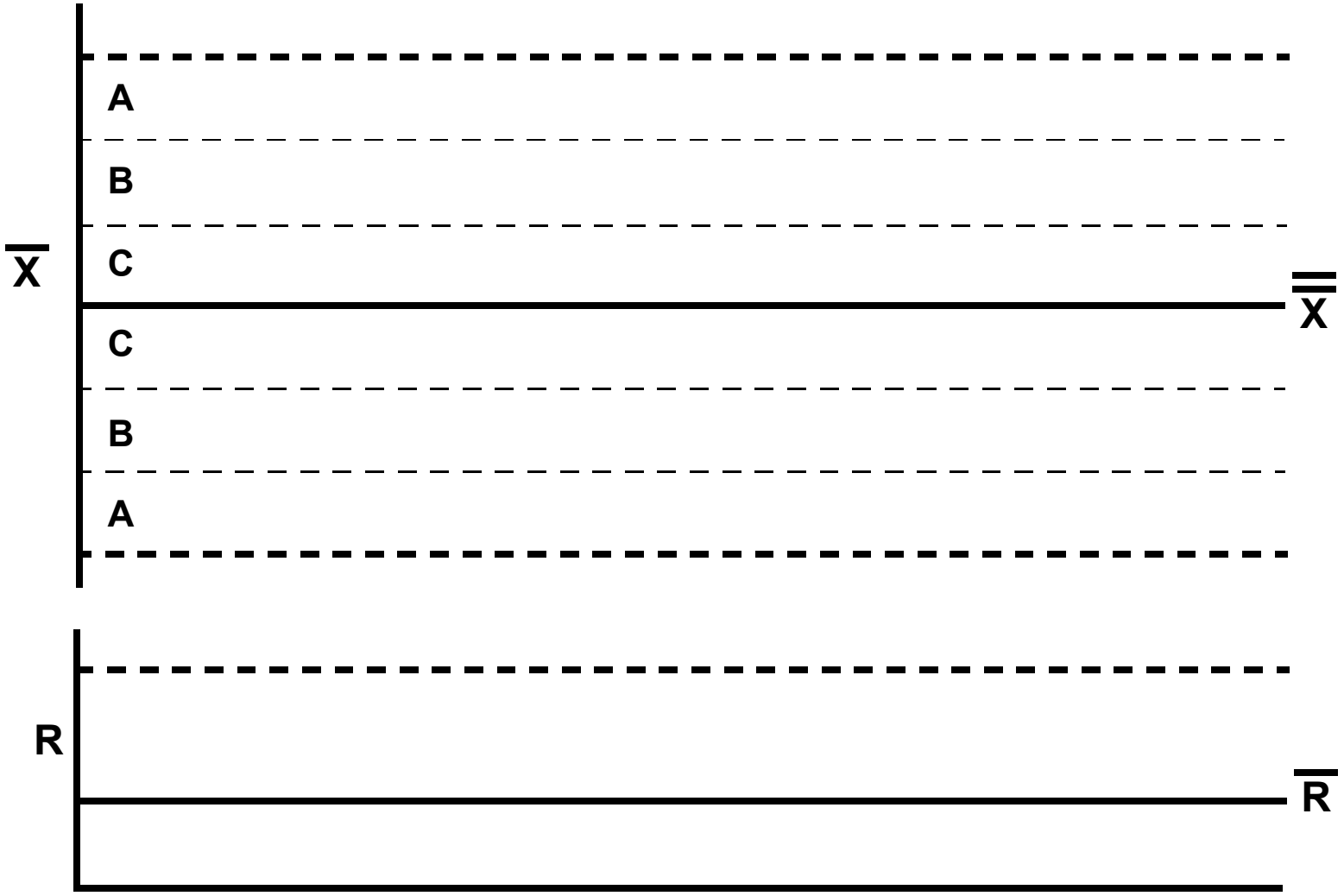
Stratification Example



From the figure $\sigma_X = 1$

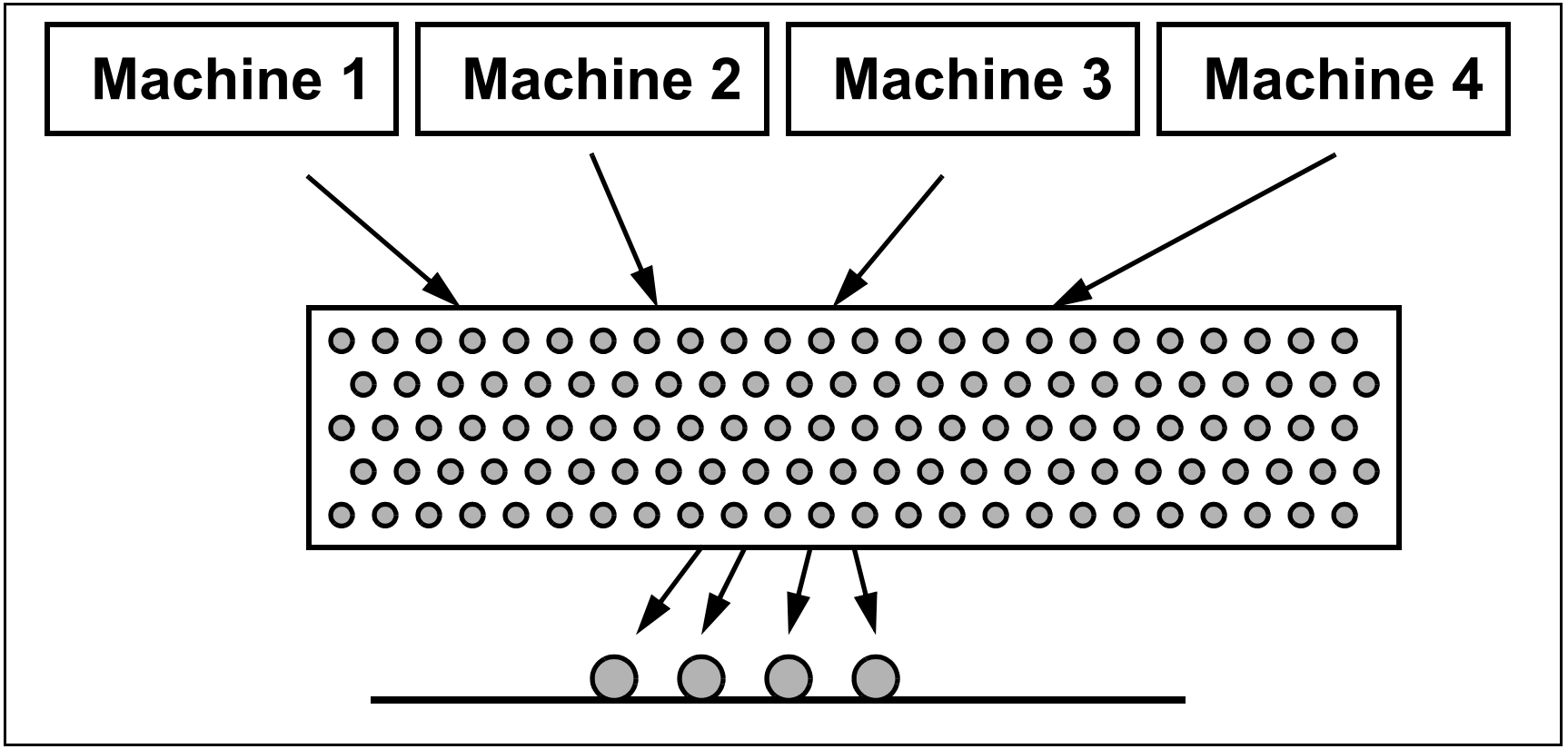
Based on ranges, $\hat{\sigma}_X = \bar{R}/d_2 = 6/2.059 \approx 3$

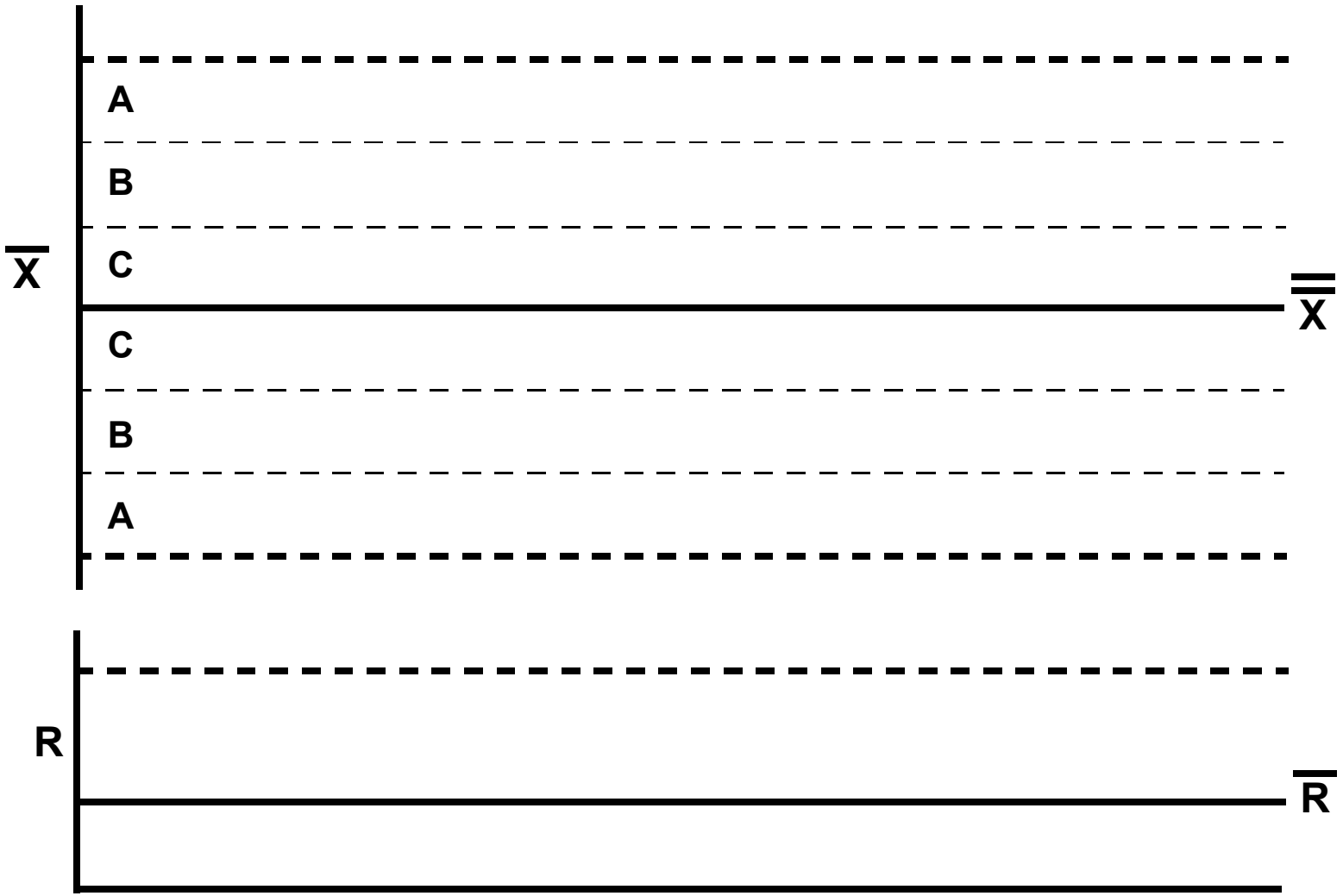

A
B
C
C
B
A
$\overline{X}$
$\overline{\overline{X}}$
R
$\overline{R}$

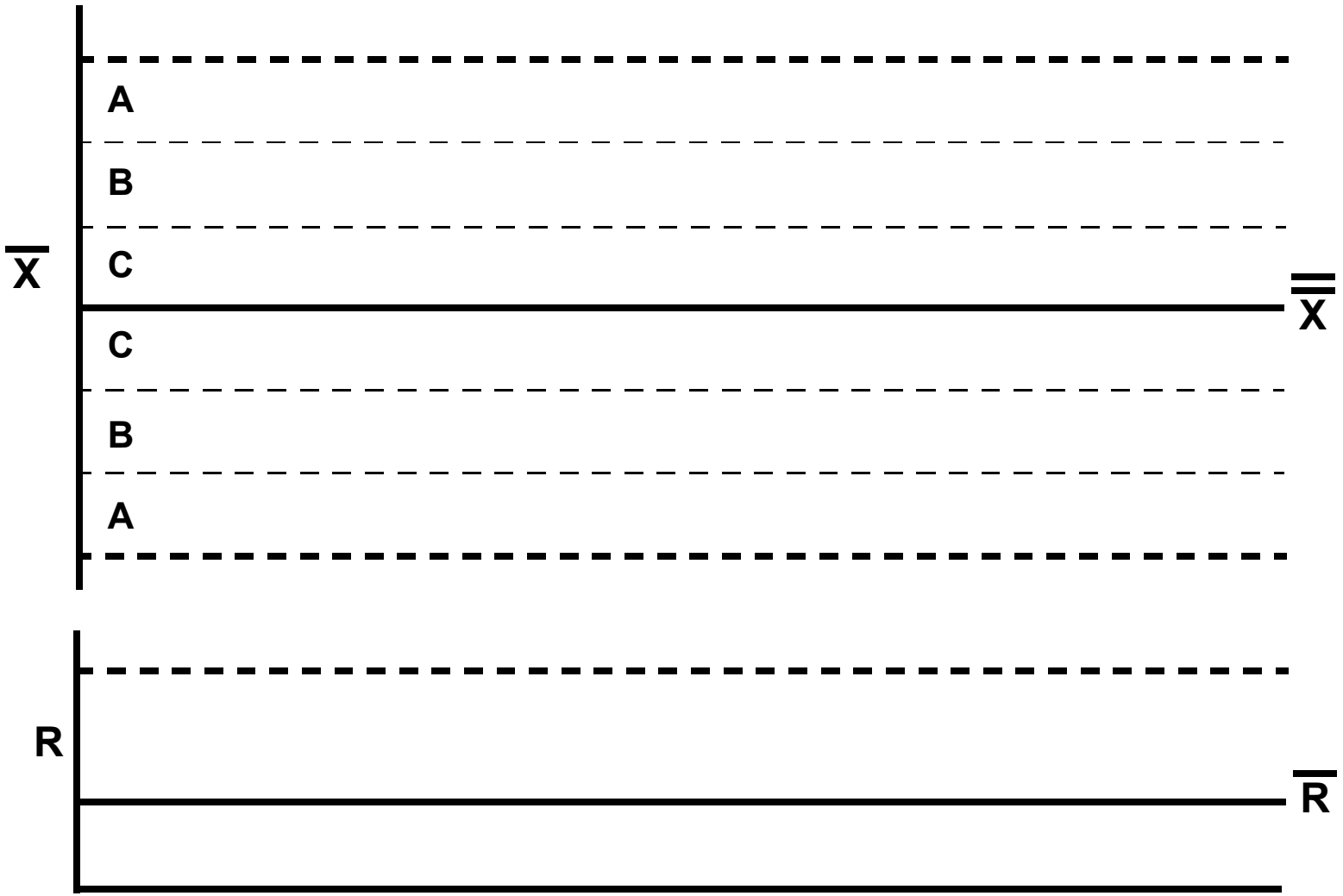

A
B
C
C
B
A
$\overline{X}$
$\overline{\overline{X}}$
R
$\overline{R}$

Mixing

What is Mixing??



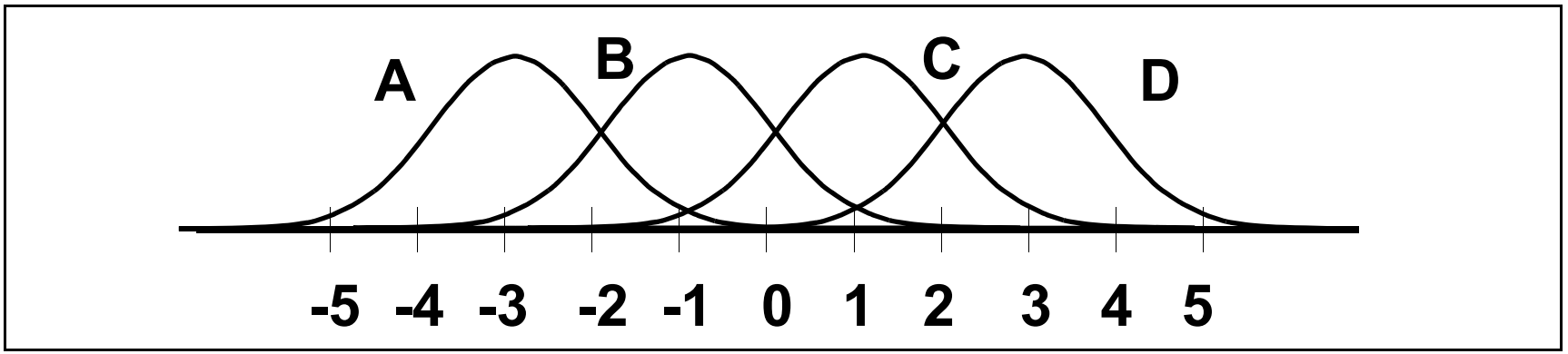

A
B
C
$\overline{X}$
$\overline{\overline{X}}$
C
B
A
R
$\overline{R}$


A
B
C
$\overline{X}$
$\overline{\overline{X}}$
C
B
A
R
$\overline{R}$

Summary

Stratification: sample has representation from each distribution; (A,B,C,D), (A,B,C,D), . . . , (A,B,C,D)

Mixing: sample extracted from "mix" that is composed all the output from the different distributions; (A,A,C,D), (B,D,A,B), . . . , (C,D,D,C)



Overcontrol

Variations due to Common Cause sources are wrongly interpreted as being due to special causes

Process Capability

The extent to which a process produces parts that meet design intent.

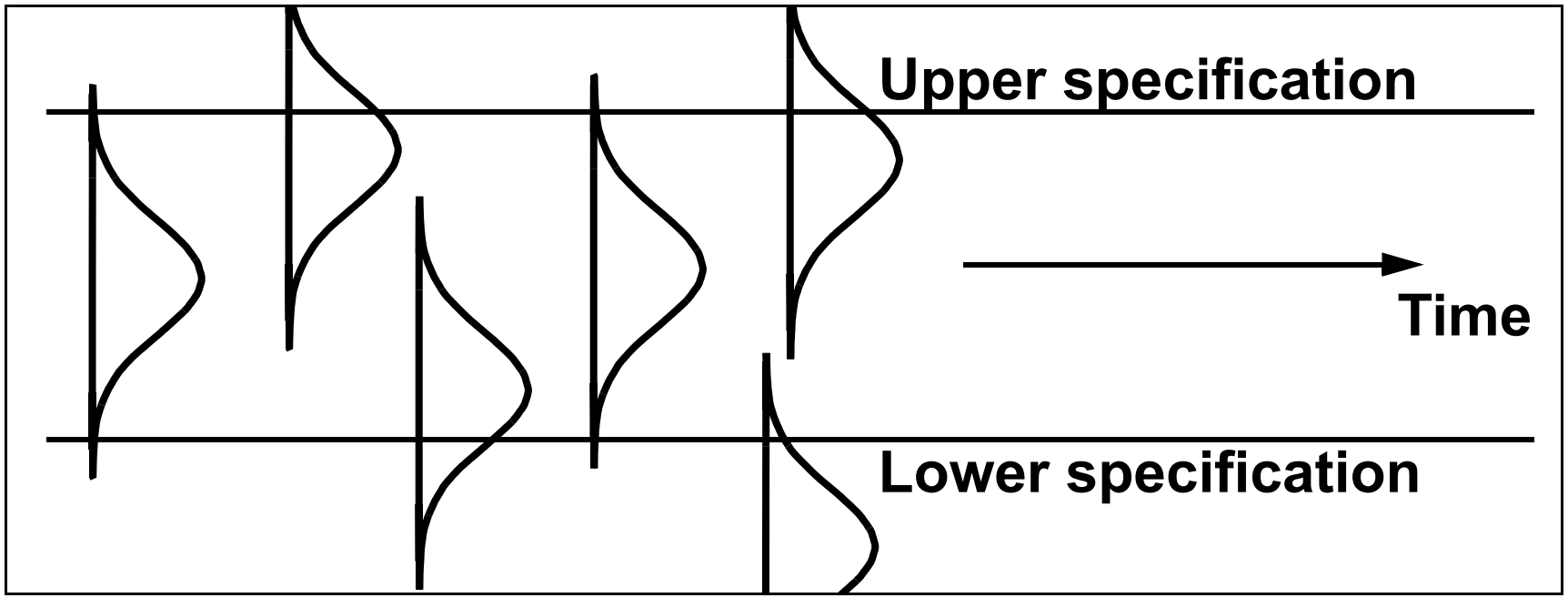
Most often, how well the process meets the engineering specifications.

Process capability -- when we quote a number for this we do not want it dependent on time.

Rule: Never assess process capability until the process is "in-control"

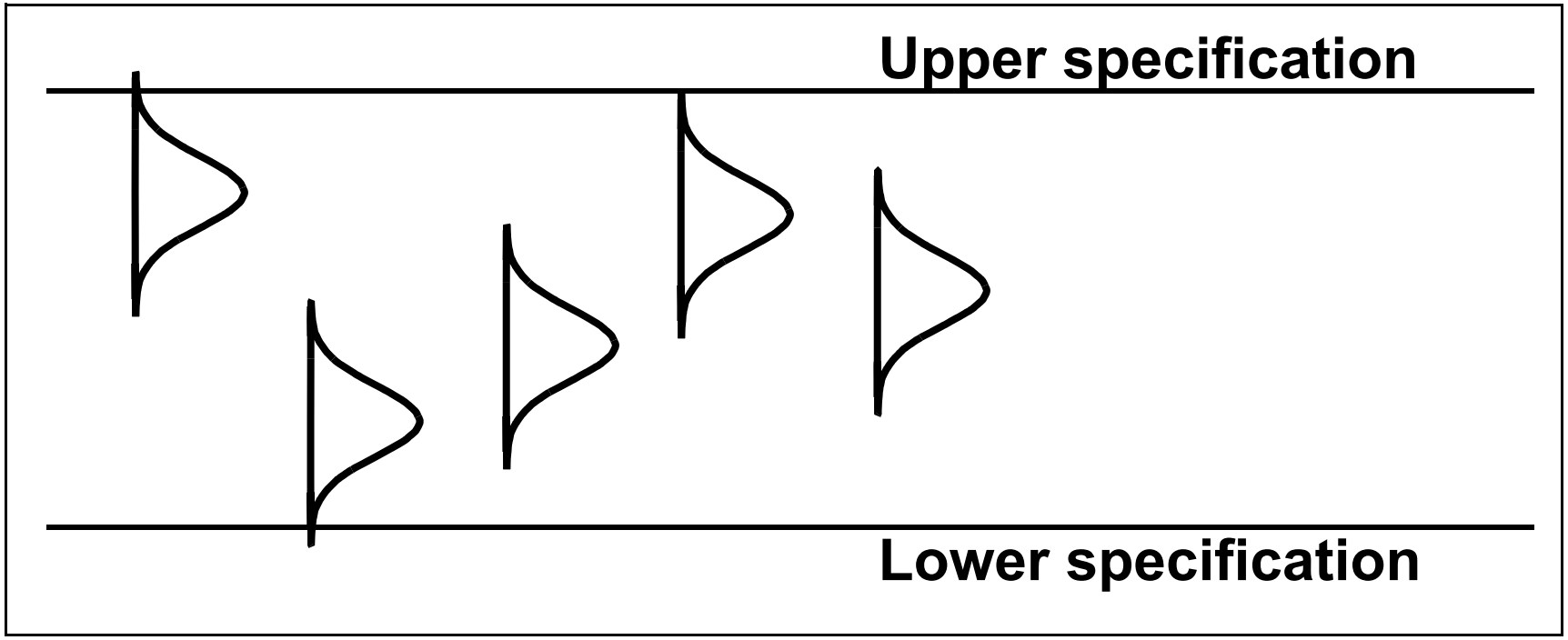
Why Process Stability

Let's say process is unstable -- mean changes vs. time

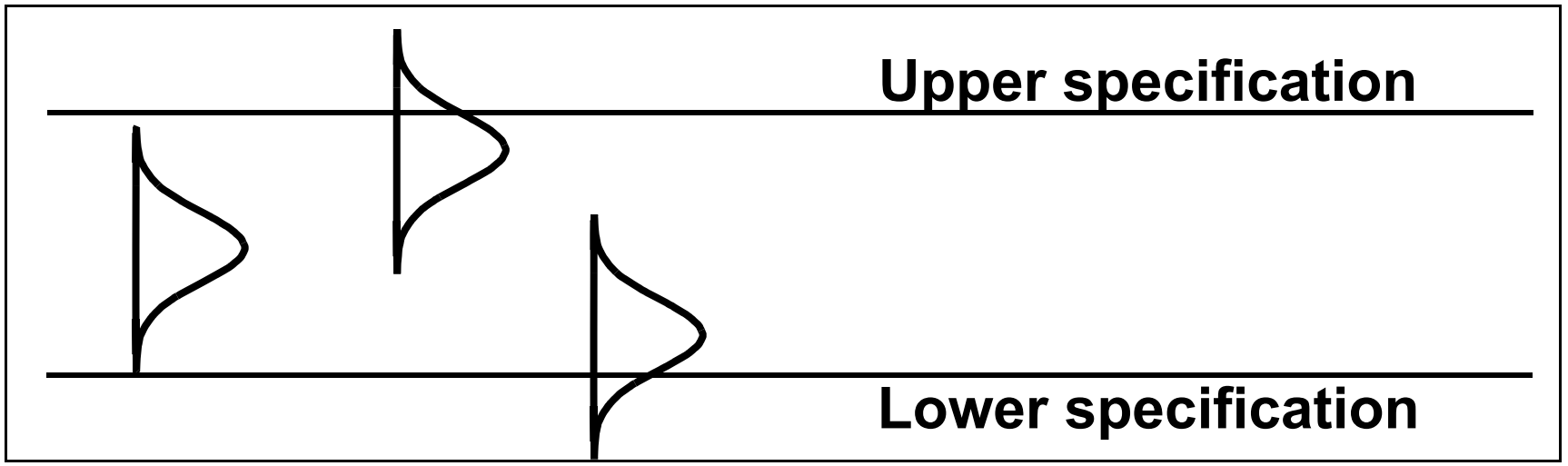


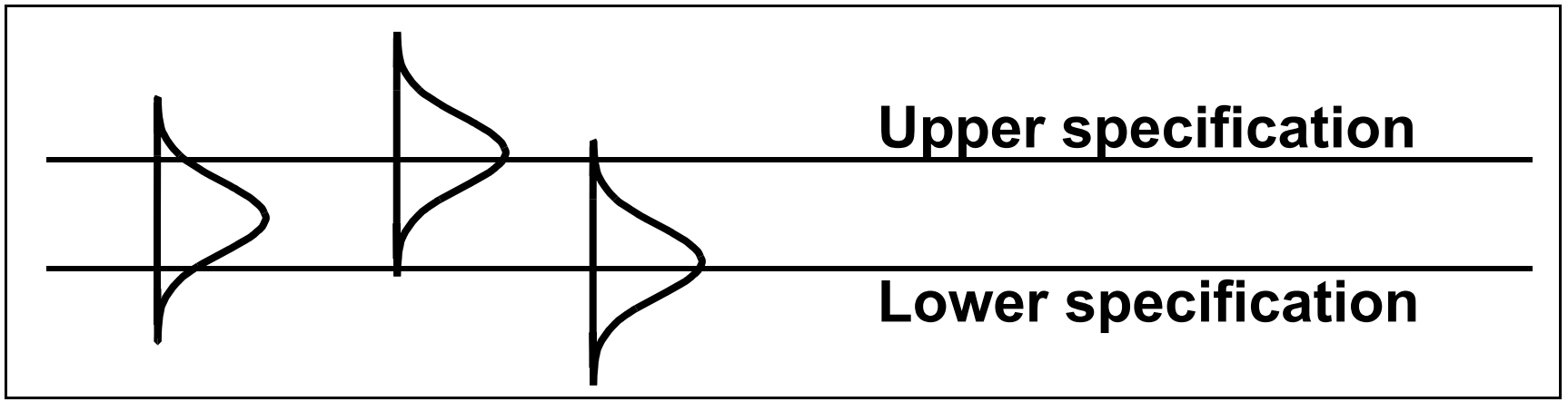
What % of the process output meets the specifications??

Process Variability & Specifications



Process variation is small relative to the width of the engineering specifications


Upper specification
Lower specification


Upper specification
Lower specification

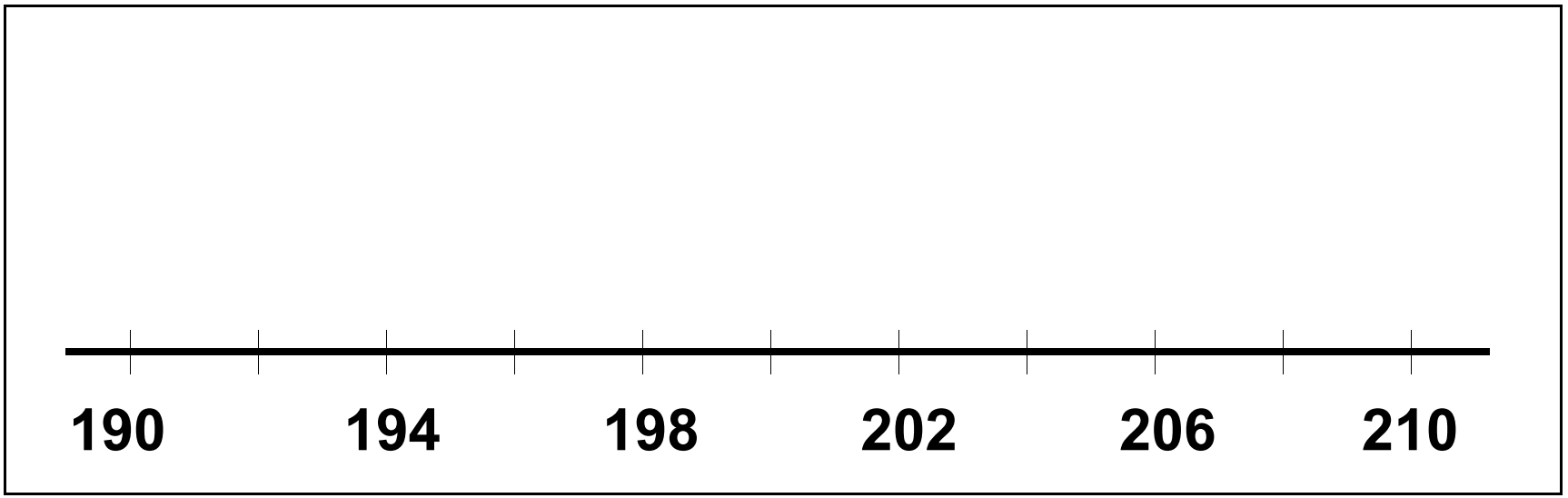
Cylinder Boring - Case Study

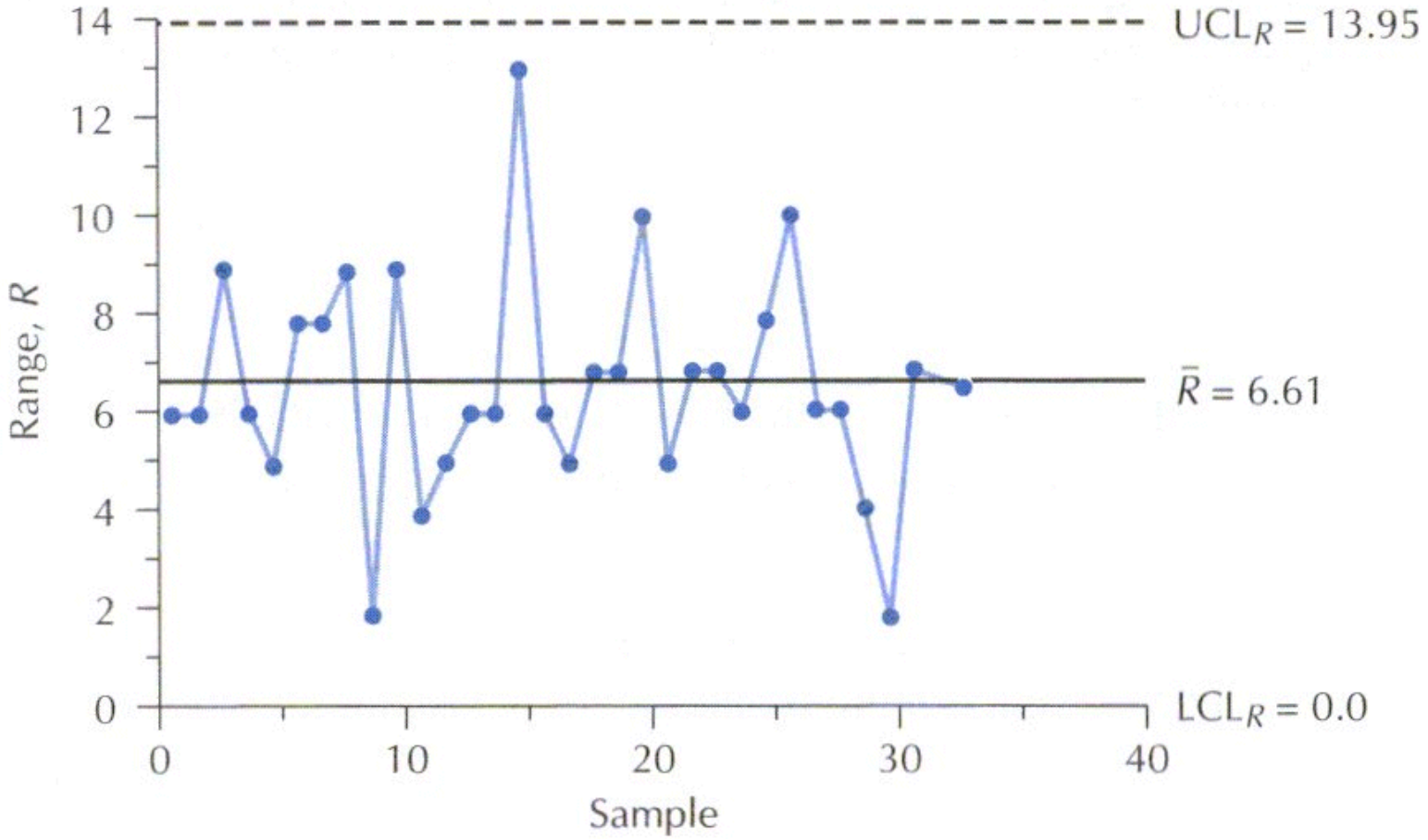
Sample	1	2	3	4	5	$\overline{X}$	R
1	205	202	204	207	205	204.6	5
2	202	196	201	198	202	199.8	6
3	201	202	199	197	196	199.0	6
4	205	203	196	201	197	200.4	9
5	199	196	201	200	195	198.2	6
6	203	198	192	217	196	201.2	25
7	202	202	198	203	202	201.4	5
8	197	196	196	200	204	198.6	8
9	199	200	204	196	202	200.2	8
10	202	196	204	195	197	198.8	9
11	205	204	202	208	205	204.6	6
12	200	201	199	200	201	200.2	2
13	205	196	201	197	198	199.4	9
14	202	199	200	198	200	199.8	4
15	200	200	201	205	201	201.4	5
16	201	187	209	202	200	199.8	22
17	202	202	204	198	203	201.8	6
18	201	198	204	201	201	201.0	6
19	207	206	194	197	201	201.0	13
20	200	204	198	199	199	200.0	6
21	203	200	204	199	200	201.2	5
22	196	203	197	201	194	198.2	7
23	197	199	203	200	196	199.0	7
24	201	197	196	199	207	200.0	10
25	204	196	201	199	197	199.4	5
26	206	206	199	200	203	202.8	7
27	204	203	199	199	197	200.4	7
28	199	201	201	194	200	199.0	6
29	201	196	197	204	200	199.6	8
30	203	206	201	196	201	201.4	10
31	203	197	199	197	201	199.4	6
32	197	194	199	200	199	197.8	6
33	200	201	200	197	200	199.6	4
34	199	199	201	201	201	200.2	2
35	200	204	197	197	199	199.4	7

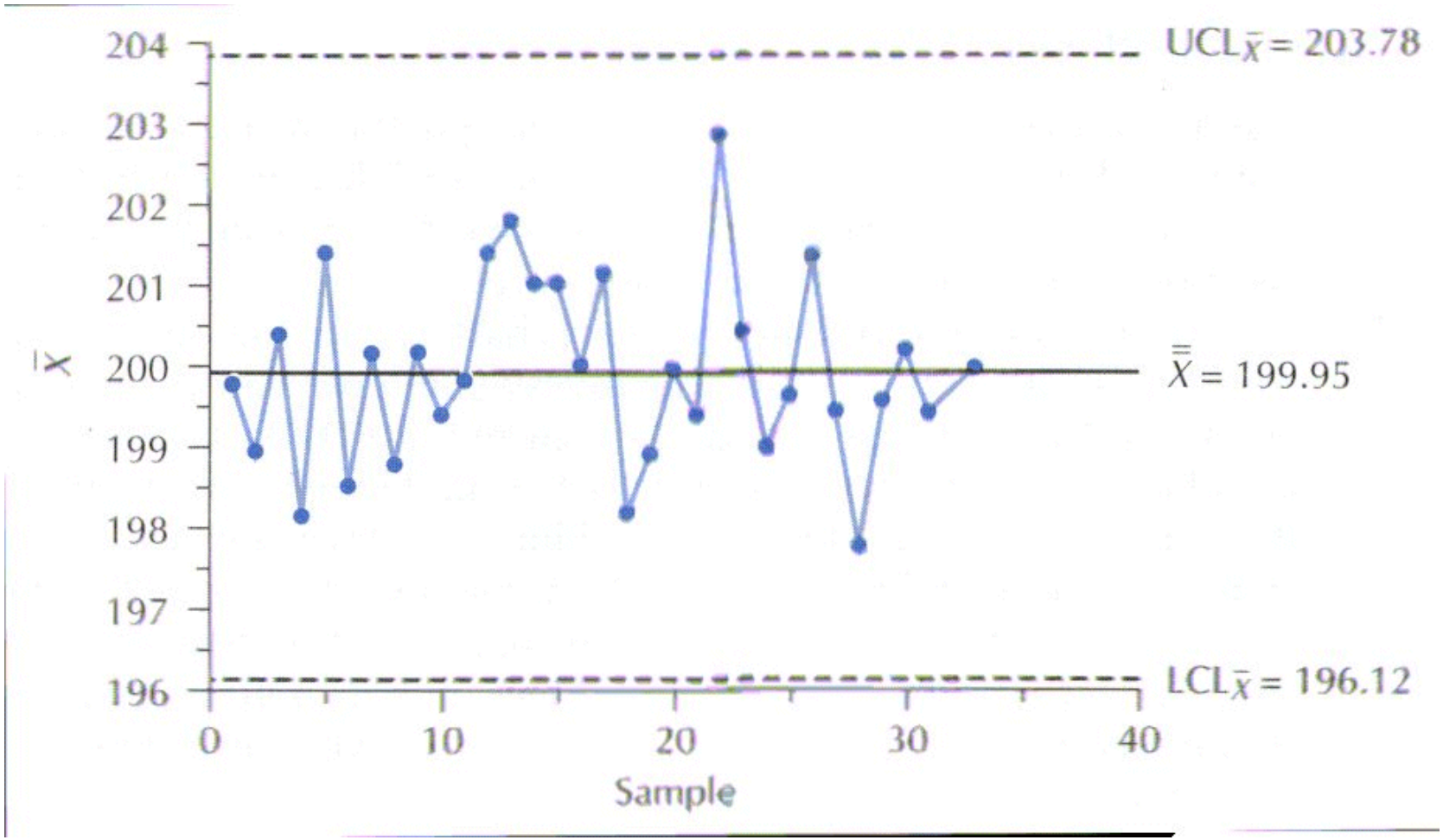
X-double-bar = 199.95
R-bar = 6.61
Process is "in control"

$\hat{\sigma}_X = \bar{R}/d_2$ **= 6.61 / 2.326 = 2.8418**

Histogram shows individuals normally distributed
Specifications are 199 +/- 4 : 195 - 203




14
12
10
8
6
4
2
0
Range, R
UCL$_R$ = 13.95
$\bar{R}$ = 6.61
LCL$_R$ = 0.0
0
10
20
30
40
Sample


204
203
202
201
200
199
198
197
196
$\bar{x}$
$UCL_{\bar{x}} = 203.78$
$\bar{\bar{X}} = 199.95$
$LCL_{\bar{x}} = 196.12$
0
10
20
30
40
Sample

Z(lo) = (195-199.95)/2.8418 = -1.742
prob = .0407

Z(hi) = (203-199.95)/2.8418 = 1.073
prob = .8586

Capability = 85.86% - 4.07% = 81.8%
Process is not capable (want % > 99.73% as a min.)

Would centering the process at the nominal value help??

Could calculate probability for this case as well.

What action should we take??

Specifications & Control Limits

Specification Limits

- Characteristic of the part in question
- Based on functional considerations
- Compare to individual part measurements
- Establish part's conformability to design intent

Control Limits

- Characteristic of the process in question
- Based on process mean and variability
- Dependent on sample size, n, and α risk
- Establish presence/absence or special causes (local faults) in the process

Specifications on Control Charts