CHAPTER 6

Control Charts for Attributes

Expected Outcomes

Know limitations of variable control charts and the different types of attibute charts.
Know the objectives of the p chart group and the applicable distribution.
Be able to construct a:
Fraction defective chart- fixed subgroup size
Fraction defective chart-variable subgroup size
Percent defective chart
Number defective chart

Attribute

- The term Attribute refers to those quality characteristics that conform to specifications or do not conform to specifications.

Attribute are used:

- Where measurements are not possible.
- Where measurements can be made but are not made because of time, cost, or need.

Attribute

Types of Attribute Charts:

1. Nonconforming Units (based on the Binomial distribution): *p* chart, *np* chart.
2. Nonconformities (based on the Poisson distribution): *c* chart, *u* chart.

The P Chart

- The *P* Chart is used for data that consist of the proportion of the number of occurrences of an event to the total number of occurrences.
- It is used in quality to report the fraction or percent nonconforming in a product, quality characteristic, or group of quality characteristics.

The P Chart

Formula:

$$p = \frac{np}{n}$$

- The fraction nonconforming, *p*, is usually small, say, 0.10 or nonconforming is very small, the subgrless.
- Because the fraction oup sizes must be quite large to produce a meaningful chart.

The P Chart

- It can be used to control one quality characteristic, as is done with X bar and R chart,
- Or to control a group of quality characteristics of the same type or of the same part,
- Or to control the entire product.
- It can be established to measure the quality produced by a work center, by a department, by a shift, or by an entire plant.

The P Chart

Objectives of the *P* Chart:

1. Determine the average quality level: This information provides the process capability in terms of attributes.
2. Bring to the attention of management any changes in the average.
3. Improve the product quality: Ideas for quality improvement.

The P Chart

P-Chart Construction for Constant Subgroup Size

1. Select the quality characteristic(s):
   a) Single quality characteristic.
   b) Group of quality characteristics.
   c) A part.
   d) An entire product.
   e) A number of products.
   f) It can be established for performance control of an operator, work center, department, shift, plant, or corporation

The P Chart

P Chart Construction for Constant Subgroup Size cont'd.

2. Determine the subgroup size and method:
   - The size of the subgroup is a function of the proportion nonconforming.
   - A minimum size of 50 is suggested as a starting point.

The P Chart

P Chart Construction for Constant Subgroup Size cont'd.

3. Collect the data:
   - At least 25 subgroups.
   - Different sources (Check sheet).
   - For each subgroup the proportion nonconforming is calculated by the formula $P = np/n$

The P Chart

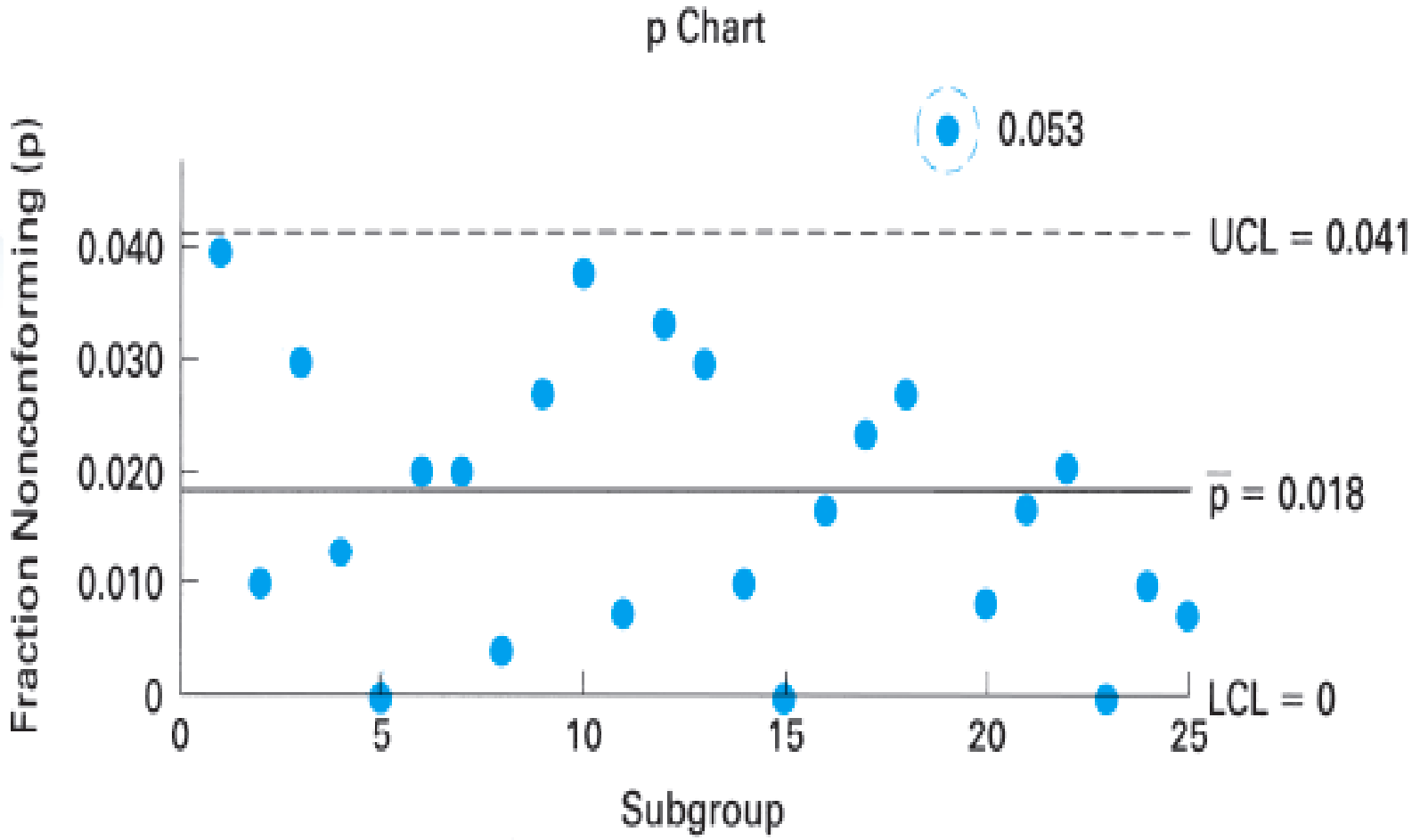
P Chart Construction for Constant Subgroup Size

4. Calculate the trial central line and the control limits:

$$\bar{p} = \frac{\sum np}{\sum n}$$

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$


p Chart
0.053
UCL = 0.041
$\bar{p}$ = 0.018
LCL = 0
Fraction Nonconforming (p)
0.040
0.030
0.020
0.010
0
0
5
10
15
20
25
Subgroup

The P Chart

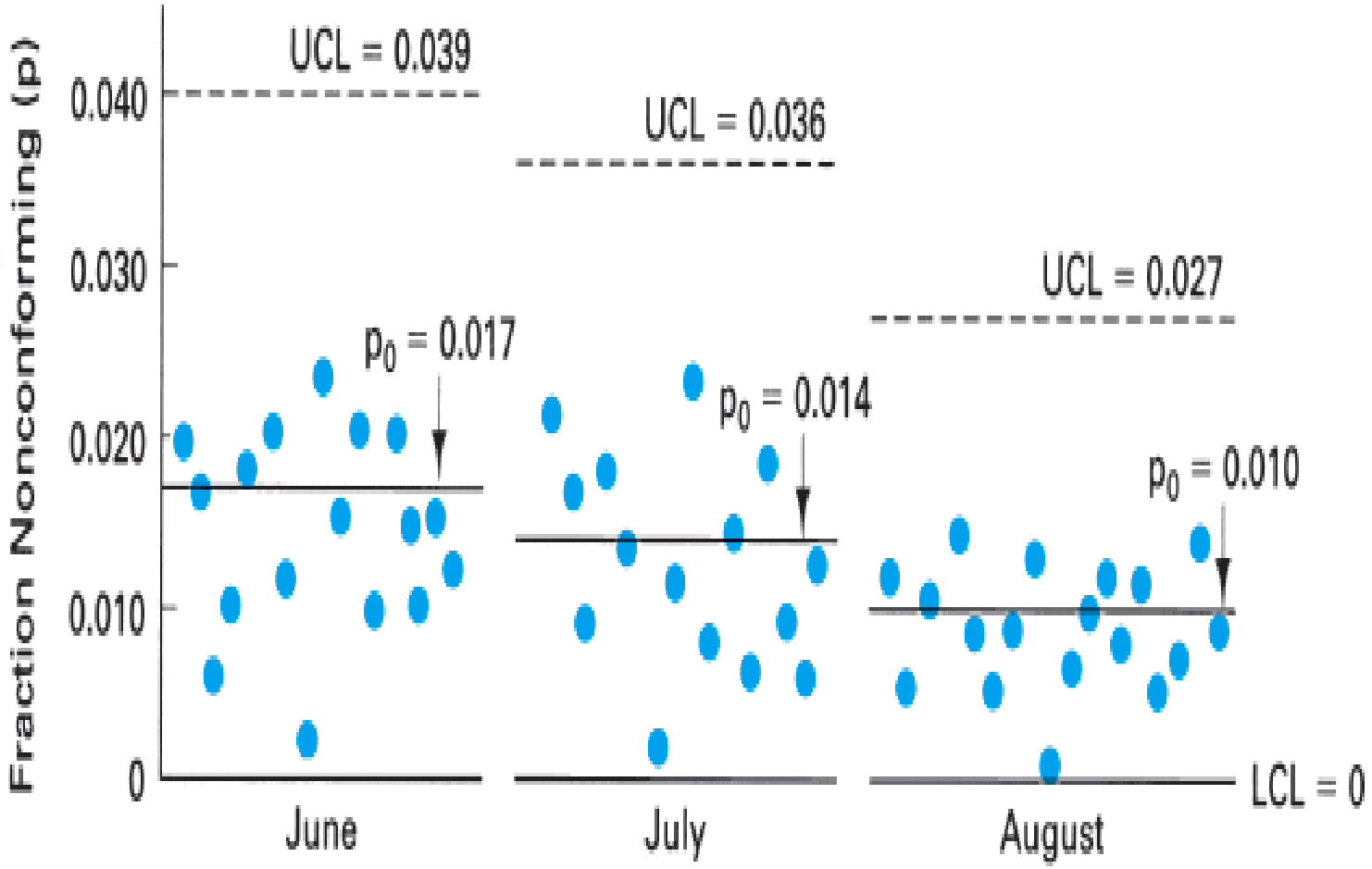
P Chart Construction for Constant Subgroup Size cont'd.

5. Establish the revised central line and control limits.

$$\overline{p_{new}} = p_0 = \frac{\sum np - np_d}{\sum n - n_d}$$

$$UCL = p_0 + 3\sqrt{\frac{p_0(1-p_0}{n}}$$

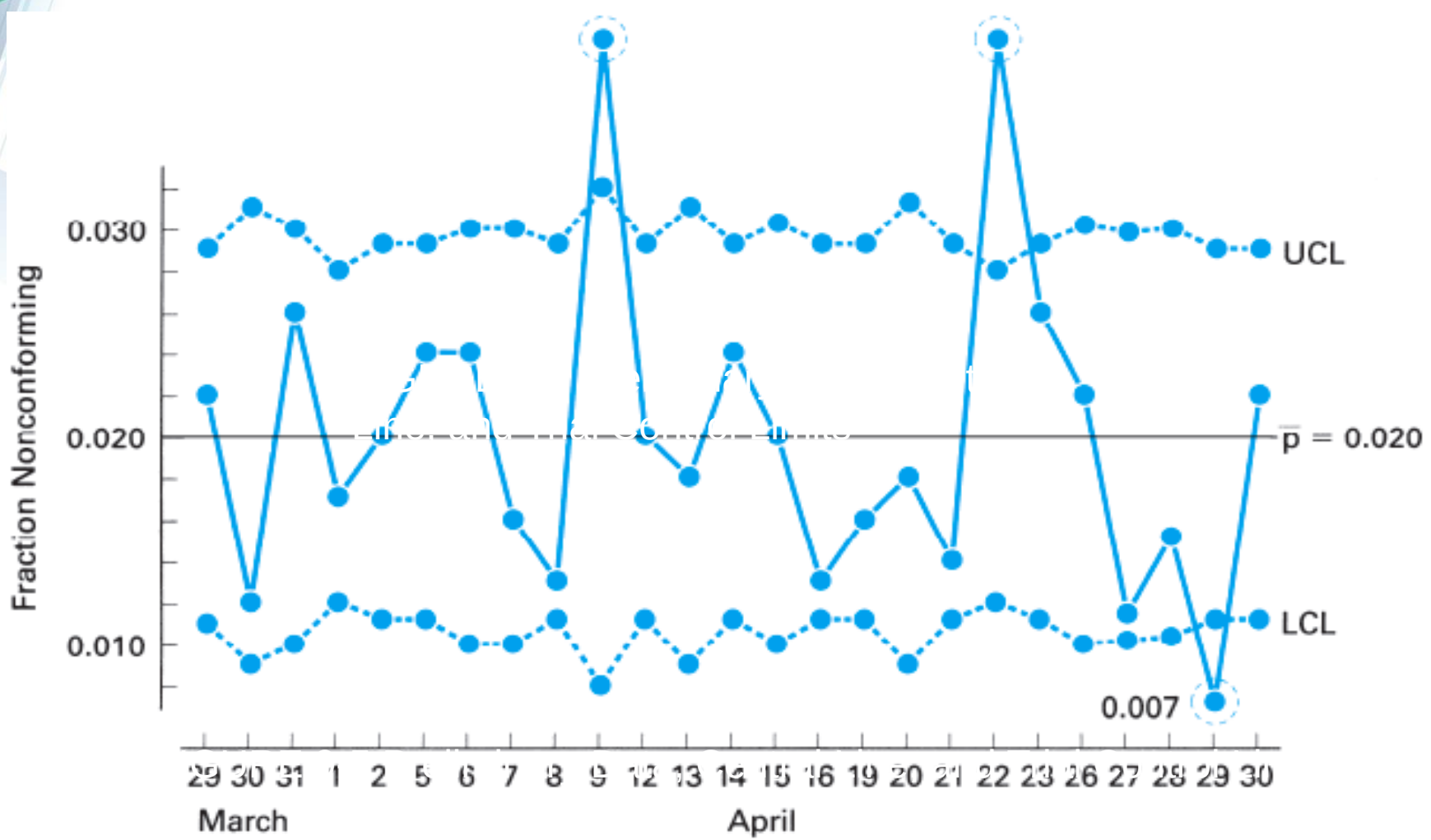
$$LCL = p_0 - 3\sqrt{\frac{p_0(1-p_0)}{n}}$$


Fraction Nonconforming (p)
0.040
0.030
0.020
0.010
0
UCL = 0.039
UCL = 0.036
UCL = 0.027
p_0 = 0.017
p_0 = 0.014
p_0 = 0.010
LCL = 0
June
July
August

The P Chart

P Chart Construction for Variable Subgroup Size

1. Collect the data.
2. Determine the trial central line and control limits: Since the subgroup size changes each day, limits must be calculated for each day.


Fraction Nonconforming
0.030
0.020
0.010
UCL
$\bar{p}$ = 0.020
LCL
0.007
29 30 31 1 2 5 6 7 8 9 12 13 14 15 16 19 20 21 22 23 26 27 28 29 30
March
April

The P Chart

P Chart Construction for Variable Subgroup Size cont'd.

2. As the subgroup size gets larger, the control limits are closer together.
3. Establish revised central line and control limits:

The P Chart

P Chart Construction for Variable Subgroup Size cont'd.

- If *Po* is known, the process of data collection and trial control limits is not necessary.
- *P* is the proportion (fraction) nonconforming in a single subgroup.
- *Pbar* is the average proportion (fraction) nonconforming of many subgroups.

The P Chart

P Chart Construction for Variable Subgroup Size cont'd.

- *Po* is the standard or reference value of the proportion (fraction) nonconforming based on the best estimate of *PBar*.
- Φ is the population proportion (fraction) nonconforming.

The P Chart

Minimizing the Effect of Variable Subgroup Size

1. Control limits for an average subgroup size: By using an average subgroup size, one limit can be calculated and placed on the control chart.

$$n_{av} = \frac{\sum n}{g}$$

$$UCL = p_0 + 3\sqrt{\frac{p_0(1-p_0}{n_{av}}}$$

$$LCL = p_0 - 3\sqrt{\frac{p_0(1-p_0)}{n_{av}}}$$

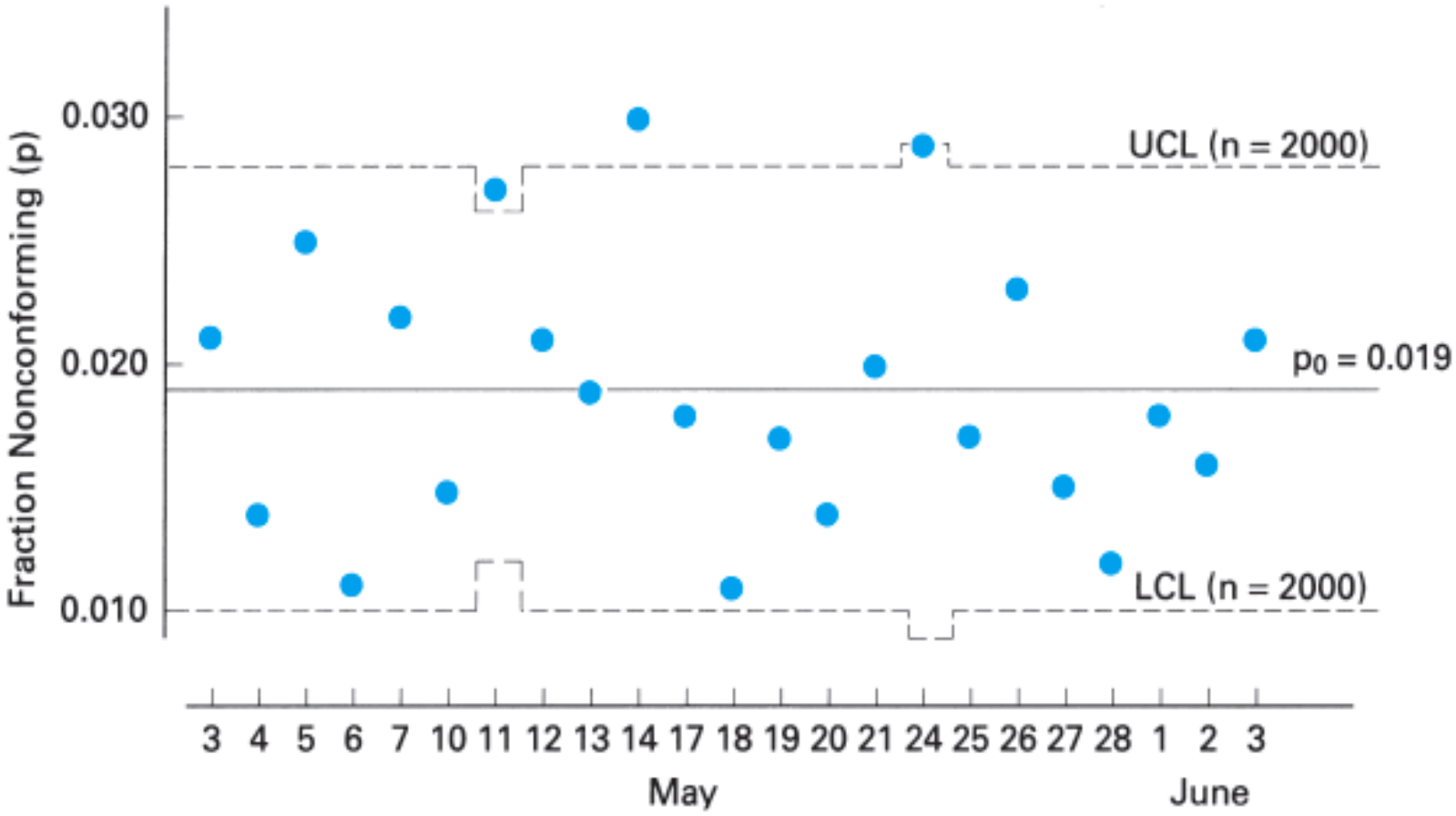


Chart for May Data Illustrating Use of an Average Subgroup Size

The np Chart

Number Nonconforming Chart (*np*):

- The *np* chart is easier for operating personnel to understand than the *p* chart.
- The limitation that this chart has is that the subgroup size needs to be constant.

The np Chart

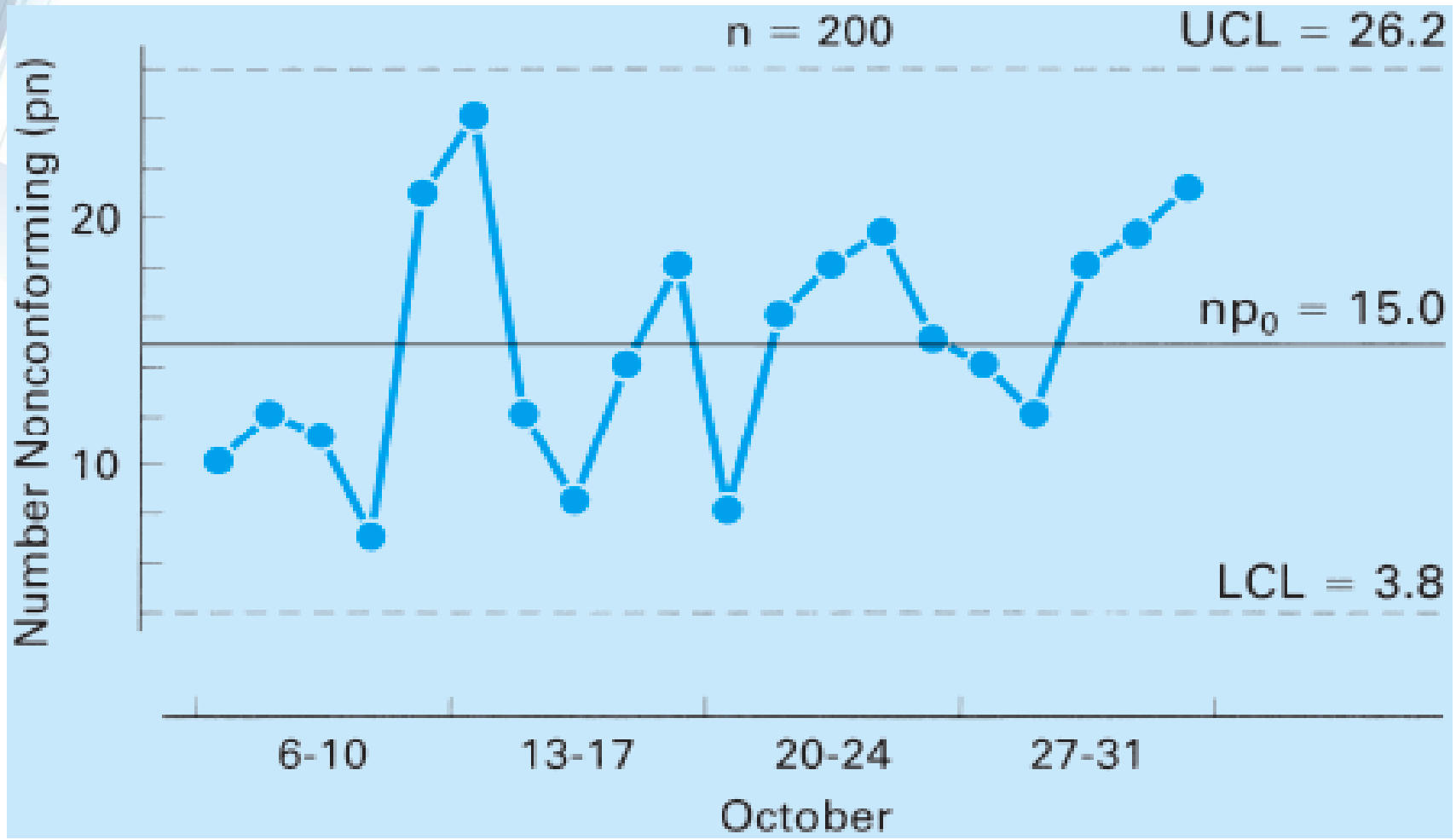
$$\text{Central Line} = np_0$$

$$\text{Control Limits} = np_0 \pm 3\sqrt{np_0(1-p_0)}$$

The np Chart

Number Nonconforming Chart (*np*):

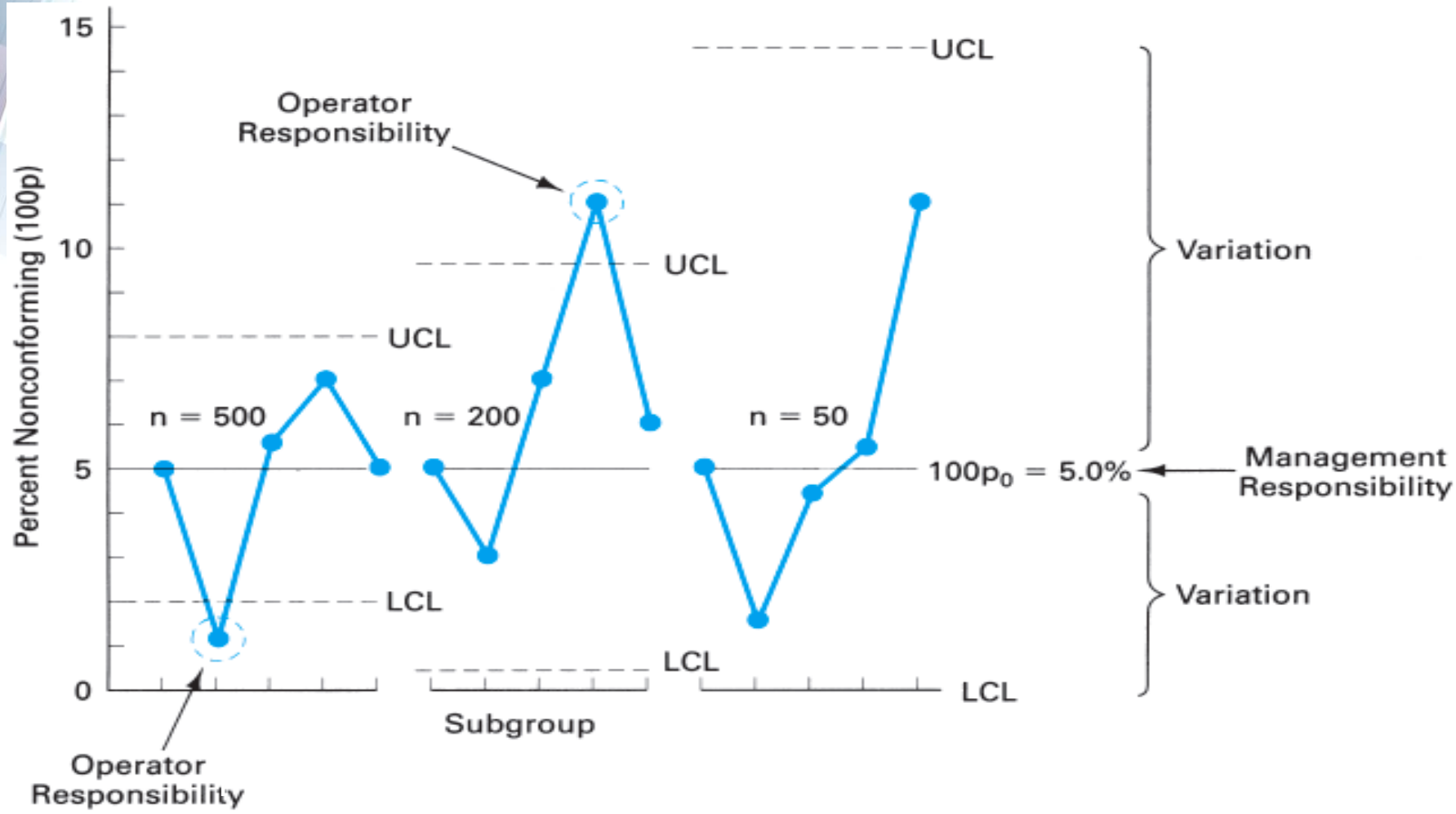
- If the fraction nonconforming *po* is unknown, then it must be determine by collecting data, calculating trial control limits, and obtaining the best estimate of p_o.



Number Nonconforming Chart (np Chart)

Process Capability

- For an attribute this process is much simpler.
- The process capability is the central line of the control chart.
- Management is responsible for the capability.
- When the plotted point is outside the control limit, operating personnel are usually responsible.


15
10
5
0
Percent Nonconforming (100p)
Operator Responsibility
UCL
UCL
UCL
n = 500
n = 200
n = 50
100p0 = 5.0%
LCL
LCL
LCL
Subgroup
Operator Responsibility
Variation
Management Responsibility
Variation