Basic Control Charts

Objectives

• Discuss different types of variation
• Review run charts and control charts
• Introduce basic control charting methods
• Discuss the interpretation of control charts
Run Charts

• Time Series Plot or Run Charts displays numeric data in time order. We will refer to them as **Run Charts**
• Used to show patterns over time.

![Time Series Plot](image)

Run Charts

• Help us spot time dependent patterns
  – Changes in the mean or variability over time

![Variability Over Time](image)

![Seasonal Fluctuations](image)

Run Charts: Trends

• Help us spot time dependent patterns or trends
  – Increasing and decreasing trends

![Positive Trend](image)

![Negative Trend](image)
Run Charts – Control Chart

- We use time series plots to discover time-related patterns in data.
- This plot suggests there is some variation in the process. Is this variation natural to the process or is something unusual going on?

Control Charts

- We answer this question by expanding on the run chart to create a control chart.
- A control chart helps us determine if a process is in statistical control/stable.
- To determine true statistical control, control charts should only be used with a normal data set.

Basic Control Charts Overview

<table>
<thead>
<tr>
<th>What is the tool?</th>
<th>Why do you use the tool?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Control Chart can be considered a road map of…</td>
<td>By using control charts, you can detect change in a process. In other words, “Something is statistically different in my process.” To obtain a basic understanding of when a process is “out of statistical control.”</td>
</tr>
<tr>
<td>– … where you have been.</td>
<td></td>
</tr>
<tr>
<td>– … where you are</td>
<td></td>
</tr>
<tr>
<td>– … where you may be headed</td>
<td></td>
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<tr>
<td>Because of the statistics, control charts can recognize good and bad changes</td>
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</tbody>
</table>
| | To visually see how your process varies within the control limits.
Common Cause vs. Special Cause Variation

Control Charts: Stable Process
- A stable process is one in which the sources of variation are consistent over time
- Processes can vary due to many different factors
- Variables that occur naturally in the process are: common-cause variation

Types of Variation - Common vs. Special
- Common Cause (Noise)*
  - Is present in every process
  - Is produced by the process itself (the way we do business)
  - Can be lessened but requires a fundamental change in the process

A process is Stable, Predictable, and In-Control when only Common Cause Variation exists in the process
Control Limits

• Control limits represent the normal amount of variation we would expect to see if the process is consistent over time
• These are calculated using the data set and are referred to as sigma limits
• Sigma limits indicate when there are unusual sources of variation affecting a process

Control Limits

• Typically, the upper control limit (UCL) is 3 sigma limits about the center line
• The lower control limit (LCL) is 3 sigma limits below the center line

In Control

• A process is in control when points are within the control limits with no obvious pattern
Special-Cause Variation

- An out-of-control process is affected by something unusual: **special-cause variation**.

Types of Variation – Common vs. Special

- Special Cause (Signals)*
  - Unpredictable
  - Typically large in comparison to common cause variation
  - Caused by unique disturbances or a series of them
  - Can be removed/lessened by basic process control and monitoring

A process exhibiting Special Cause variation is said to be **Out-of-Control and Unstable**

The Basic Control Chart - Key Elements

- **UCL** = Upper Control Limit
- **LCL** = Lower Control Limit
- Data Plotted Over Time
- Over Time means in chronological order
**Rules of Standard Deviation**

*“Where does the data lie?”*

- 3 Sigma: 99.7% of Data Points
- 2 Sigma: 95% of Data Points
- 1 Sigma: 68% of Data Points

**The Item We Are Measuring**

**% of Data Points**

- UCL
- LCL

**Control Chart Rules**

- **Rule 1:** One point more than 3 sigmas from center line
- **Rule 2:** Nine points in a row on the same side of center line
- **Rule 3:** Two out of three points more than 2 sigmas from center line (same side)
- **Rule 4:** Four out of five points more than 1 sigma from center line (same side)
- **Pattern Rule:** A pattern repeats itself
- **Rule of Seven:** Seventh or more consecutive data points fall on one side of the mean

When one of these rules is broken, we say that the process is “out of statistical control”
**Rule 1 of Detection**

One point more than 3 sigmas from the center line

![Diagram for Rule 1 of Detection](image1)

**Rule 2 of Detection**

Nine points in a row on the same side of the center line

![Diagram for Rule 2 of Detection](image2)

**Rule 3 of Detection**

Two out of three points more than 2 sigmas from the center line (same side)

![Diagram for Rule 3 of Detection](image3)
Rule 4 of Detection
Four out of five points more than 1 sigma from the center line (same side)

Detecting Lack of Control
• What do you do when you determine that the process is out of control?

• Go do some Investigating:
  – Could be anything from data entry errors to good things occurring

Basic Control Charts - Limitations
Control charts will not pinpoint what or why something has changed
Control Charts vs. Specification Limits

- Process control limits are calculated based on data from the process
- Specification limits come from the customer
- Product specification limits are not found on the control chart
- Understanding how the process matches up against customer requirements is important to know

Control Limits vs. Spec Limits

<table>
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<tr>
<th>Upper Control Limits = UCL</th>
<th>Upper Specification Limits = USL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Control Limits = LCL</td>
<td>Lower Specification Limits = LSL</td>
</tr>
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Is the process below making defects?
Control Limits vs. Spec Limits

Upper Control Limits = UCL
Lower Control Limits = LCL
Upper Specification Limits = USL
Lower Specification Limits = LSL

Is The Process Below Making Defects?

Three Big Control Chart Errors

1) Putting specification limits on a Control Chart
2) Treating UCL and LCL as specification limits
3) Not putting data in chronological order

When you do any of these the control chart becomes just an inspection tool - it’s no longer a control chart

Basic Control Chart Fundamentals

• Control charts require maintenance and should be used sparingly
• At least 10 data points (samples of parts) must be gathered prior to building these control charts
• Appropriate action must be taken when signaled by the control chart
Reading Control Charts

Control Charts can tell us about the process.
- Decreasing or Increasing over time:

![Decreasing Chart](image1)
![Increasing Chart](image2)

Which is Out Of Control?

Control Charts Variation

Control Charts also show when variation is increasing or decreasing over time.

![Variation Increasing Chart](image3)
![Variation Decreasing Chart](image4)

Control Charts Variation

- Can show us patterns: When you see patterns in the data – your process is Out of Control

![Pattern Chart](image5)

I see a pattern!
Control Charts

• Is this process Out of Control?

Control Chart Road Map

Questions?