EIN 5226

Variable Control Charts

Part B

Chapter 10 Sections 9-14

Need:
Table of control chart factors
Calculator

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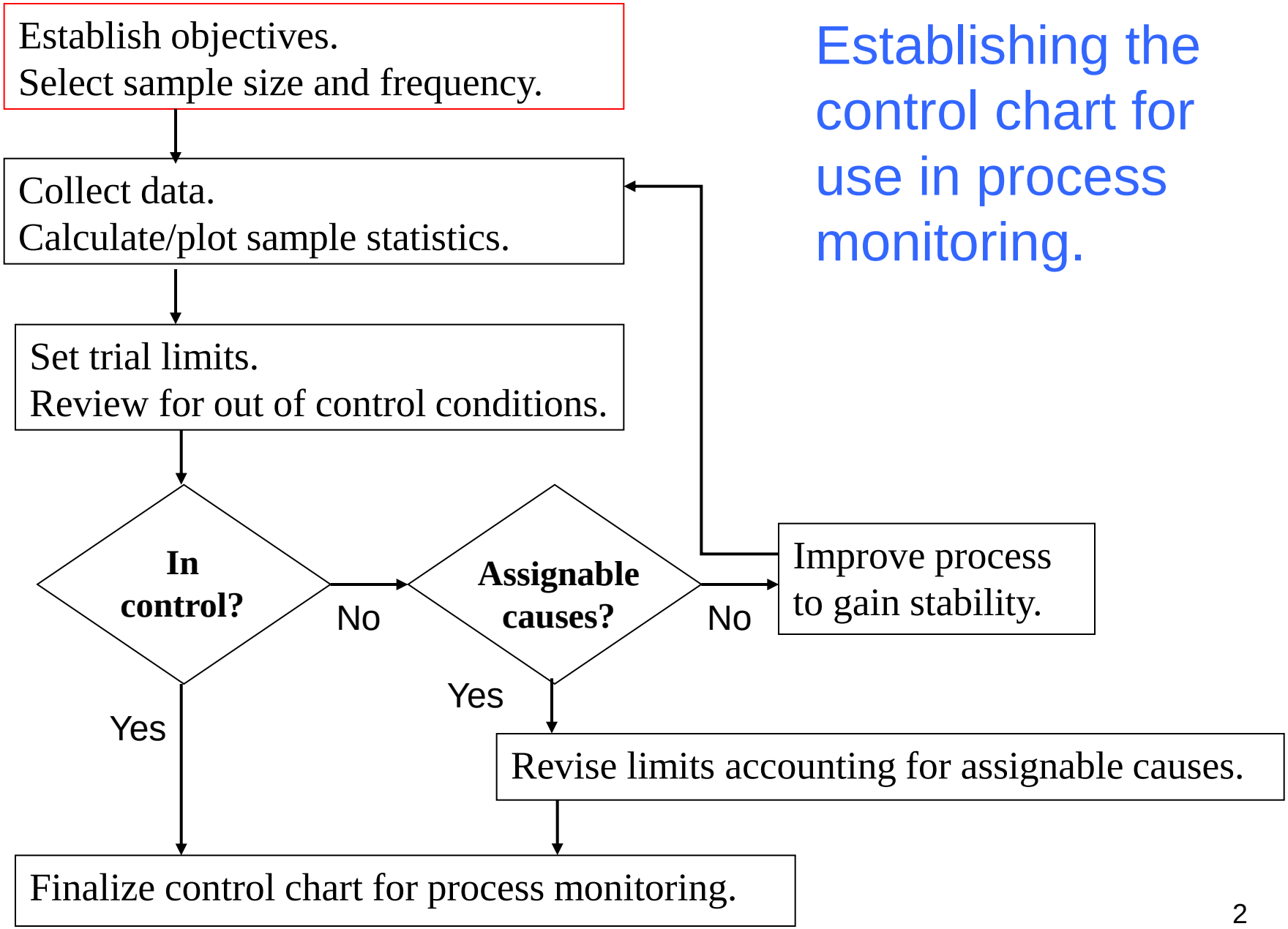
Establishing the control chart for use in process monitoring.



Planning steps

How should you collect the sample?

How large should the sample be?

How frequently should the sample be collected?

Rational sampling

- Combination of the method of selection, size of the sample and sampling frequency
- Considers the objectives of sampling and cost

Rational Subgrouping

Rational subgrouping

- Sample with relatively homogeneous conditions within the subgroup.
- Common cause variation is reflected in the range (or standard deviation) of the sample
- Assignable causes arise between subgroups, and thus show up on the $\bar{x}$ chart.

Rational Subgrouping

Under rational subgrouping

Subgroup should consists of items produced at approximately the same time, under the same conditions.

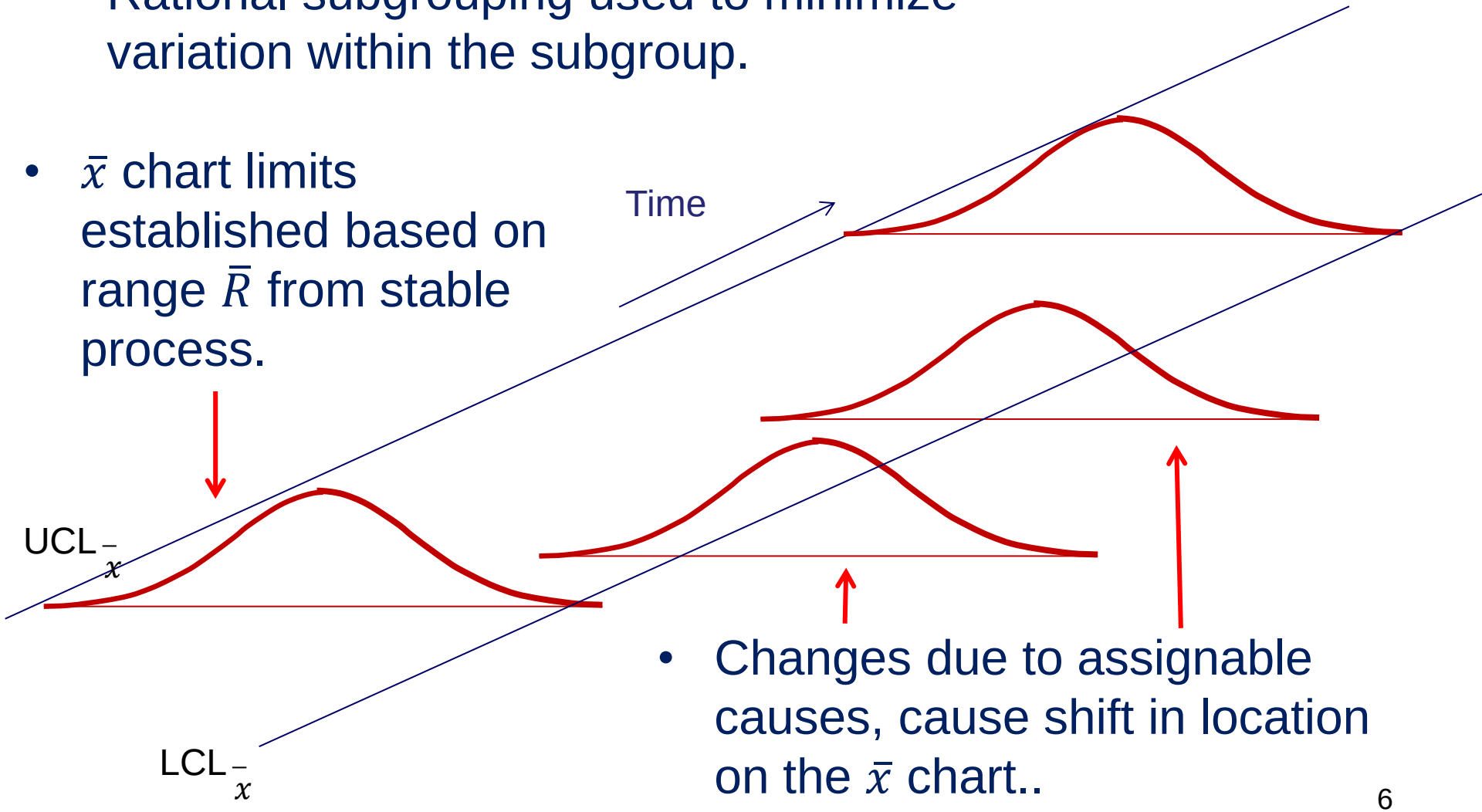
- Same material, procedures, machine, operator

Subgroup should not have known and predictable differences.

Rational Subgrouping

- Rational subgrouping used to minimize variation within the subgroup.

- $\bar{x}$ chart limits established based on range $\bar{R}$ from stable process.



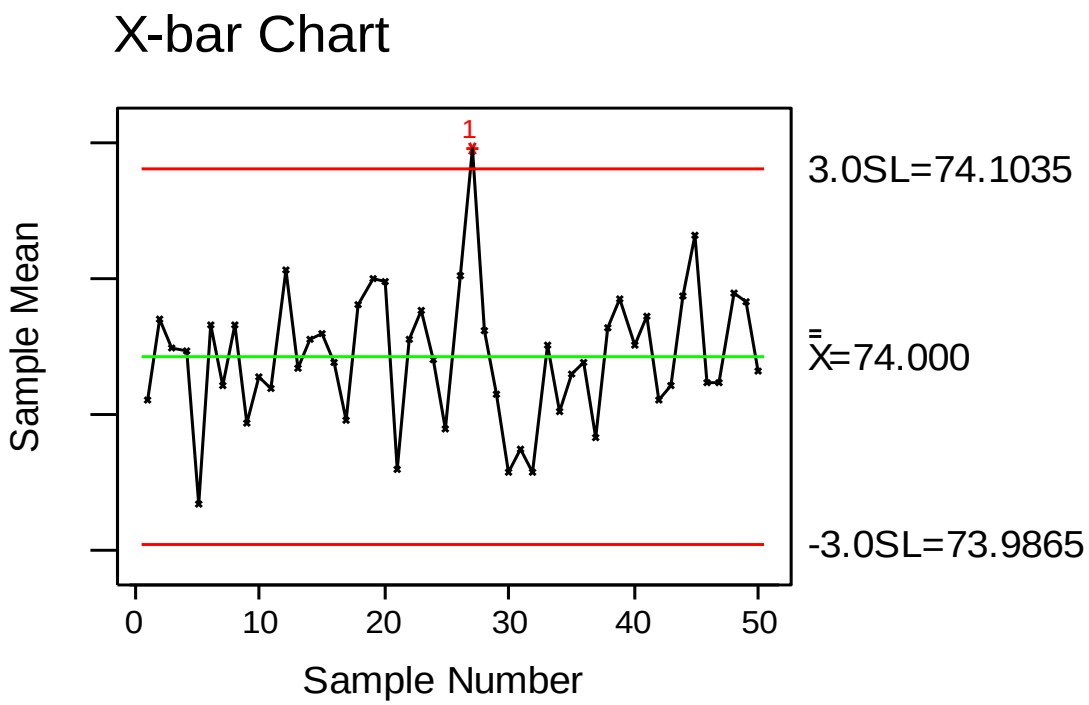
- Changes due to assignable causes, cause shift in location on the $\bar{x}$ chart..

When designing a control chart you must

- Determine the sample size to be selected
- Specify the frequency of selection

It's a matter of cost

- Cost to sample
- Cost to investigate when we do not need to investigate.
- Cost of the process shifting on us and us not detecting it.



Cost to investigate when we do not need to investigate.

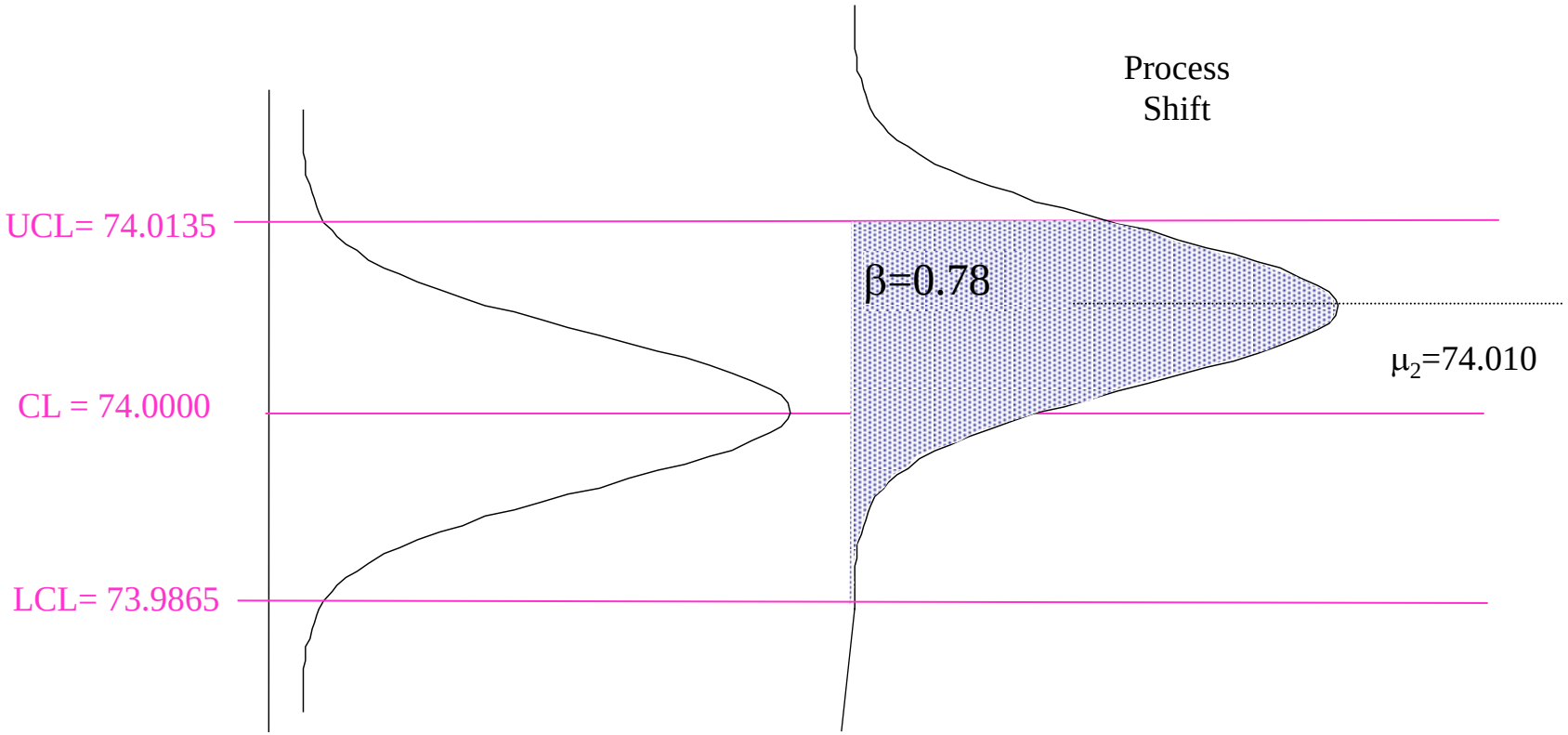
- Point outside the control limits when the process has not changed.
- Type I Error (α) - Concluding the process has changed when it has not.
- How much does it cost to investigate this?
- How often is it acceptable for this to happen?

Cost of the process shifting and we do not detect it.

- A point lies inside the control limits when the process has really changed.
- Type II Error (β) - Concluding the process has not shifted when it has.
- How far can a process shift before we are greatly concerned?
- What would be the consequences of not detecting a shift right away?
- How erratic or stable is the process.

Type II error - β

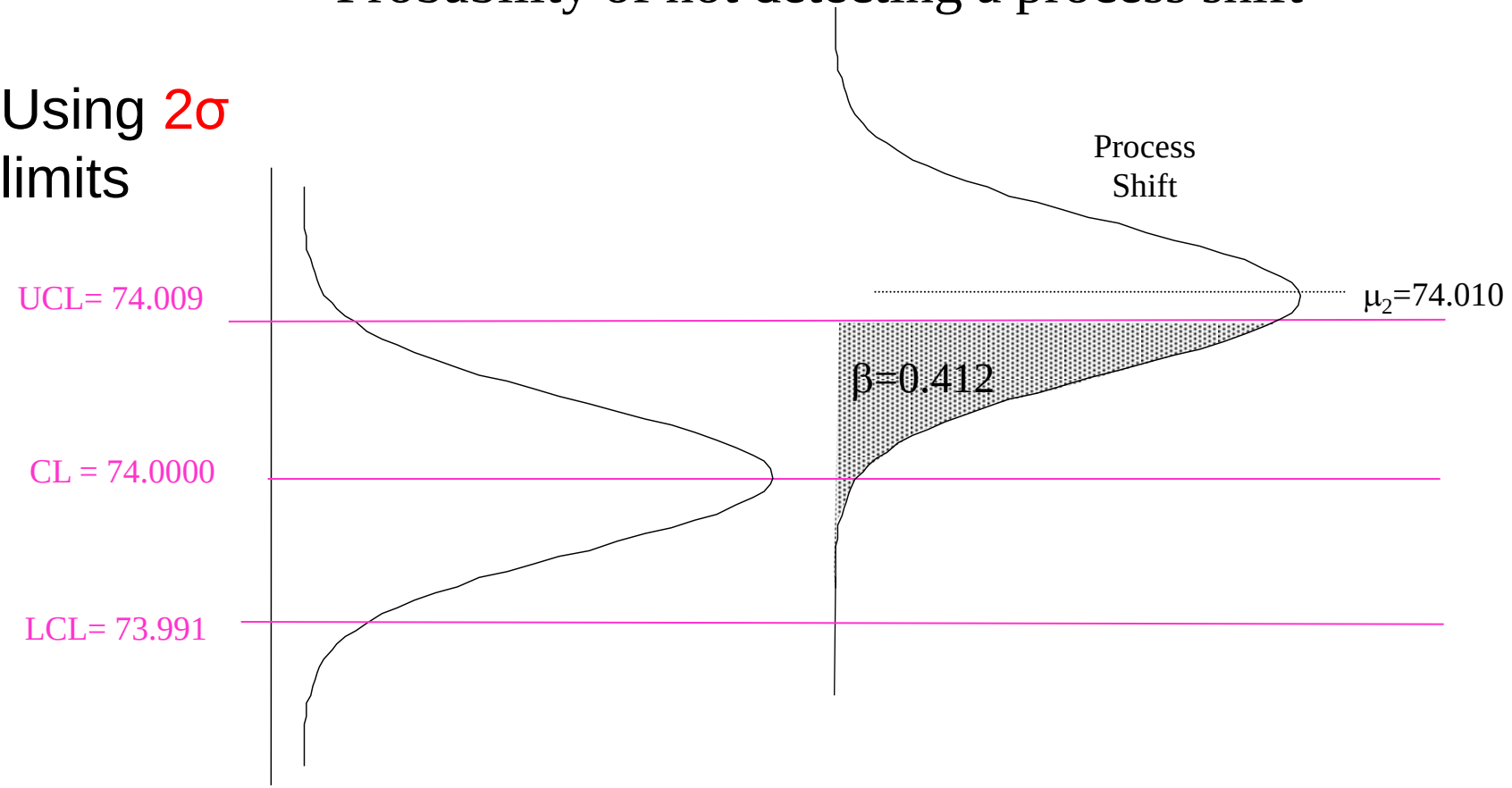
Probability of not detecting a process shift



Type II error - β

Probability of not detecting a process shift

Using 2σ limits



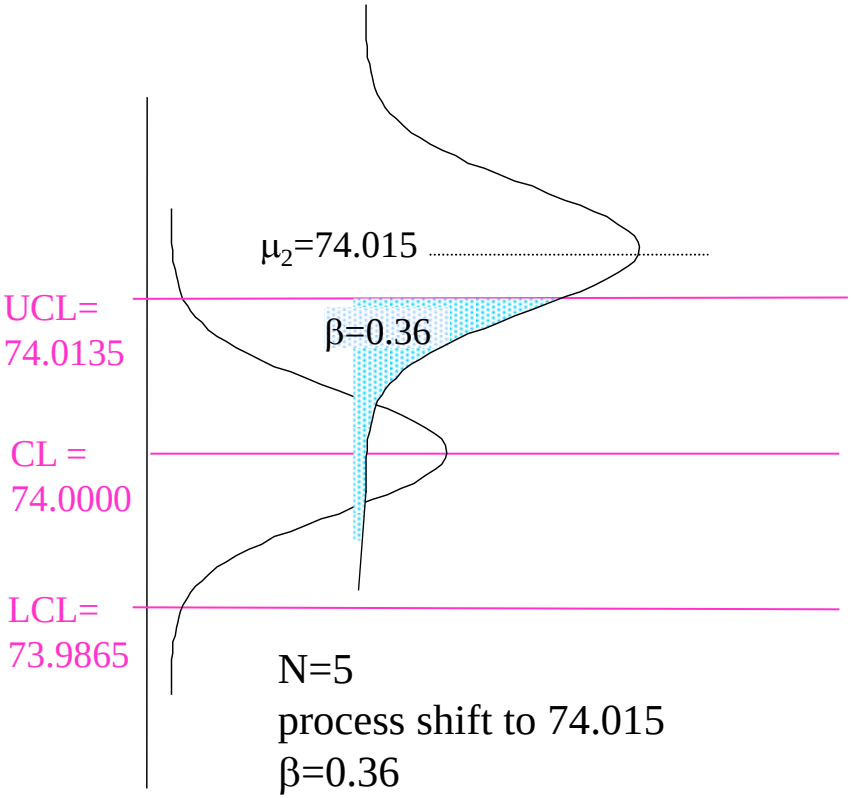
If use 2σ limits instead of three:

- Reduce Type II error – more likely to catch process shift
- Increase Type I error – about 5% of out of limit points will not be due to special causes.

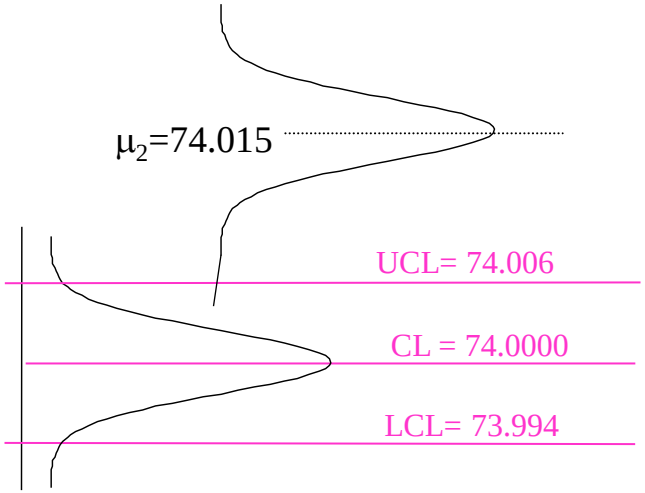
Type II error - β

Probability of not detecting a process shift

Impact of sample size on the control chart



N=5
process shift to 74.015
β=0.36



N=25
process shift to 74.015
β=0.000003

Comprehension

T / F The reason when increasing the sample size, that control limits are more narrow is due to the central limit theorem.

In using control charts, which of the following can be done to more quickly detect a process shift?

A. Sample more frequently

B. Increase the sample size

C. Use control limits at less than 3σ

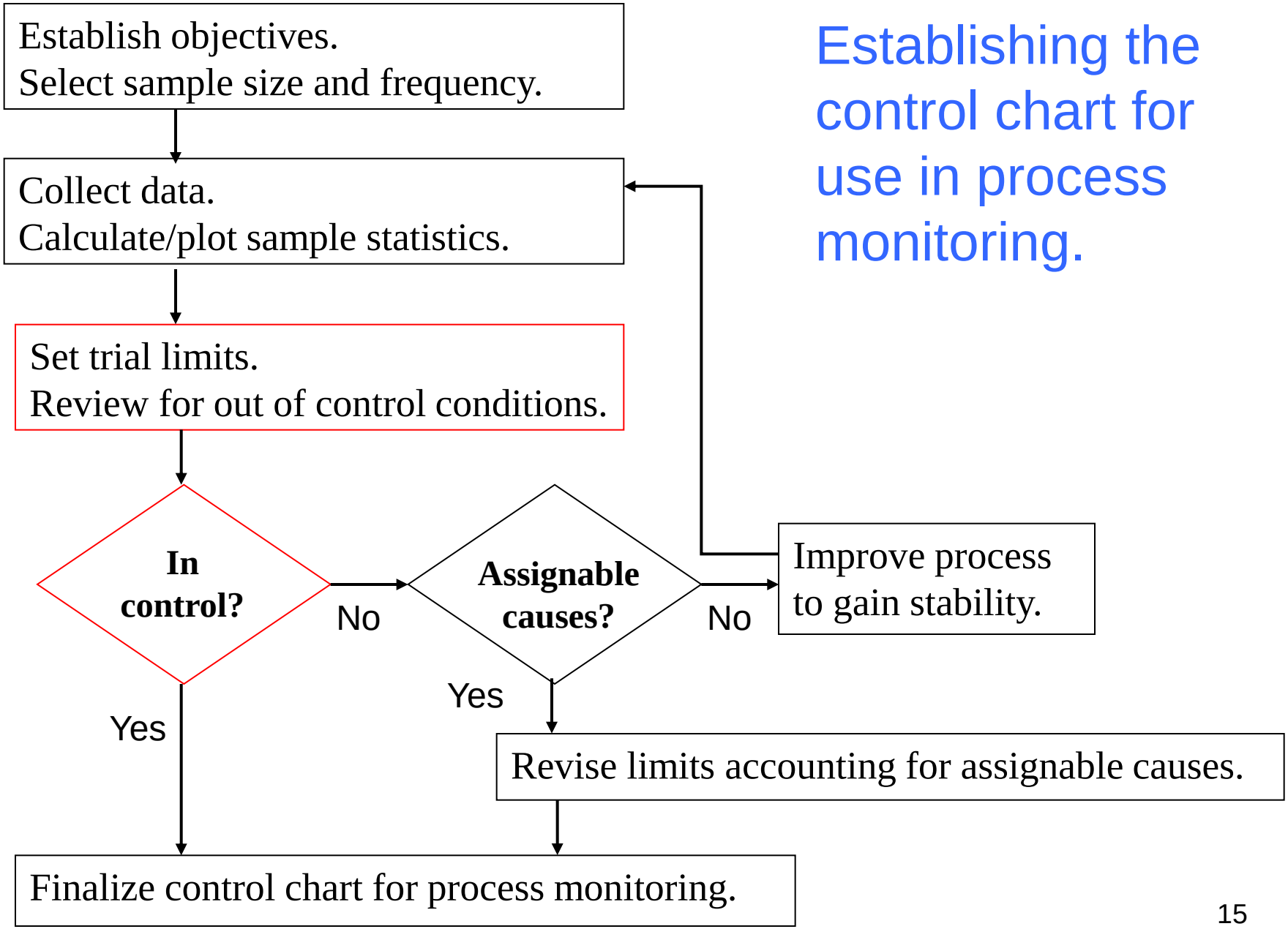
D. All of the above.

Sample Size and Frequency

KNOW YOUR PROCESS!

- How stable is the process?
- How capable is the process?
- How often is it likely to shift?
- What is the cost of sampling?
- What is the impact of missing a process shift?

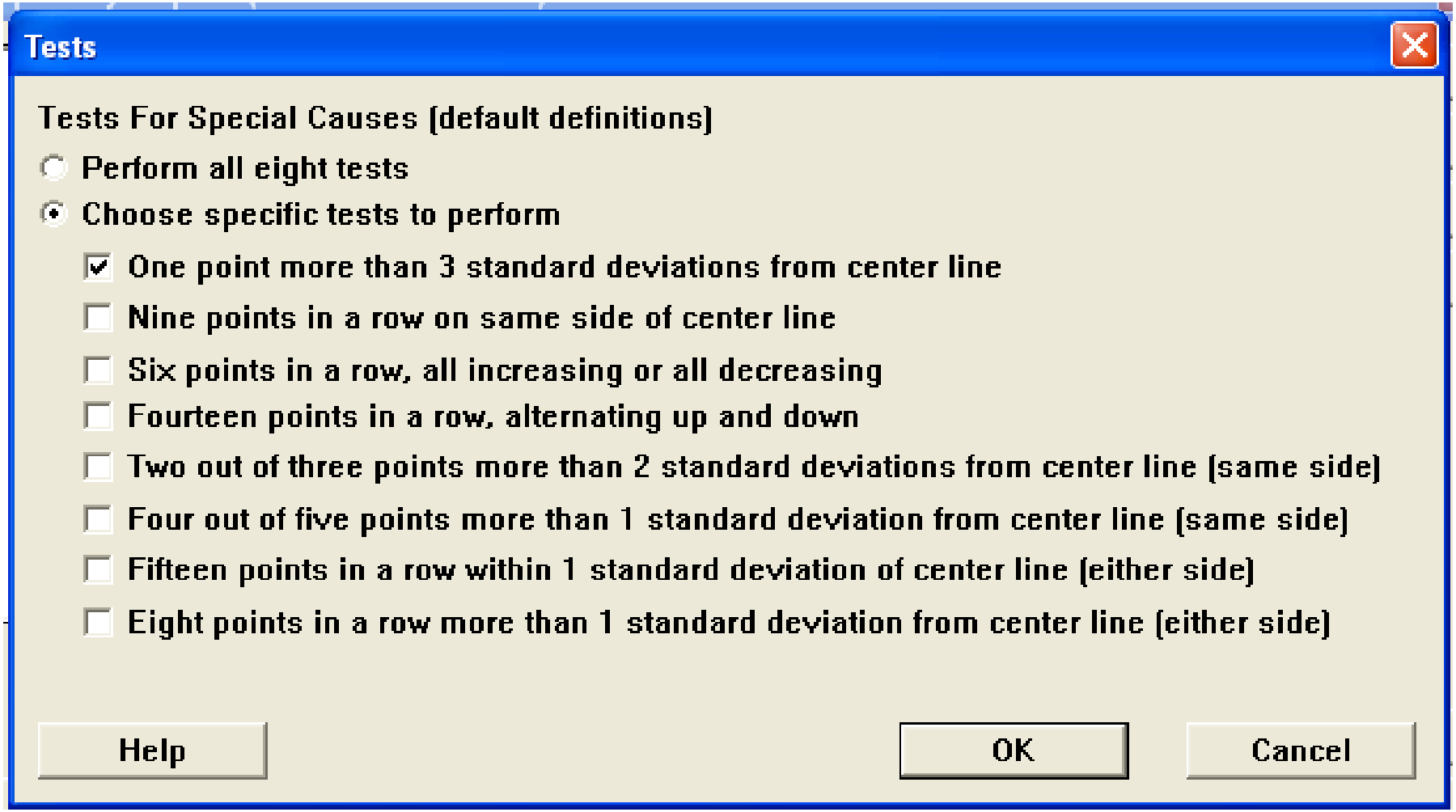
Establishing the control chart for use in process monitoring.

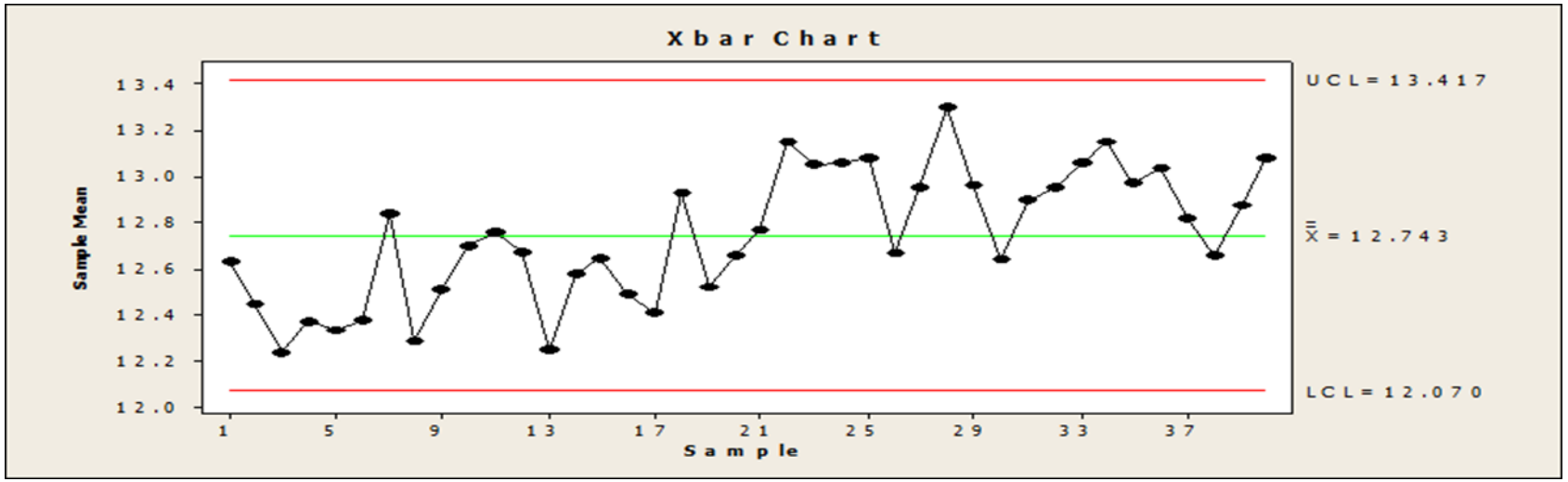


Deviation from a stable system

Potential signals on the control chart

- Point out of the control limits
- Shift or run
- Trend or drift
- Non-random behavior such as cycles
- Non-normal behavior – such as more points further from center line than close


Tests
Tests For Special Causes (default definitions)
Perform all eight tests
Choose specific tests to perform
One point more than 3 standard deviations from center line
Nine points in a row on same side of center line
Six points in a row, all increasing or all decreasing
Fourteen points in a row, alternating up and down
Two out of three points more than 2 standard deviations from center line (same side)
Four out of five points more than 1 standard deviation from center line (same side)
Fifteen points in a row within 1 standard deviation of center line (either side)
Eight points in a row more than 1 standard deviation from center line (either side)
Help
OK
Cancel



Tests For Special Causes (default definitions)

- ○ Perform all eight tests
- ◉ Choose specific tests to perform
  - ☑ One point more than 3 standard deviations from center line
  - ☐ Nine points in a row on same side of center line
  - ☐ Six points in a row, all increasing or all decreasing
  - ☐ Fourteen points in a row, alternating up and down
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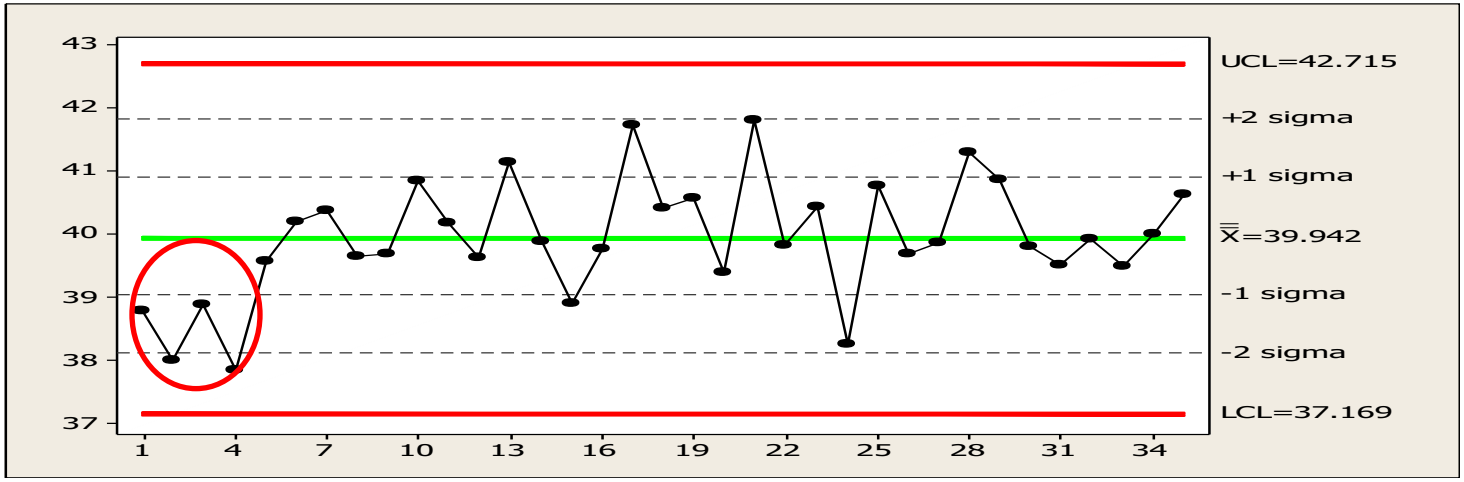
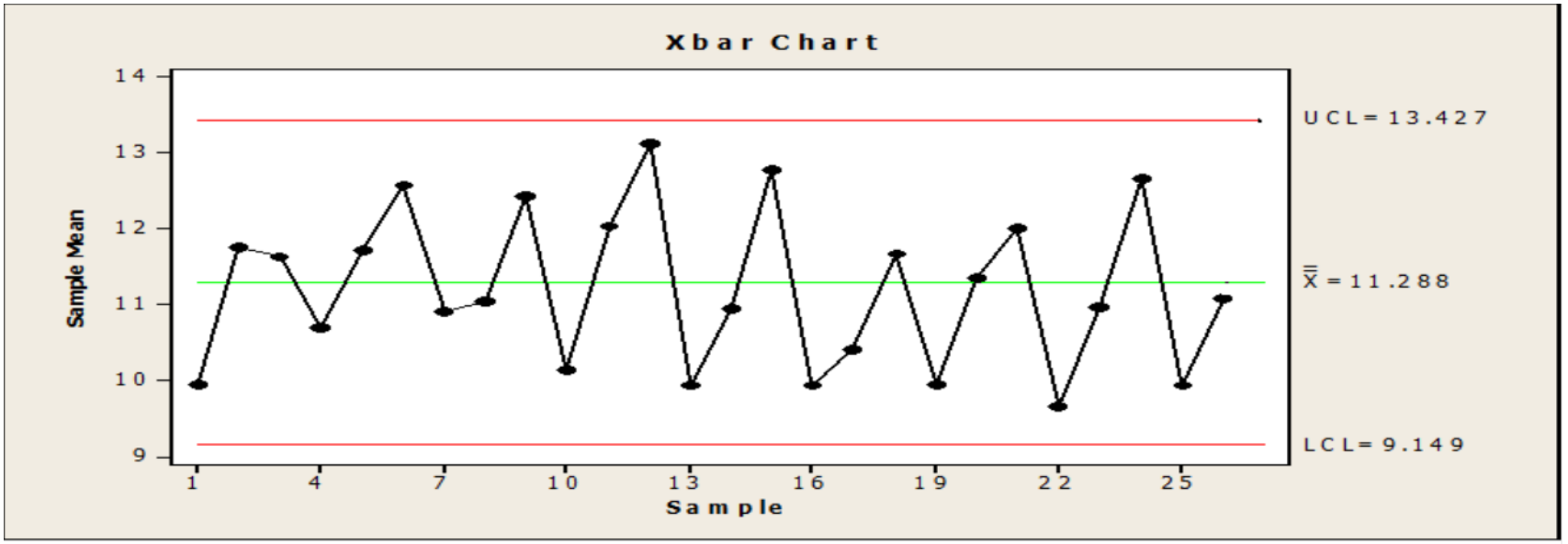
  - ☐ Eight points in a row more than 1 standard deviation from center line (either side)



What is the probability that two points out of three will be beyond a 2 sigma on the same side?

Probability of a point being beyond 2 sigma limit
= (1-.95)/2 = .025
Combinations of 2 out of 3 = 3 (XXO XOX OXX)
Probability of any one of those combinations
= (.025)(.025)(1-.025) = .00061
Times three possible combinations
= 3 (.00061) = .00183 >> 0.18%



T / F
The Minitab rules would not identify this cycle.

Tests For Special Causes (default definitions)

- ○ Perform all eight tests
- ◉ Choose specific tests to perform
  - ☑ One point more than 3 standard deviations from center line
  - ☐ Nine points in a row on same side of center line
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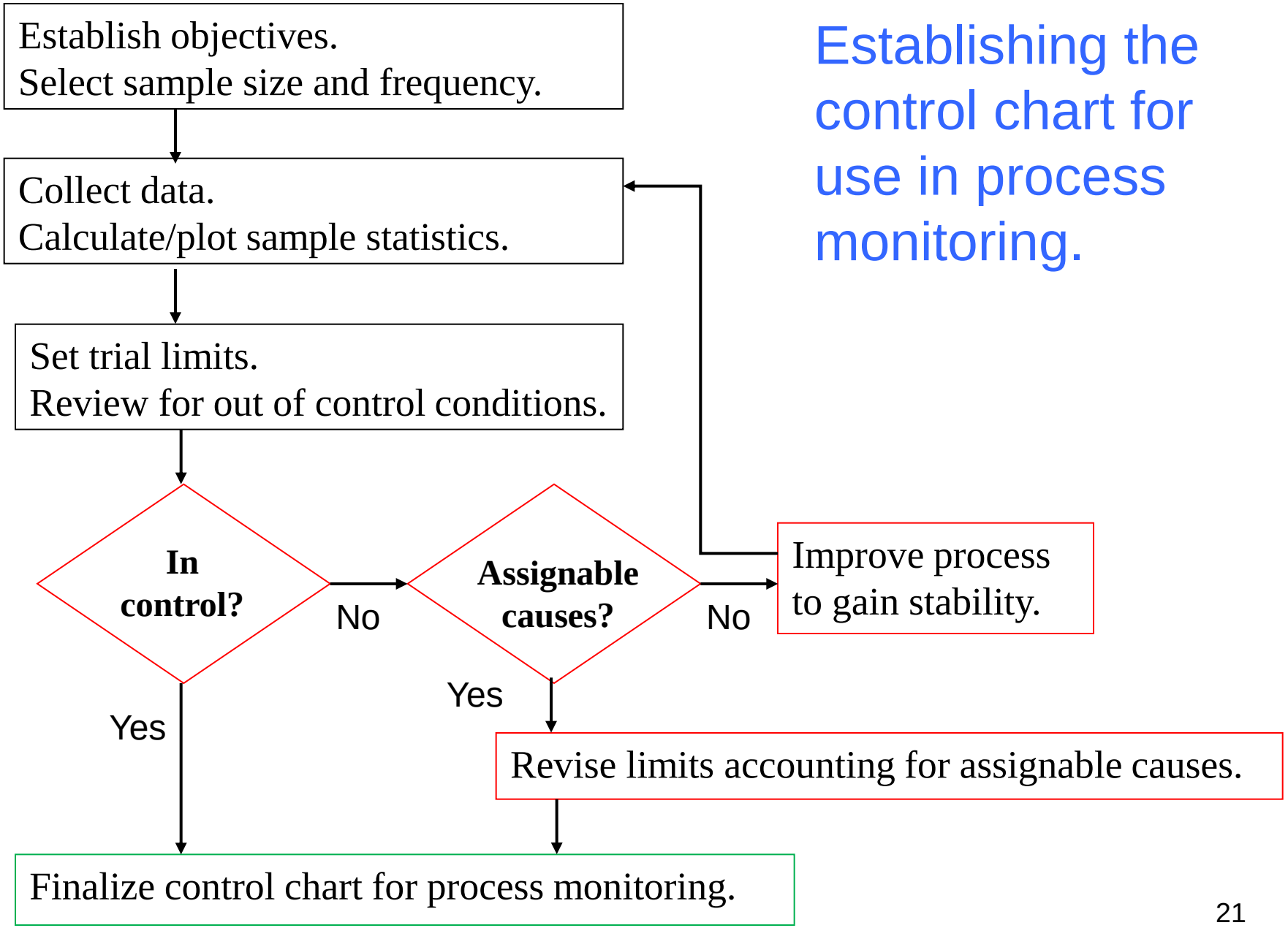
Establishing the control chart for use in process monitoring.



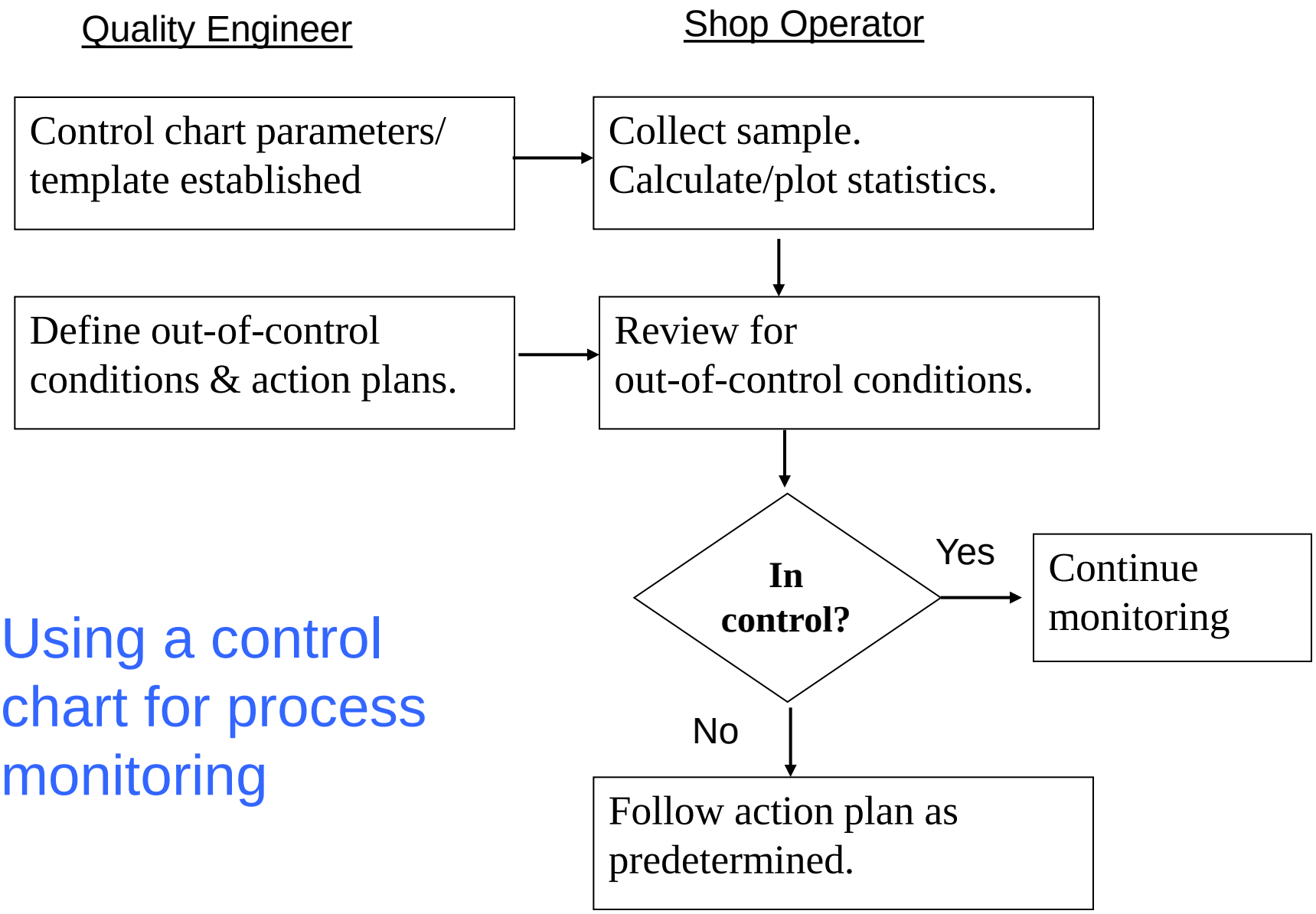
Statistical Process Control (SPC)

Control Charts

Charts used for real time process monitoring

- Limits on chart s are those established by stable process- one with only common cause variation
- Additional sample statistics plotted during process operation
- As points added, charts reviewed for deviation from stable process
- Looking for assignable causes of variation so that action can be taken to prevent reoccurrence of negative causes.

Using a control chart for process monitoring



Practice Problem

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R} \qquad UCL_R = D_4\bar{R}$$

$$CL_{\bar{x}} = \bar{\bar{x}} \qquad CL_R = \bar{R}$$

$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R} \qquad LCL_R = D_3\bar{R}$$

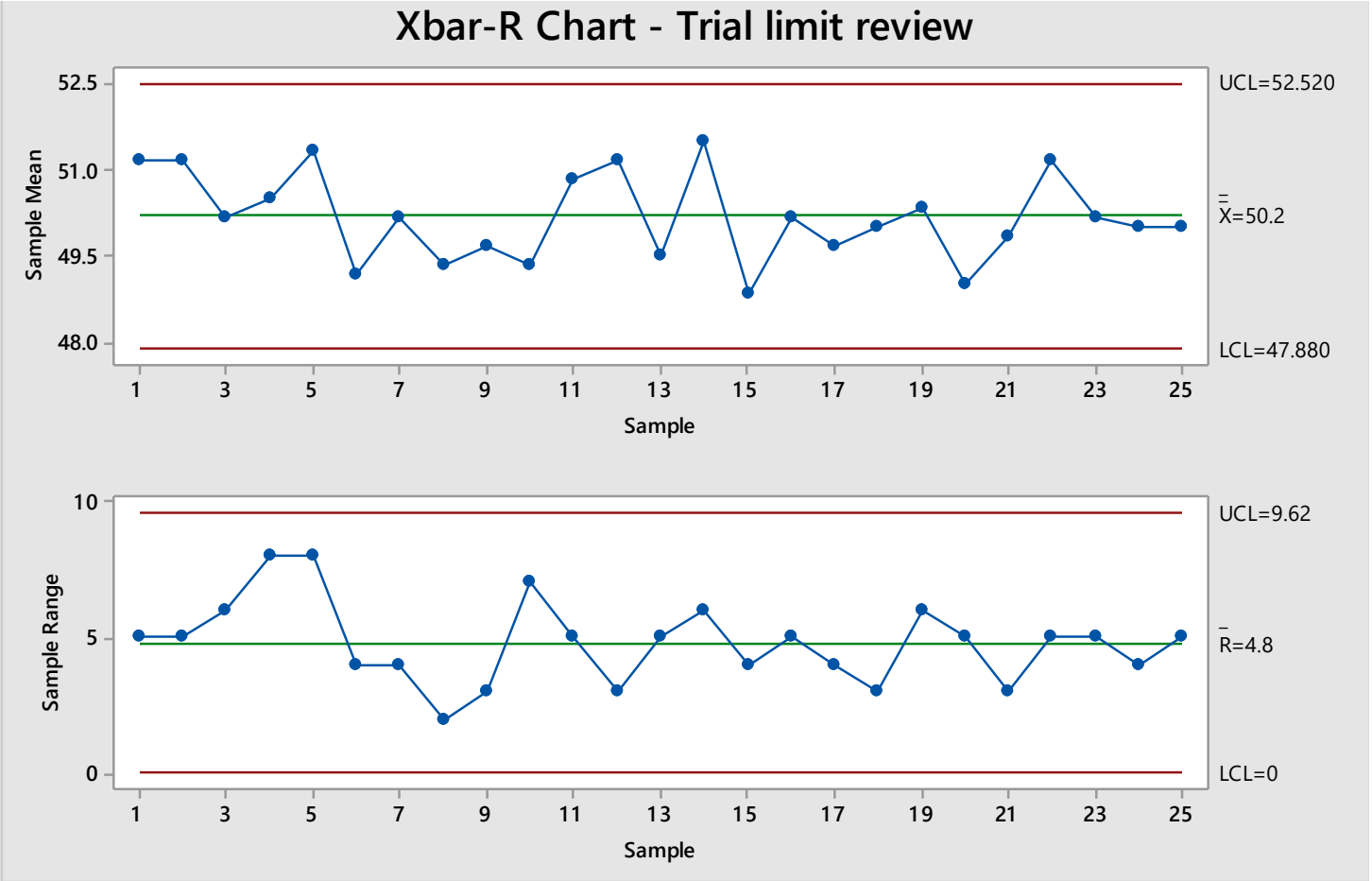
The quality control plan for a certain production process is to be developed taking samples of size 6.
25 samples are taken. $\bar{\bar{X}}$ and $\bar{R}$ were determined to be 50.2 and 4.8 respectively.

The upper and lower control limits on the xbar chart are

	$UCL_{\bar{x}}$	$LCL_{\bar{x}}$		$UCL_{\bar{x}}$	$LCL_{\bar{x}}$
A)	52.52	47.88	B)	52.97	47.43
C)	53.18	47.22	D)	56.38	44.02

The upper and lower control limits on the R chart are

	UCL_R	LCL_R		UCL_R	LCL_R
A)	10.15	0	B)	9.51	0.36
C)	9.62	0	D)	9.24	0.36



The data collected from the process is plotted against the trial limits. From review of the charts, the next step is to

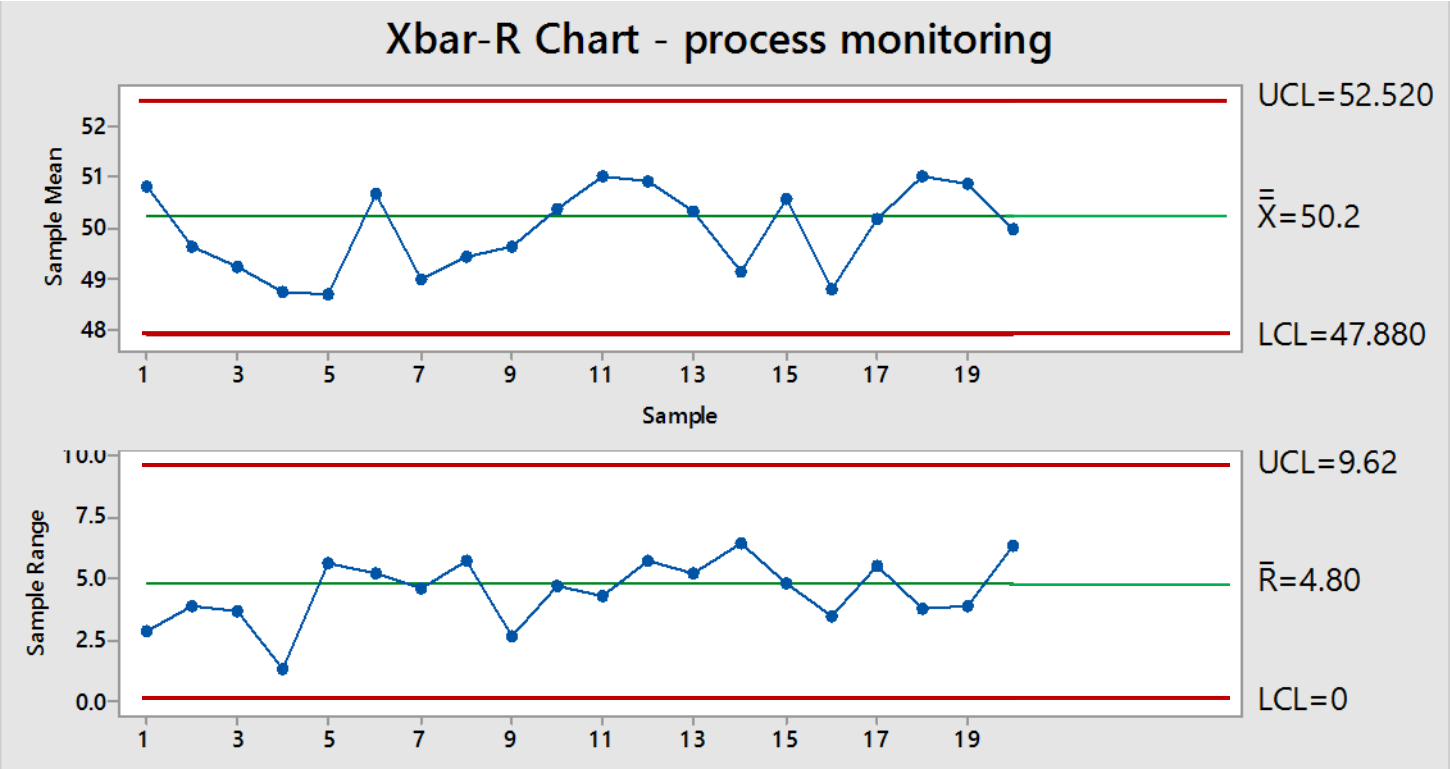
A. Finalize the limits and create template for process monitoring

B. Investigate the special causes identified.

Out of control Conditions Defined (for Operator)

Stop production and notify your supervisor if any of the following conditions occur:

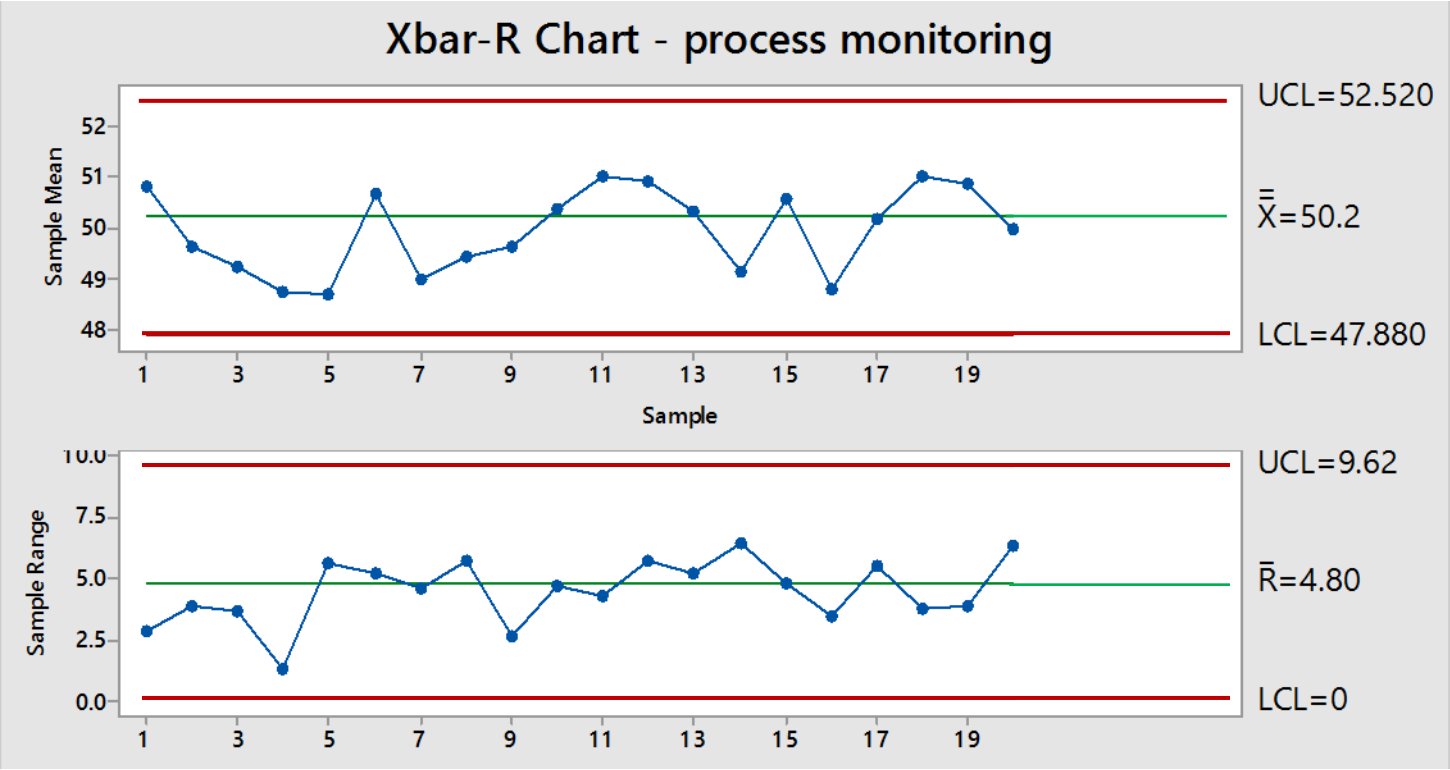
- Point falls outside of the control limits.
- 7 points in a row on same side of the centerline.
- 6 points in a row increasing or decreasing.



The chart is placed into production and the operator plots points as required per the sample plan. So far,

A. The process appears to continue to be stable.

B. One or more special causes need to be investigated.



The next sample taken includes values of 46, 49, 49, 56, 50, 48.

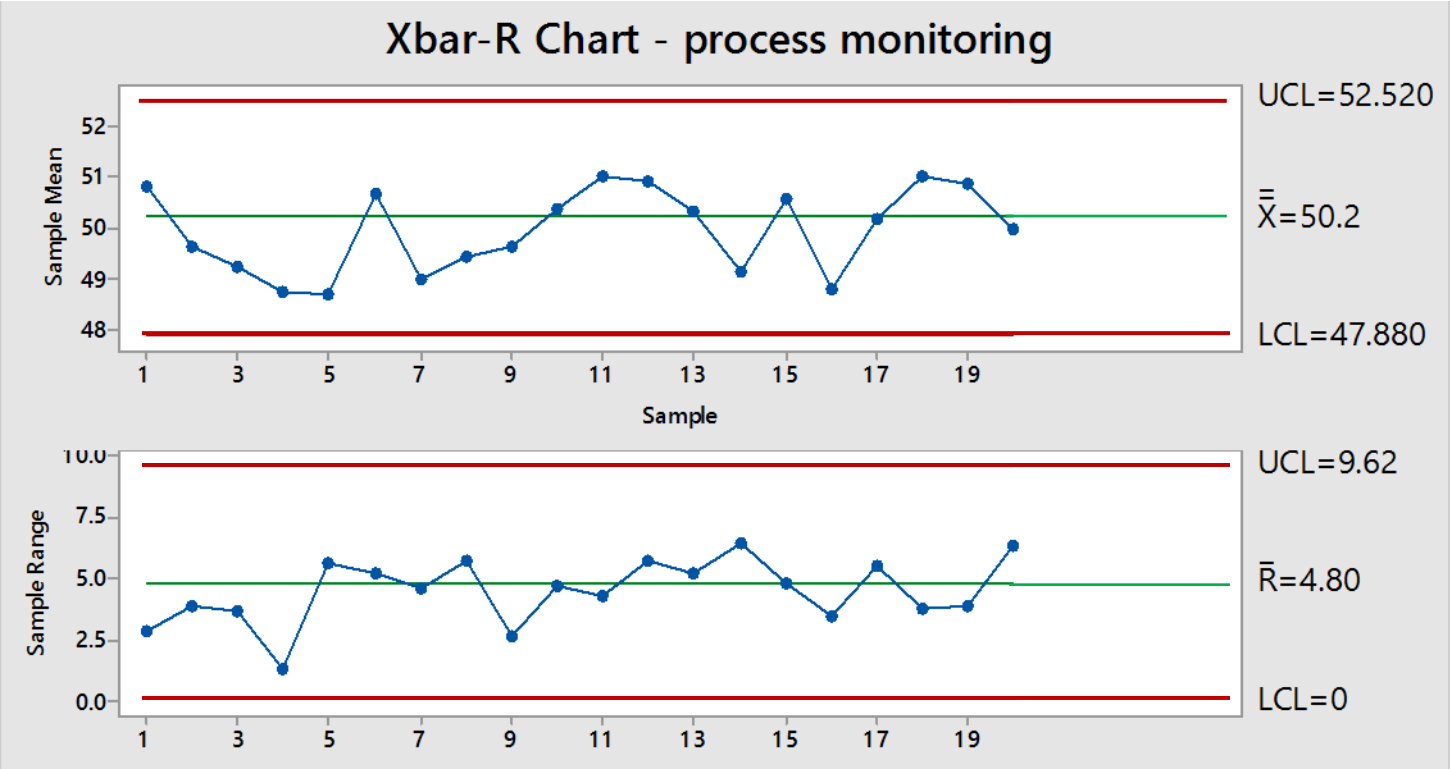
The value which should be plotted on the $\bar{x}$ chart is

A. 49 B. 49.7 C. 56 D. 50

Action which should be taken relative to the $\bar{x}$ chart is

A. No action. The sample average is within the control limits.

B. The operator should notify the supervisor because several of the individual sample values were outside the limits.

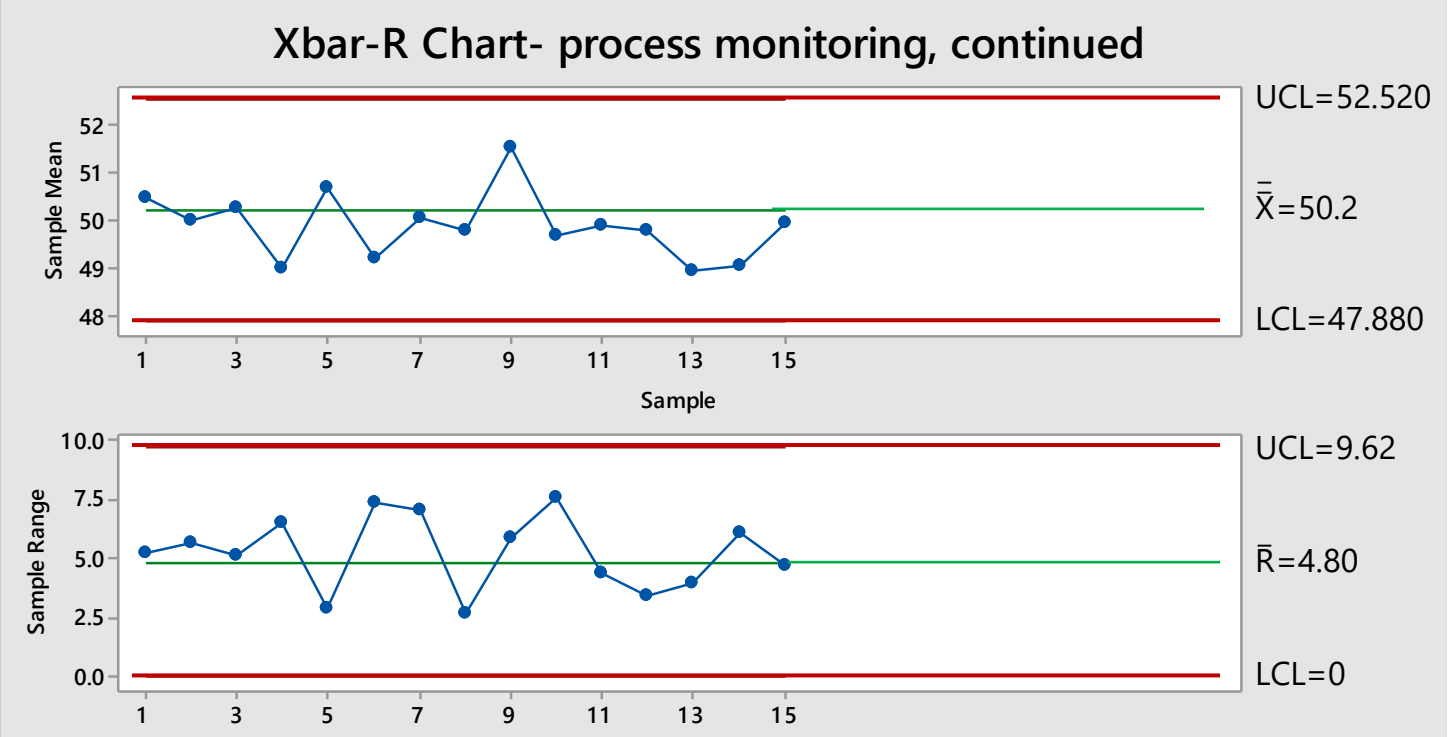


The next sample taken includes values of 46, 49, 49, 56, 50, 48.

Action which should be taken relative to the r chart is

A. No action. The sample range is within the control limits.

B. The operator should notify the supervisor because the sample range is above the upper control limit..

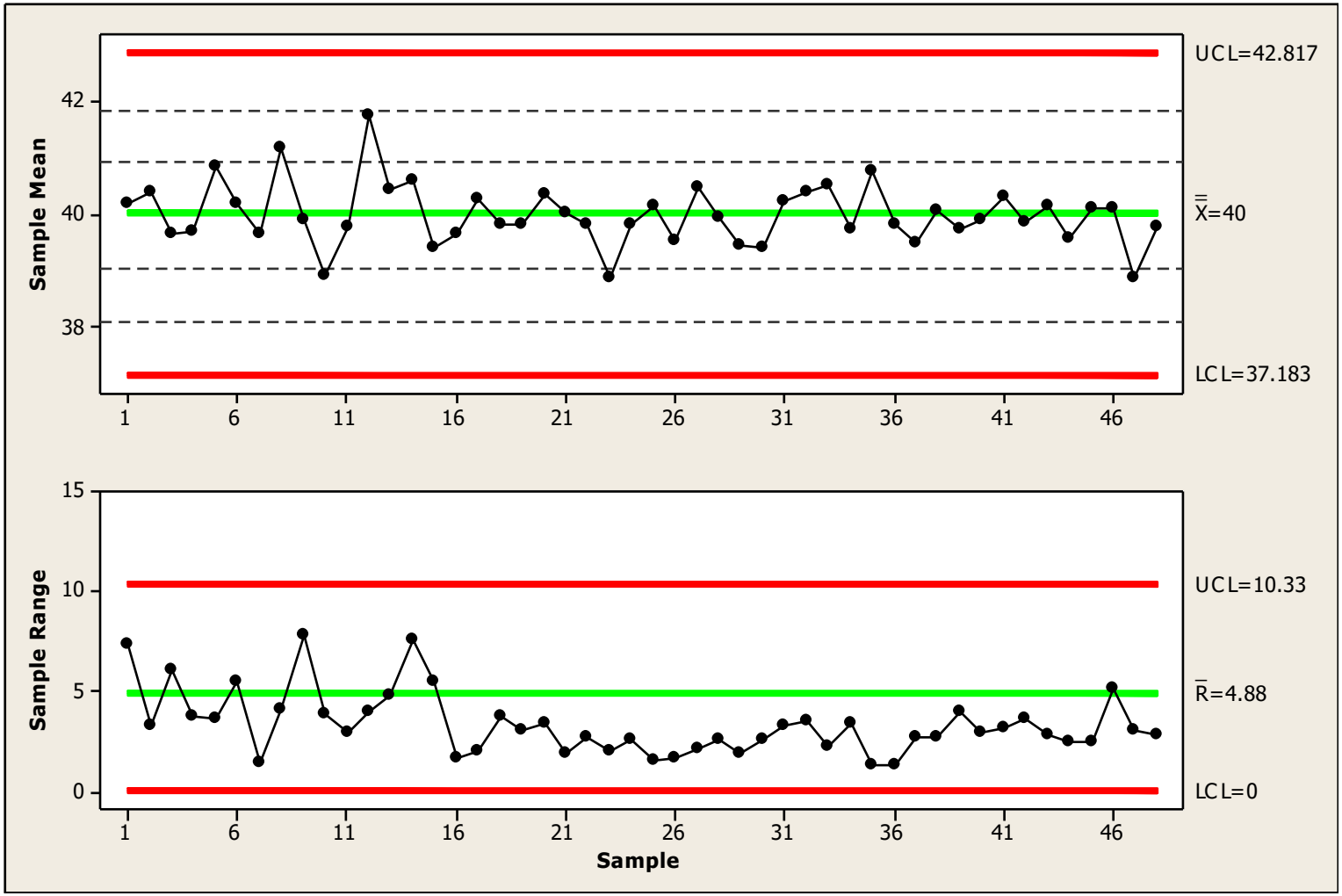


Process monitoring continues. The next sample for the chart above includes values of 48, 52, 49, 56, 51, and 50. Action which should be taken relative based on the new sample is

A. No action. Special cause conditions defined are not met.

B. Notify supervisor because the sample mean is below the centerline giving 7 points in a row below.

C. Notify supervisor because the sample range is above the upper control limit.


Sample Mean
42
40
38
UCL=42.817
$\bar{\bar{X}}$=40
LCL=37.183
1
6
11
16
21
26
31
36
41
46
Sample Range
15
10
5
0
UCL=10.33
$\bar{R}$=4.88
LCL=0
Sample

Purpose of Control Charts

<u>During initial establishment</u>

Verity process is stable/in statistical control

Identify need for actions to gain control

Provide inputs for process capability analysis

<u>During process monitoring</u>

Identify special causes of variation

Negative causes

- Identify need for action to prevent reoccurrence

Positive causes

– Initiate action where possible to repeat

Related Assignments

Please see Blackboard for associated assignments..