Statistical Process Control

SUPPLEMENT 6

PowerPoint presentation to accompany
Heizer and Render
Operations Management, Eleventh Edition
Principles of Operations Management, Ninth Edition

PowerPoint slides by Jeff Heyl

Learning Objectives

1. Apply quality management tools for problem solving
2. Identify the importance of data in quality management

Introduction

Statistical Quality Control
- Statistical Process Control (SPC)
- Acceptance Sampling (AS)

- Statistical process control is a statistical technique that is widely used to ensure that the process meets standards.
- Acceptance sampling is used to determine acceptance or rejection of material evaluated by a sample.

Introduction

Pottery Making Process

Preparing the clay for throwing

Wedging

Throwing

Pinching pots

Painting

Firing

Introduction

Statistical Process Control Chart (SPC)

- Variability is inherent in every process.

Variation
- Natural Variation
- Assignable Variation

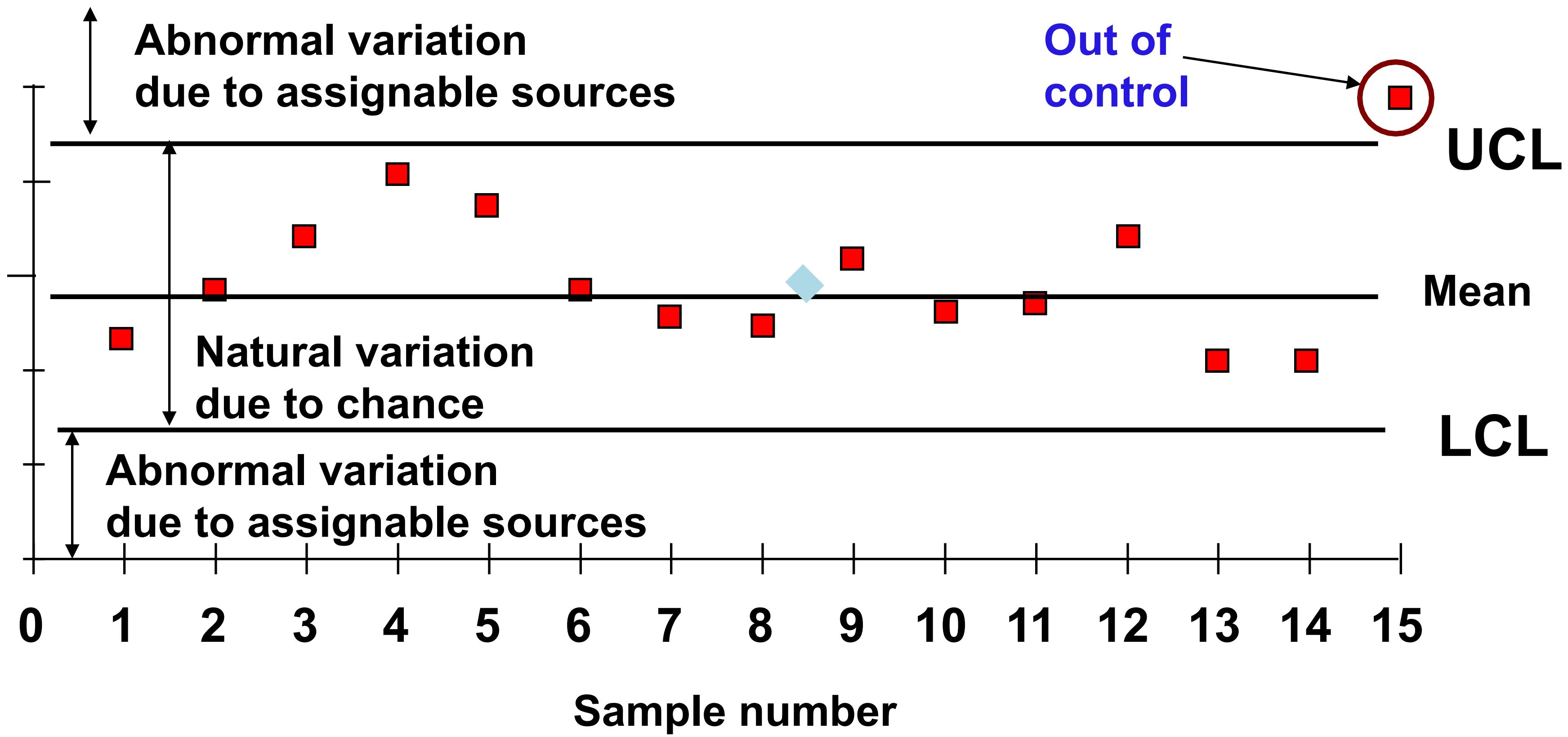
  - Natural variation – can not be eliminated
  - Assignable variation -- Deviation that can be traced to a specific reason: machine vibration, tool wear, new worker.

Statistical Process Control Chart (SPC)

- The essence of SPC is the application of statistical techniques to prevent, detect, and eliminate defective products or services by identifying assignable variation.

Statistical Process Control Chart (SPC)

A control chart is a time-ordered plot obtained from an ongoing process



Statistical Process Control Chart (SPC)

- Control Charts
  - Control Charts for Variable Data
    - $\bar{x}$ -charts (for controlling central tendency)
    - R-charts (for controlling variation)
  - Control Charts for Attribute Data
    - p-charts (for controlling percent defective)
    - c-charts (for controlling number of defects)

- ***Variable Data*** (continuous): quantifiable conditions along a scale, such as speed, length, density, etc.
- ***Attribute Data*** (discrete): qualitative characteristic or condition, such as pass/fail, good/bad, go/no go.

Statistical Process Control Chart (SPC)

1. Take random samples
2. Calculate the upper control limit (UCL) and the lower control limit (LCL)
3. Plot UCL, LCL and the measured values
4. If all the measured values fall within the LCL and the UCL, then the process is assumed to be in control and no actions should be taken except continuing to monitor.
5. If one or more data points fall outside the control limits, then the process is assumed to be out of control and corrective actions need to be taken.

$\bar{x}$–Charts

Upper control limit (UCL) = $\bar{\bar{x}} + A_2\bar{R}$

Lower control limit (LCL) = $\bar{\bar{x}} - A_2\bar{R}$

where $\bar{R}$ = *average range of the samples*

A_2 = *control chart factor from Table S6.1(page 241)*

$\bar{\bar{x}}$ = *average of the sample means*

$\bar{x}$–Charts

Hour 1

Box Number	Weight of Oat Flakes
1	17
2	13
3	16
4	18
5	17
6	16
7	15
8	17
9	16

Range=18-13=5

Hour 2

Box Number	Weight of Oat Flakes
1	14
2	16
3	15
4	14
5	17
6	15
7	15
8	14
9	17

Range=17-14=3

$\bar{R} = (5+3)/2 = 4$

$\bar{x}$-Charts

Upper control limit (UCL) = $\bar{\bar{x}} + A_2\bar{R}$

Lower control limit (LCL) = $\bar{\bar{x}} - A_2\bar{R}$

where $\bar{R}$ = *average range of the samples*

A_2 = *control chart factor from Table S6.1 (page241)*

$\bar{\bar{x}}$ = *average of the sample means*

$\bar{x}$–Charts

Hour 1	
Box Number	**Weight of Oat Flakes**
1	17
2	13
3	16
4	18
5	17
6	16
7	15
8	17
9	16

Average=(17+13+…+16)/9=16.11

Hour 2	
Box Number	**Weight of Oat Flakes**
1	14
2	16
3	15
4	14
5	17
6	15
7	15
8	14
9	17

Average=(14+16+…+17)/9=15.22

$$\bar{\bar{x}} = (16.11+15.22)/2 = 15.665$$

$\bar{x}$–Charts

Upper control limit (UCL) = $\bar{\bar{x}} + A_2\bar{R}$

Lower control limit (LCL) = $\bar{\bar{x}} - A_2\bar{R}$

where $\bar{R}$ = *average range of the samples*

A_2 = *control chart factor from Table S6.1 (page241)*

$\bar{\bar{x}}$ = *average of the sample means*

$\bar{x}$–Charts

Sample Size n	Mean Factor A_2	Upper Range D_4	Lower Range D_3
2	1.88	3.27	0
3	1.02	2.58	0
4	.73	2.28	0
5	.58	2.12	0
6	.48	2.00	0
7	.42	1.92	0.08
8	.37	1.86	0.14
9	.34	1.82	0.18
10	.31	1.78	0.22
11	.29	1.74	0.26

$\bar{x}$–Charts

$$\textit{Upper control limit}\ (\text{UCL}) = \bar{\bar{x}} + A_2\bar{R}$$

$$\textit{Lower control limit}\ (\text{LCL}) = \bar{\bar{x}} - A_2\bar{R}$$

where $\bar{R}$ = *average range of the samples*

A_2 = *control chart factor from Table S6.1 (page241)*

$\bar{\bar{x}}$ = *average of the sample means*

$\bar{x}$–Charts

Example S6.1: Eight samples of seven tubes were taken at random intervals. Construct the $\bar{x}$-chart with 3-σ control limit. Is the current process under statistical control? Why or why not? Should any actions be taken?

Sample number	Mean	Range
1	6.36	0.16
2	6.38	0.18
3	6.35	0.17
4	6.40	0.20
5	6.32	0.15
6	6.34	0.16
7	6.39	0.16
8	6.34	0.18

Sample size = n = 7

A_2 = ?

$\bar{x}$–Charts

Sample Size n	Mean Factor A_2	Upper Range D_4	Lower Range D_3
2	1.88	3.27	0
3	1.02	2.58	0
4	.73	2.28	0
5	.58	2.12	0
6	.48	2.00	0
7	.42	1.92	0.08
8	.37	1.86	0.14
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$\bar{x}$–Charts

Example S6.1: Eight samples of seven tubes were taken at random intervals. Construct the $\bar{x}$-chart with 3-σ control limit. Is the current process under statistical control? Why or why not? Should any actions be taken?

Sample number	Mean	Range
1	6.36	0.16
2	6.38	0.18
3	6.35	0.17
4	6.40	0.20
5	6.32	0.15
6	6.34	0.16
7	6.39	0.16
8	6.34	0.18

$A_2 = 0.42$

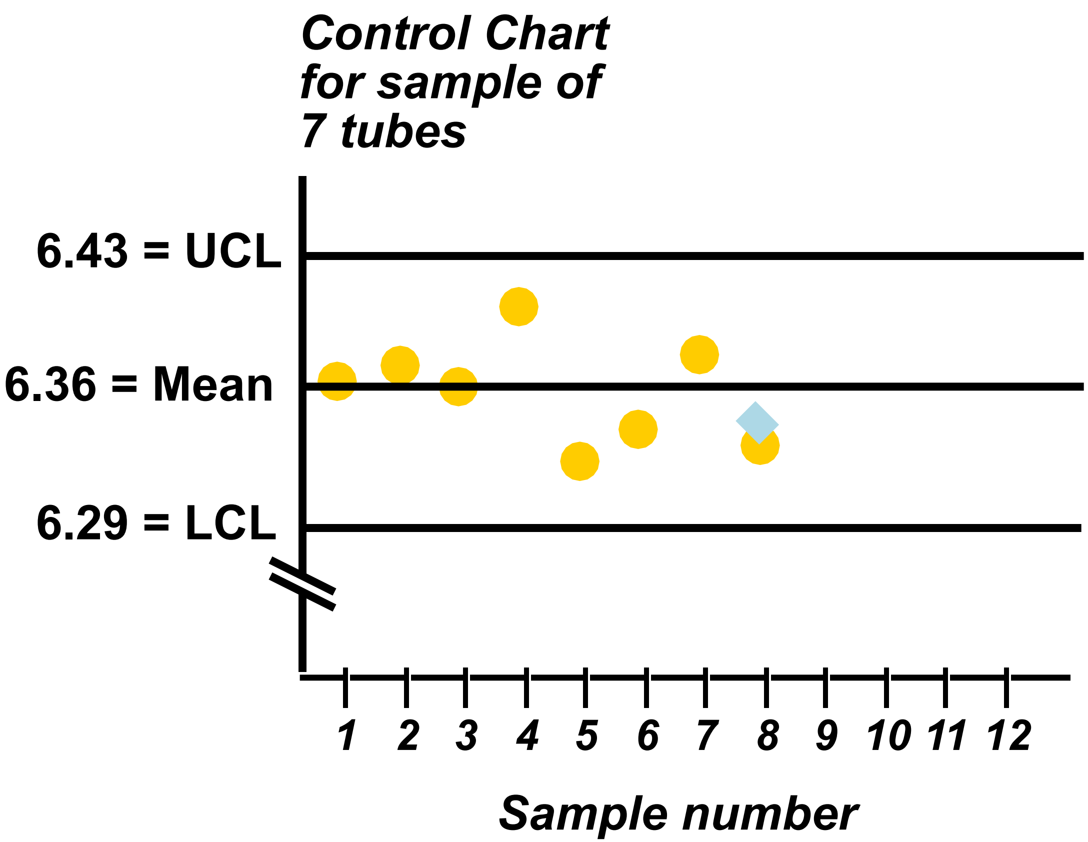
$$\bar{\bar{x}} = \frac{6.36 + 6.38 + \ldots + 6.34}{8} = 6.36 \text{ oz}$$

$$\bar{R} = \frac{0.16 + 0.18 + \ldots + 0.18}{8} = 0.17 \text{ oz}$$

$$UCL = \bar{\bar{x}} + A_2\bar{R} = 6.36 + 0.42(0.17) = 6.43 \text{ oz}$$

$$LCL = \bar{\bar{x}} - A_2\bar{R} = 6.36 - 0.42(0.17) = 6.29 \text{ oz}$$

$\bar{x}$–Charts



It is assumed that the **central tendency of process** is in control with 99.73% confidence. No actions need to be taken except to continuously monitor this process.

Steps in Creating Charts

1. Take samples from the population and compute the appropriate sample statistic
2. Use the sample statistic to calculate control limits
3. Plot control limits and measured values
4. Determine the state of the process (in or out of control)
5. Investigate possible assignable causes and take actions

R-Charts

Upper control limit **(UCL) =** $D_4\bar{R}$

Lower control limit **(LCL) =** $D_3\bar{R}$

where

$\bar{R}$ = *average range of the samples*

D_3 *and* D_4 = *control chart factors from Table S6.1 (Page 241)*

R-Charts

Sample Size n	Mean Factor A_2	Upper Range D_4	Lower Range D_3
2	1.88	3.27	0
3	1.02	2.58	0
4	.73	2.28	0
5	.58	2.12	0
6	.48	2.00	0
7	.42	1.92	0.08
8	.37	1.86	0.14
9	.34	1.82	0.18
10	.31	1.78	0.22
11	.29	1.74	0.26

R-Charts

Example S6.2

Average range $\bar{R}$ **= 5.3** ***pounds***
Sample size n **= 5**
From **Table S6.1** D_4 **= ?** D_3 **= ?**

R-Charts

Sample Size n	Mean Factor A_2	Upper Range D_4	Lower Range D_3
2	1.88	3.27	0
3	1.02	2.58	0
4	.73	2.28	0
5	.58	2.12	0
6	.48	2.00	0
7	.42	1.92	0.08
8	.37	1.86	0.14
9	.34	1.82	0.18
10	.31	1.78	0.22
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