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Six Sigma Basics

Learning Objectives

At the end of this module, you will be able to:

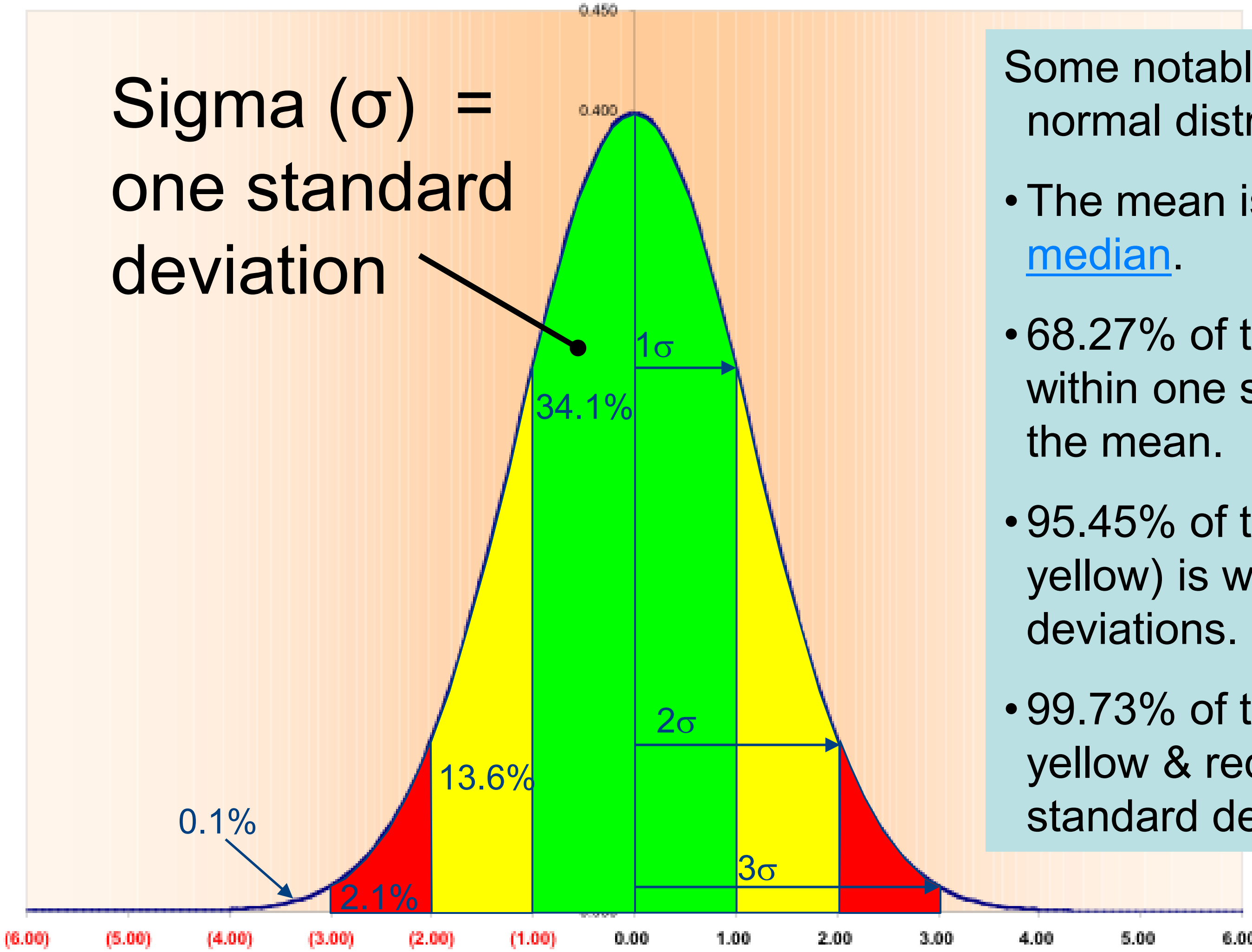
- Recognize that Six Sigma is a valuable approach for improving process quality
- Interpret a basic Statistical Process Control chart
- Distinguish between process and specified control limits
- Describe a capable process

What is Six Sigma?

- A *Strategy* to improve process quality by identifying and eliminating defects and minimizing variation in process outputs
- A data driven approach based on *Measurement* of the process variation using Statistical Process Control
- A structured *Implementation* approach based on a DMAIC cycle and certified experts

The goal of Six Sigma is to reduce process variation

Standard Normal Distribution Curve



Some notable qualities of the normal distribution:

- The mean is also its mode and median.
- 68.27% of the area (green) is within one standard deviation of the mean.
- 95.45% of the area (green & yellow) is within two standard deviations.
- 99.73% of the area (green & yellow & red) is within three standard deviations

Defects

- "Defect" is defined as any process output that does not meet the customer's specifications.
- Improving quality means reducing the defects per million opportunities (DPMO). There are two attributes to this metric that can be controlled:
  - *Opportunities* – reducing the number of steps, handoffs and other "opportunities" will help improve quality
  - *Defects* – reducing the number of defects for each process step through continuous process improvement will help improve quality

Six Sigma – Practical Meaning

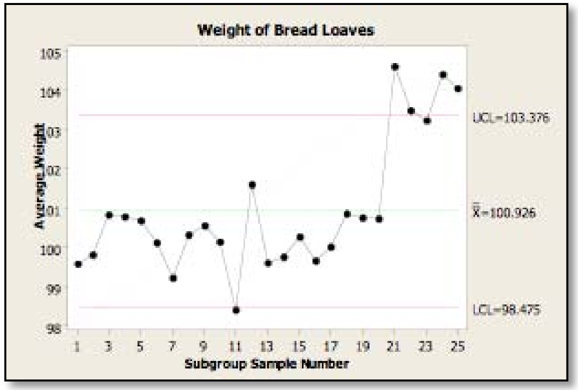
99% GOOD (3.8 Sigma)

- 20,000 lost articles of mail per hour
- Unsafe drinking water for almost 15 minutes per day
- 5,000 incorrect surgical operations per week
- Two short or long landings at most major airports each day
- 200,000 wrong drug prescriptions each year
- No electricity for almost seven hours each month

99.99966% GOOD (6 Sigma)

- Seven articles of mail lost per hour
- One unsafe minute every seven months
- 1.7 incorrect operations per week
- One short or long landing every five years
- 68 wrong prescriptions each year
- One hour without electricity every 34 years

Statistical Process Control



- Control charting is the primary tool of SPC
- Control charts provide information about the stability/predictability of the process, specifically with regard to its:
  - Central tendency (to target value)
  - Variation
- SPC charts are time-sequence charts of important process or product characteristics

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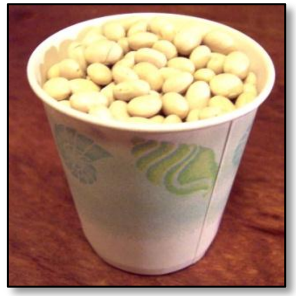
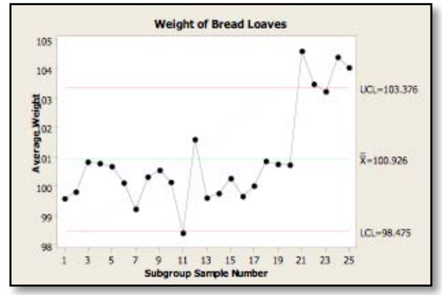
Class Exercise

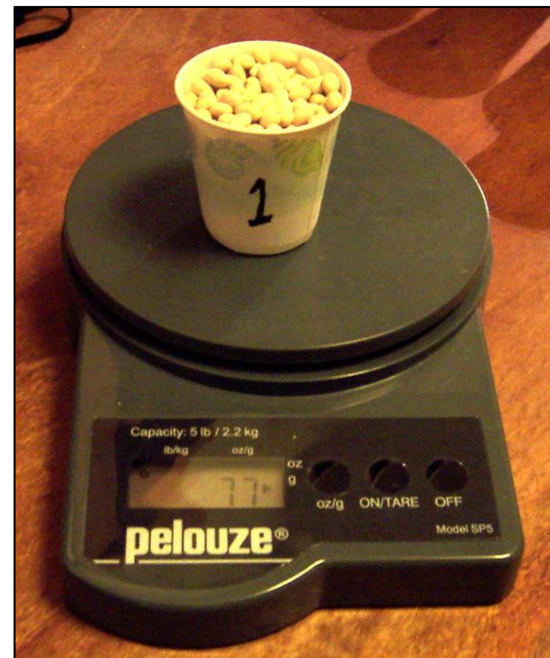




- Pharmacy wants to monitor the dispensing of doses of White Bean Medicine
- A 3 cup sample will be taken each day and weighed and recorded on a check sheet
- Data will be entered into two control charts (one for means or averages and one for range)
- Data for the first twenty days will establish the current process capability
- From then on, the pharmacy will monitor the dosages by entering daily samples into the control chart
- Process improvements will be made as needed, based upon data collected.

What To Do

Phase I Process Capability

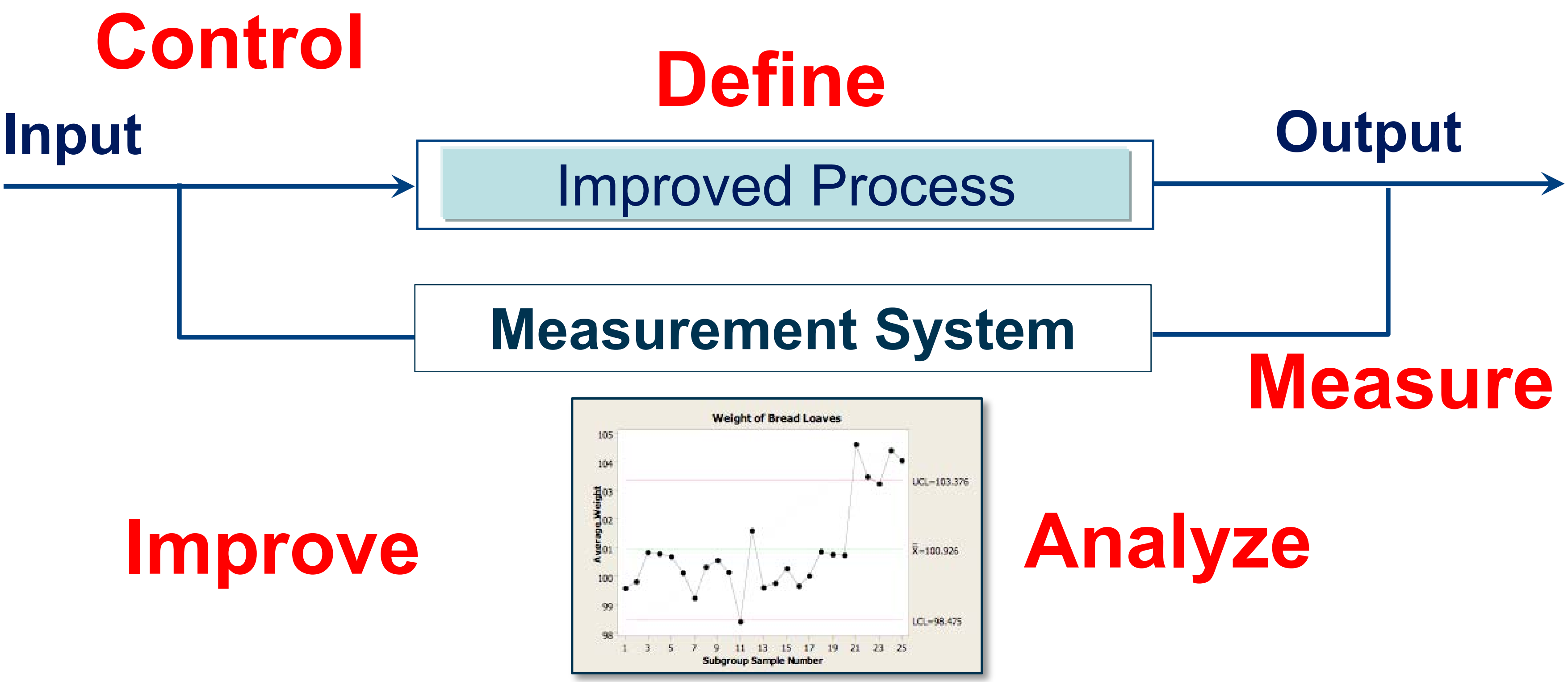


- Select three cups with the same sample number (day)
- Weigh each on the digital scale
- Record the data on the check sheet form and calculate the mean (average) and report the results to the instructor
- Also report the lowest and highest weights for each day. Calculate range = highest - lowest

Six Sigma Process - DMAIC

- **Define**
  - Who are the customers and what are their requirements
  - Identify key characteristics important to the customer
- **Measure**
  - Categorize key input and output characteristics, verify measurement systems
  - Collect data and establish the baseline performance
- **Analyze**
  - Convert raw data into information to provide insights into the process
- **Improve**
  - Develop solutions to improve process capability and compare the results to the baseline performance
- **Control**
  - Monitor the process to assure no unexpected changes occur

Simple DMAIC Example



- DMAIC is easy to see in process control applications
- The same steps can be used to analyze more complex systems, often in tandem with lean tools

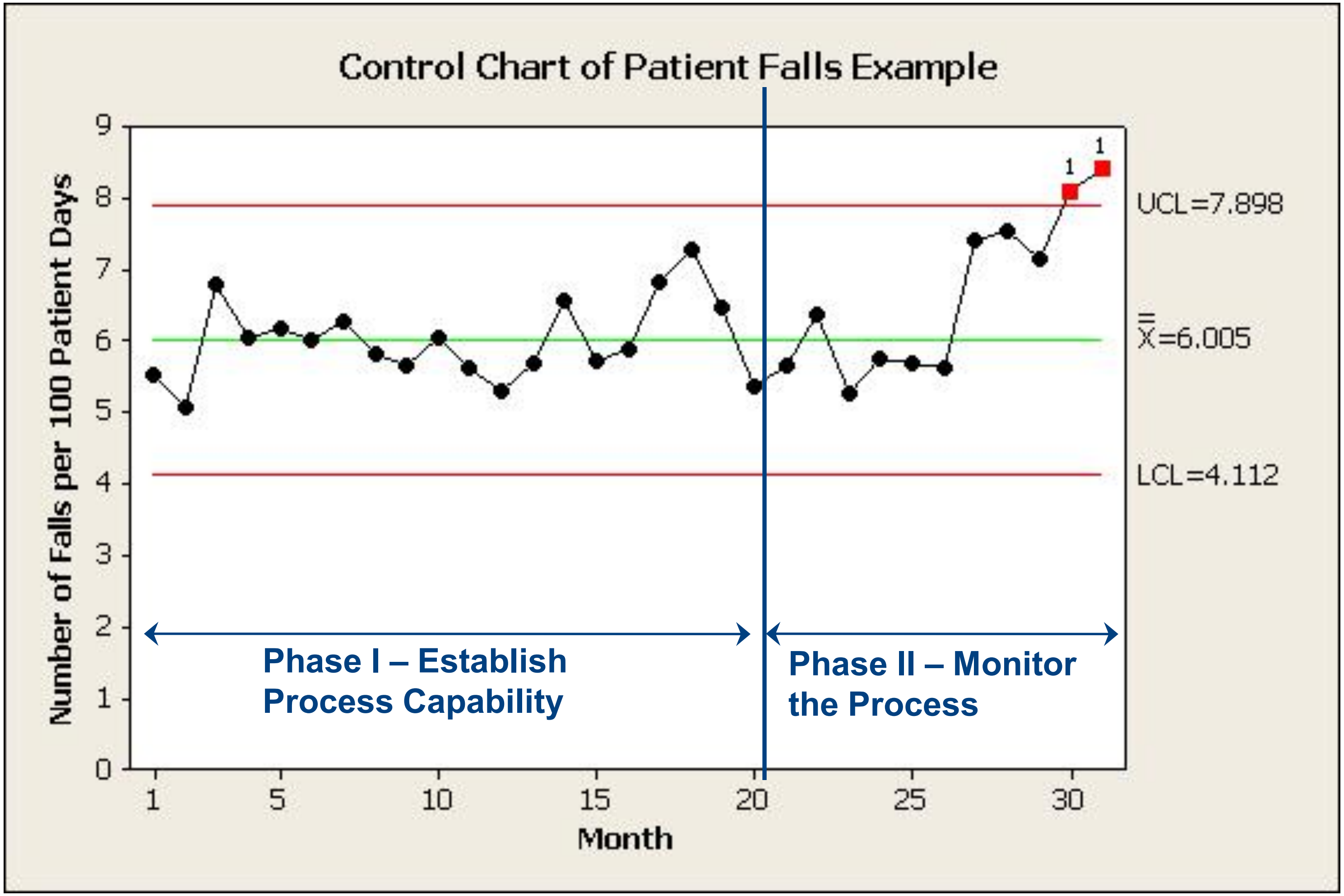
Types of Process Variation

- ***Common Cause Variation*** **is the sum of many „chances causes,‟ none traceable to a single major cause. Common cause variation is essentially the noise in the system. When a process is operating subject to common cause variation it is in a state of statistical control.**

- ***Special Cause Variation*** **is due to differences between people, machines, materials, methods, etc. The occurrence of a special (or assignable) cause results in an out of control condition.**

Control charts provide a means for distinguishing between common cause variability and special cause variability

Control Chart Example - Patient Falls



UCL

LCL

Reference: National Quality Measures Clearing House
http://qualitymeasures.ahrq.gov/expert/printView.aspx?id=16454

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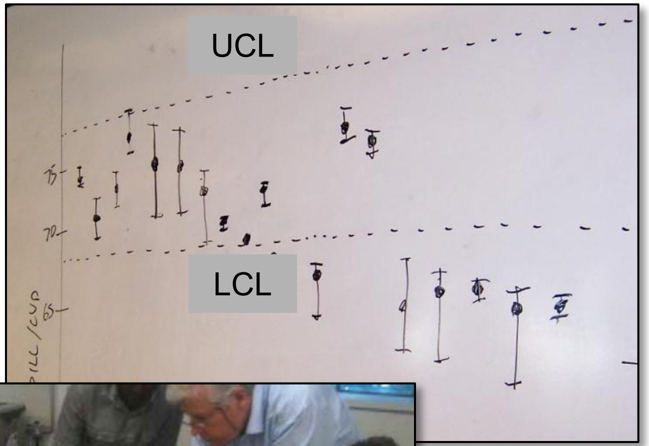
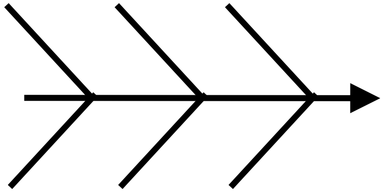
What To Do

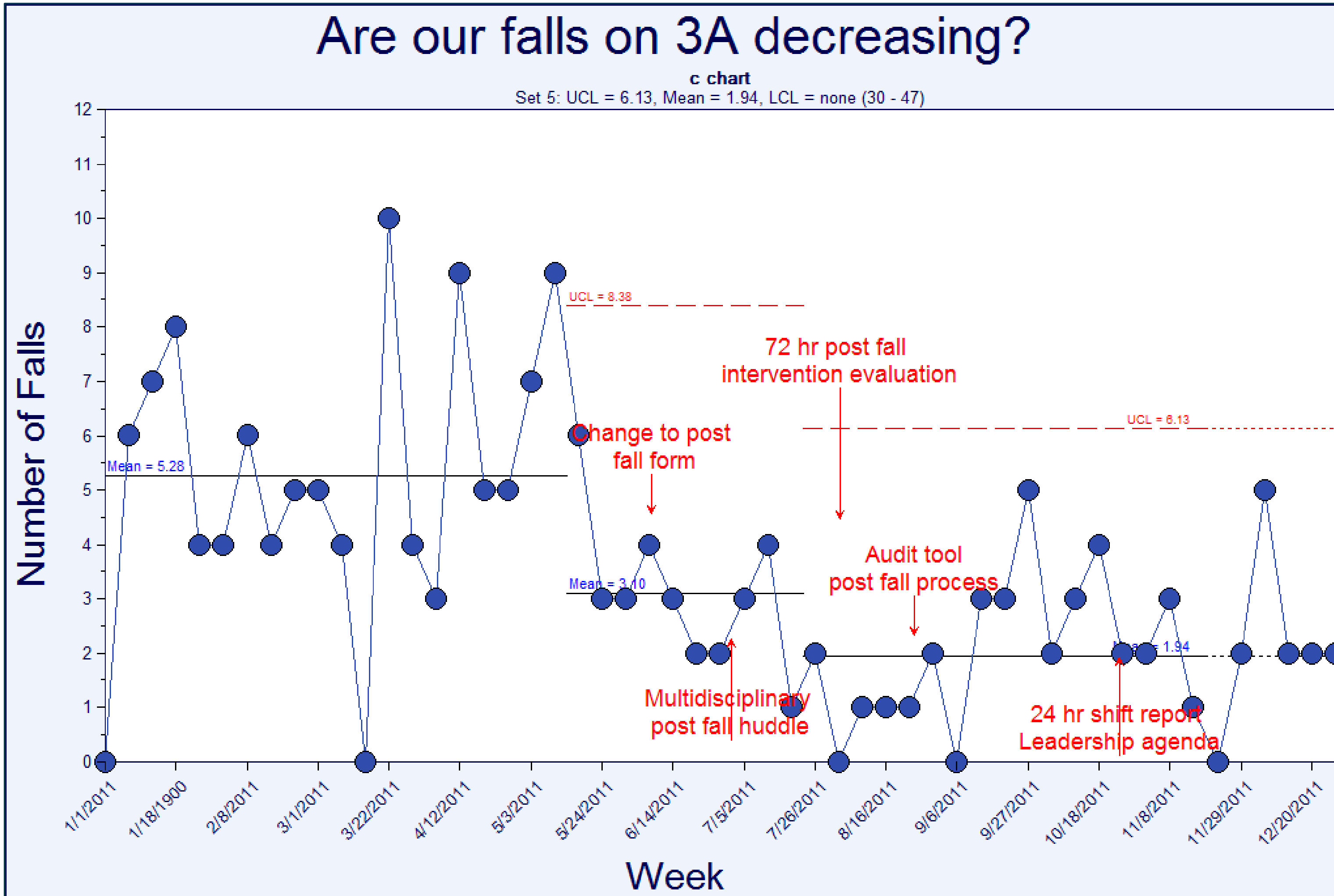
Phase II Process Monitoring

- Draw control limits on your chart based on the first 20 samples.
- Weigh a new sample (3 cups), record the data on the 2nd check sheet and calculate the average and range.
- Plot the average and range on the charts, and decide if the process is in control.
- If the process goes out of control, stop and investigate the cause using a fishbone diagram.





Control Chart Example - c Chart for Resident Falls



Courtesy of Faten Mitchell, Quality Improvement Advisor, Health Quality Ontario. Used with permission.

Source: Faten Mitchell, Quality Improvement Advisor, Health Quality Ontario

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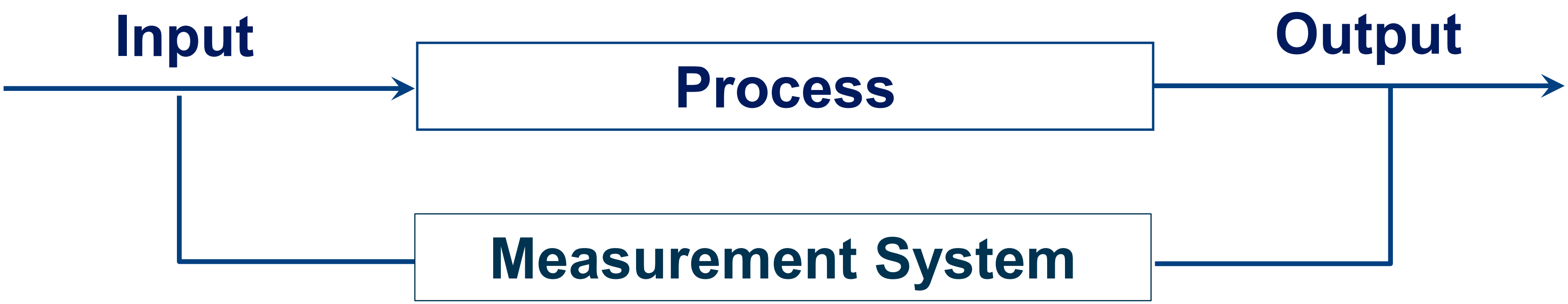
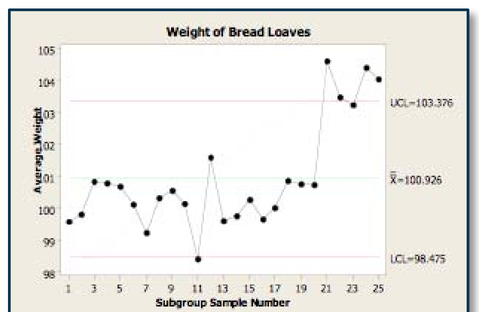
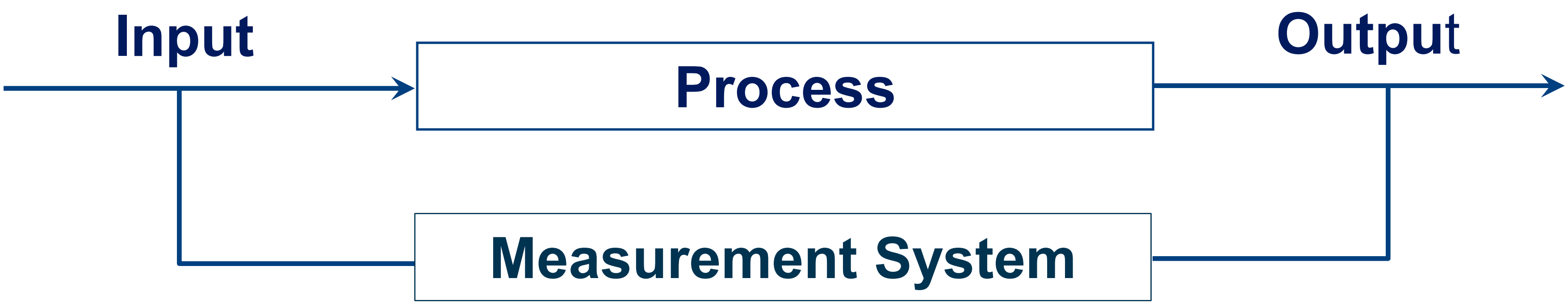
Process Improvement and Control Charts - Starting

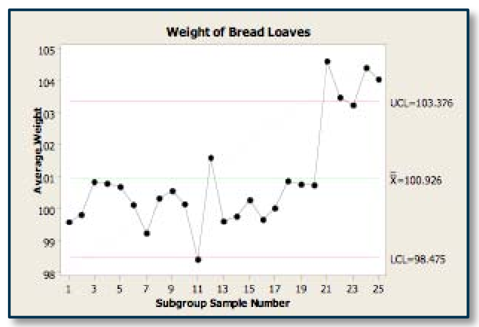




- In early stages, control charts (usually on output variables) are used to understand the behavior of the process
- After corrective actions, place charts on critical *input* variables

Process Improvement and Control Charts - Sustaining





- The goal: Monitor and control *inputs* and, over time, eliminate the need for SPC charts by having preventative measures in place
- If a chart has been implemented, remove it if it is not providing valuable and actionable information

Process Capability

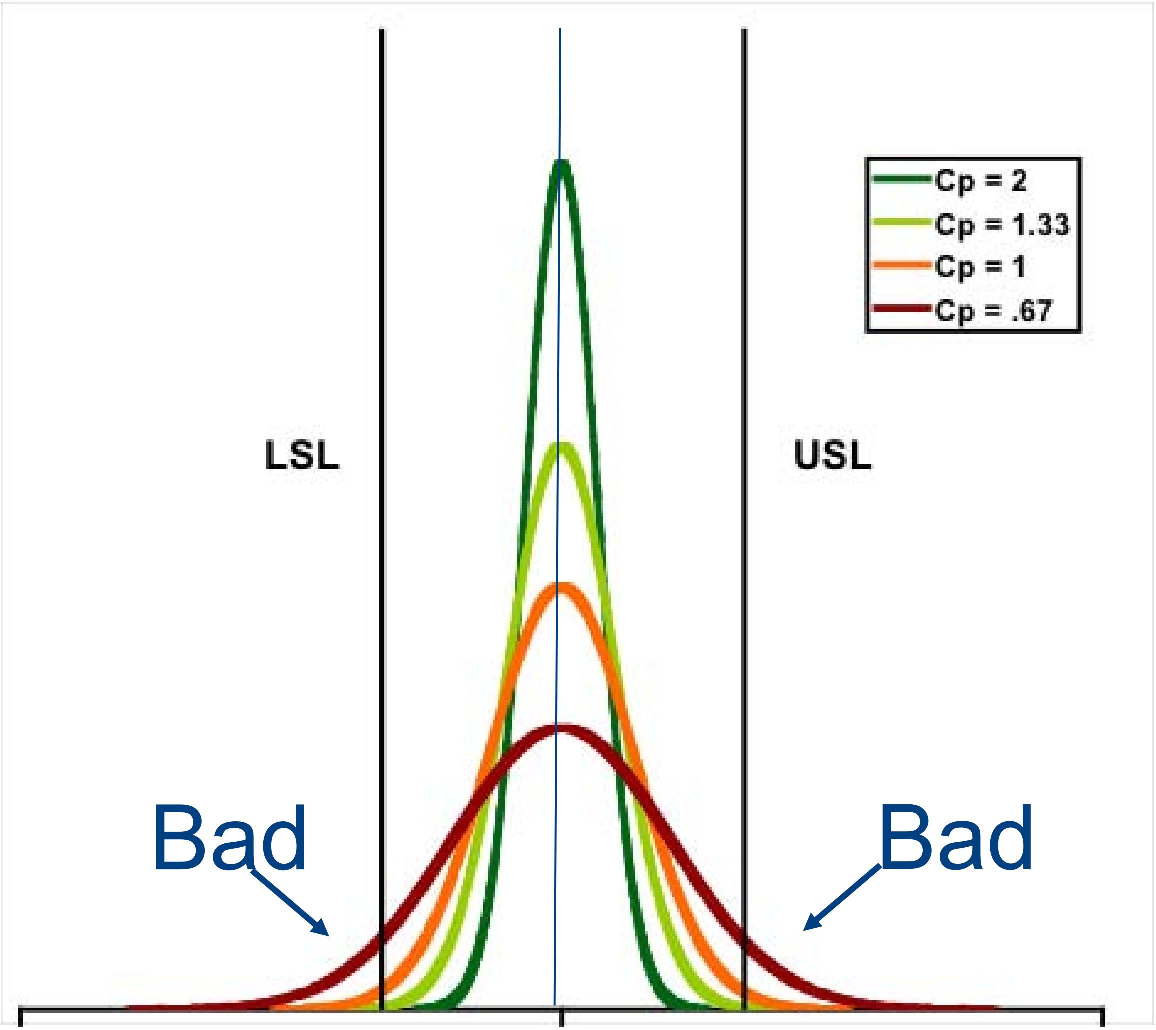
- *"Process Capability* is broadly defined as the ability of a process to meet customer expectations" (Bothe, 1997)
- Once we have a process in control then we can answer the question of whether the process is capable of meeting the customer"s specifications.

Customer and Process Quality Defined

- Process Quality is a measure of the capability of a process to produce to its expected capability
  - *The upper and lower values between which the process must be controlled are known as upper and lower control limits (UCL and LCL)*
- Customer Quality is the conformance to customer specifications within a tolerance band
  - *The upper and lower values that the customer is willing to accept are known as upper and lower specification limits (USL and LSL)*

How can we assure Process Capability?

Assessing Process Capability

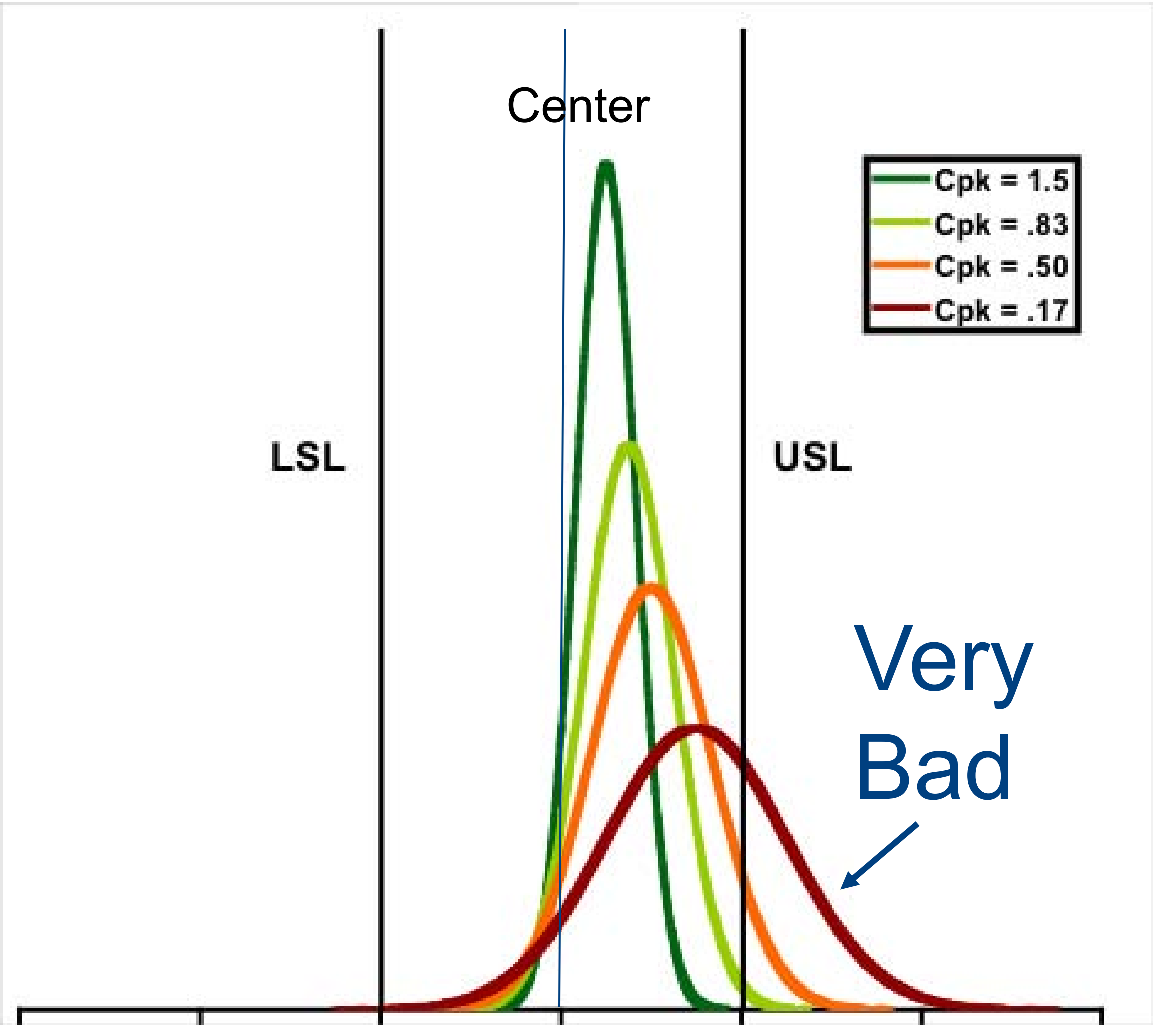


C_p, a term used to define process capability, is mathematically expressed by:

$$C_p = \frac{USL - LSL}{6\sigma}$$

The figure shows centered distributions with various C_p levels. Note C_ps less than two have visible tails outside the acceptable limits.

Non-Centered Distributions



If the distribution is off center, the probability of a bad result drastically increases. In this case C_{pk} is used. It is the smaller of

$$C_{pk} = \frac{USL - Mean}{3\sigma}$$

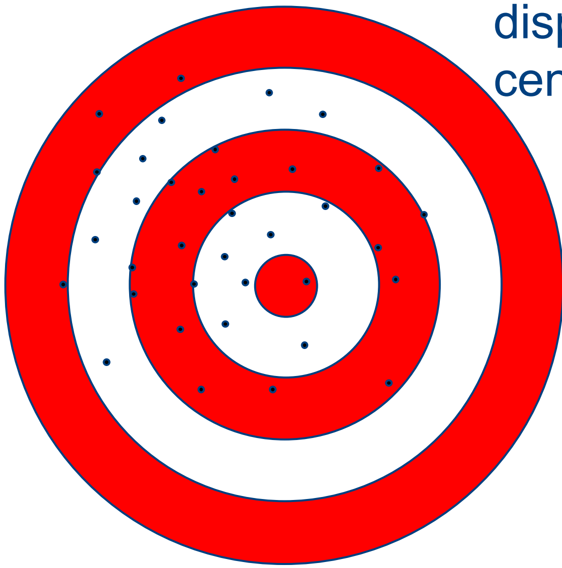
or

$$C_{pk} = \frac{Mean - LSL}{3\sigma}$$

This figure shows the same distributions off-center by 1.5σ. The C_{pk}s are smaller than the corresponding C_ps. This illustrates the need to both control variation and accurately hit the desired mean.

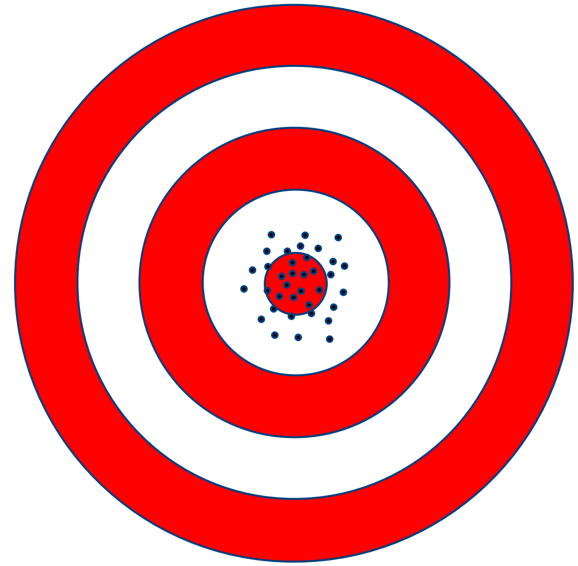
Cp versus Cpk

In this case, the shooter (archer) has a bad eye – the shots are widely dispersed and slightly off-center



C_p is low

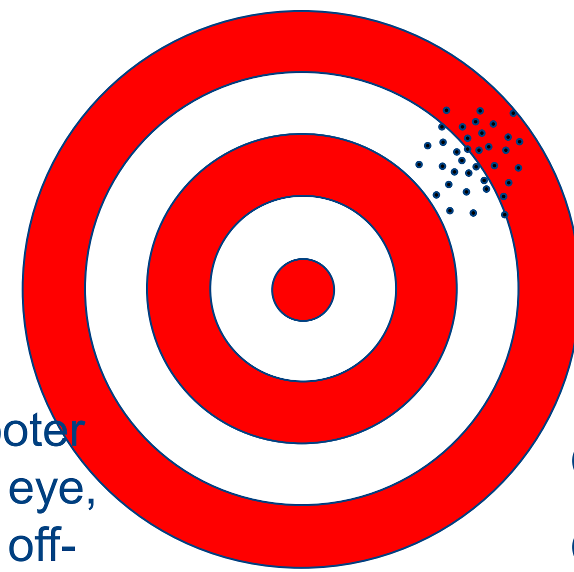
C_{pk} is low



C_p is high

C_{pk} is high

In this case, the shooter (archer) has a good eye, and has now adjusted the gun (bow) sight to bring the shots on target



In this case, the shooter (archer) has a good eye, but all the shots are off-center

C_p is high

C_{pk} is low

Implications of a Six Sigma Process

Six Sigma is defined as 3.4 defects per million opportunities, or a first pass yield of 99.9997%

"Sigma"	Mean On-Target Cp	Mean On-Target DPMO	Process Mean Shifted 1.5 σ Cpk	Process Mean Shifted 1.5 σ DPMO
6	2.00	0.00197	1.50	3.40
5	1.67	0.57330	1.17	233
4	1.33	63	0.83	6,210
3	1.00	2,700	0.50	66,811
2	0.67	45,500	0.17	308,770
1	0.33	317,311	-0.17	697,672

With a Six Sigma process even a significant shift in the process mean results in very few defects

Wrap Up

- Six Sigma is an effective quality system
  - Widely deployed in manufacturing
  - Actively being pursued in healthcare
- Control charts are an effective visual aid in monitoring process capability
  - Other SPC analysis tools are available
- If "customer" specifications for process quality (USL, LSL) can be established, Six Sigma methods can help achieve desired outcomes.

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Reading List

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Harry, M. and Schroeder, R., *Six Sigma*, Currency Doubleday, New York, 2000

Henderson, G.R., *Six Sigma Quality Improvement with Minitab*, John Wiley & Sons, 2006.

Ledolter, J. and Burrill, C.W., *Statistical Quality Control, Strategies and Tools for Continual Improvement,* John Wiley & Sons, Inc., 1999

Acknowledgements

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