SJSU SAN JOSÉ STATE UNIVERSITY

# Introduction to Statistical Quality Control

# Why is quality important?
## A simple example

- Family of four visit burger place once of month
- Each orders hamburger (bun, meat, special sauce, cheese, pickle, onion, lettuce, tomato), fries, and drink
- Each component is good 99% of the time. Good enough?

$$P\{\text{Single meal good}\} = (0.99)^{10} = 0.9044$$

$$\text{Family of four, once a month: } P\{\text{All meals good}\} = (0.9044)^{4} = 0.6690$$

$$P\{\text{All visits during the year good}\} = (0.6690)^{12} = 0.0080$$

$$P\{\text{single meal good}\} = (0.999)^{10} = 0.9900, P\{\text{Monthly visit good}\} = (0.99)^{4} = 0.9607$$

$$P\{\text{All visits in the year good}\} = (0.9607)^{12} = 0.6186$$

Montgomery 1

# Why is Quality important?

**TABLE 1.5**
**Quality Costs**

| Prevention Costs | Internal Failure Costs |
|---|---|
| Quality planning and engineering | Scrap |
| New products review | Rework |
| Product/process design | Retest |
| Process control | Failure analysis |
| Burn-in | Downtime |
| Training | Yield losses |
| Quality data acquisition and analysis | Downgrading (off-specing) |
| **Appraisal Costs** | **External Failure Costs** |
| Inspection and test of incoming material | Complaint adjustment |
| Product inspection and test | Returned product/material |
| Materials and services consumed | Warranty charges |
| Maintaining accuracy of test equipment | Liability costs |
| | Indirect costs |

Quality Opportunity Costs: Lost customers, fewer repeat purchases, fewer referrals -> lost sales; poor reputation -> lower pricing

Montgomery 1 https://en.wikipedia.org/wiki/Quality_costs

# ISE 235: Quality Assurance & Reliability

**Inbound Quality**

- Acceptance Sampling

**Process Quality**

- Statistical Process Control
- Capability Analysis
- Measurement Systems Analysis

**In-Use**

- Reliability & Failure
  - Component
  - System
- Maintainability & Availability

# What is *Quality*?

| Focus | Definition | Who defines? |
|---|---|---|
| Product | Fitness for use | Customer |
| Process | $1/\sigma^2$ | Engineer |

## A *Quality Characteristic* is…

A property that can be assessed to distinguish higher from lower quality

Montgomery 1

https://en.wikipedia.org/wiki/Quality_(business)

# How do we come up with product quality characteristics?

## Eight Dimensions of Quality (Garvin 1987)

| | Dimension | Description |
|---|---|---|
| 1 | Performance | How well will it do its intended job? |
| 2 | Reliability | How often will it fail? |
| 3 | Durability | How long will it last? |
| 4 | Serviceability | How easy is it to repair? |
| 5 | Aesthetics | Does it have sensory appeal? |
| 6 | Features | What does it do? |
| 7 | Perceived | What is the reputation of the product, brand and/or company? |
| 8 | Conformance | Is it as the designer intended? |

Montgomery 1 https://en.wikipedia.org/wiki/Eight_dimensions_of_quality

# How do we come up with <u>service</u> quality characteristics?

| | |
|---|---|
| **Reliability** | • Perform promised service dependably and accurately<br>• Example: receive mail at same time each day |
| **Responsiveness** | • Willingness to help customers promptly<br>• Example: when 3 or more people in checkout line, open a line |
| **Assurance** | • Ability to convey trust and confidence<br>• Example: being polite and showing respect for customer |
| **Empathy** | • Ability to be approachable, show sensitivity to customer<br>• Example: call center agent recognizes customer is unsatisfied |
| **Tangibles** | • Condition of physical facilities and facilitating goods<br>• Example: clean, well-maintained, quiet hotel room |



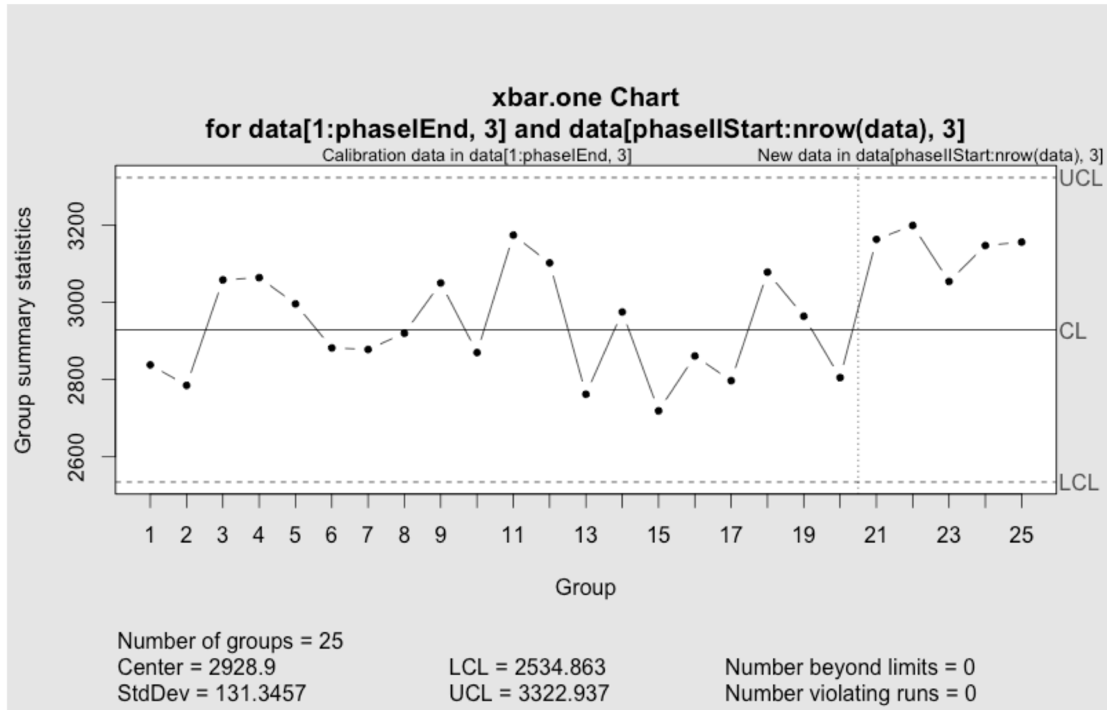
https://en.wikipedia.org/wiki/SERVQUAL

# How do we come up with process quality characteristics?

- Identify product or service quality characteristics
- Identify process characteristics that affect product or service quality characteristics

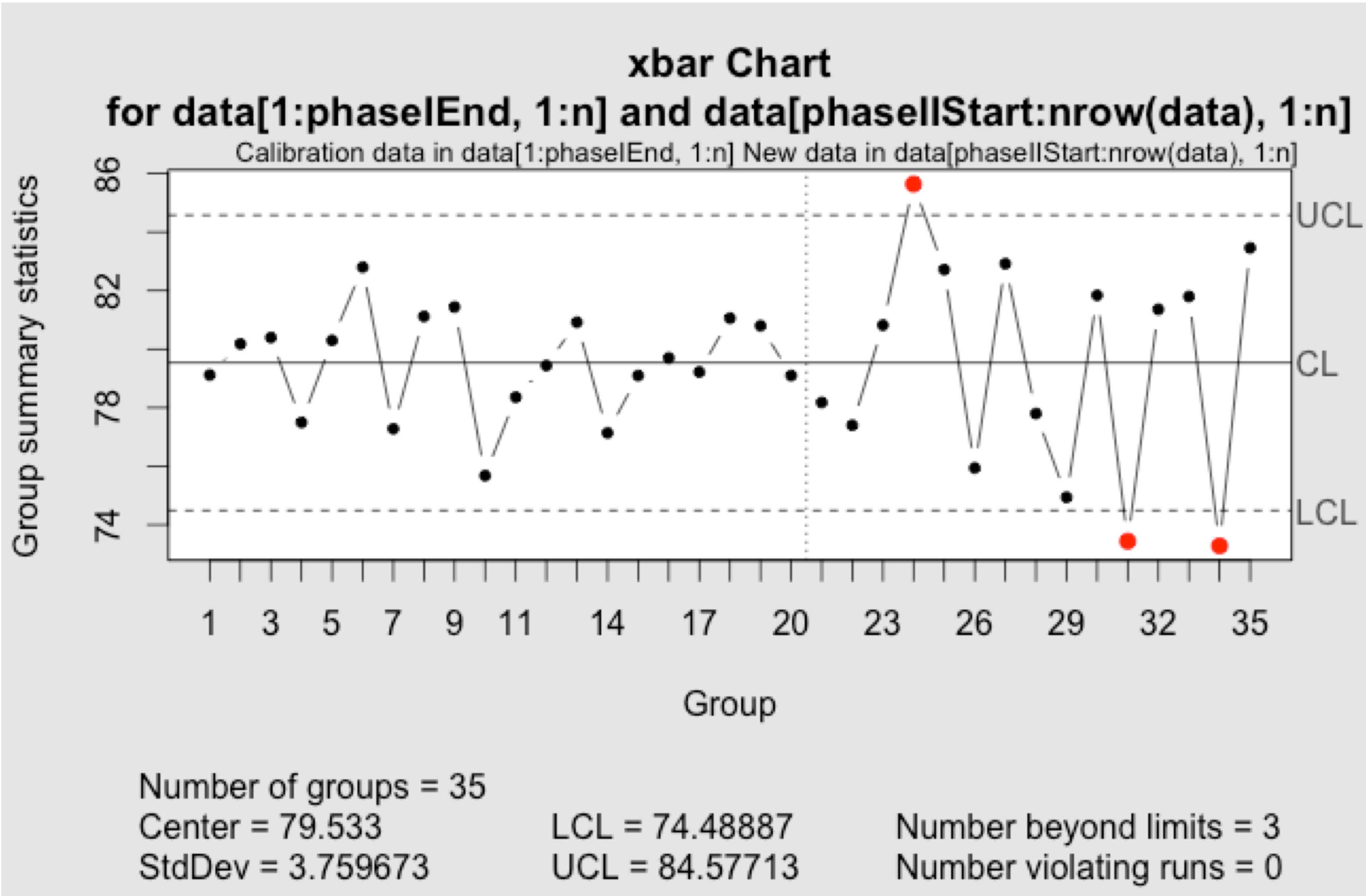
- For example, crispy, golden French fries require 325$^{o}$F temperature for 6 minutes
  - Process quality characteristics: temperature and duration

# Walter Shewhart, Statistical Quality Control, 1924



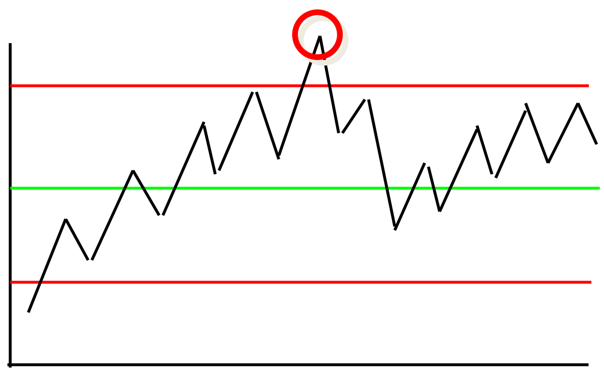

https://en.wikipedia.org/wiki/Walter_A._Shewhart

# Control Charts separate common from special causes



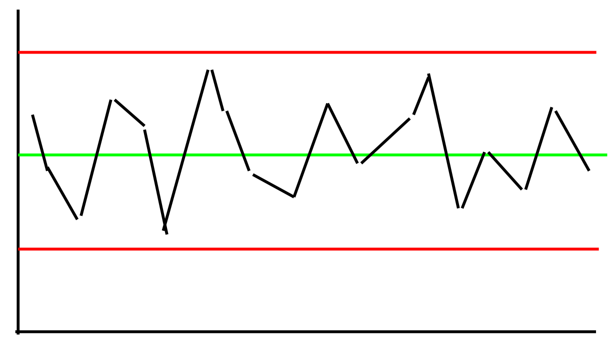
# Control charts distinguish *special cause* from *common cause* variation

Special Cause Variation



- Outliers
- Trends
- Patterns

Common Cause Variation



- Random
- Stable
- Consistent

# Control vs. Specification Limits WARNING!

- **Control** limits are derived from natural process variability, or the n**atural tolerance** limits of a process
- **Specification** limits are determined externally, for example by customers or designers
- There is no mathematical or statistical relationship between them!
- Do NOT put spec limits on x-bar charts!

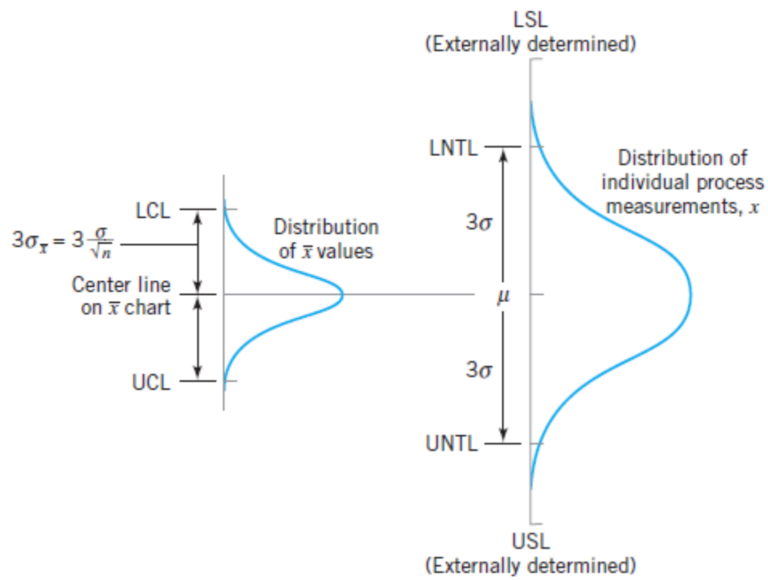
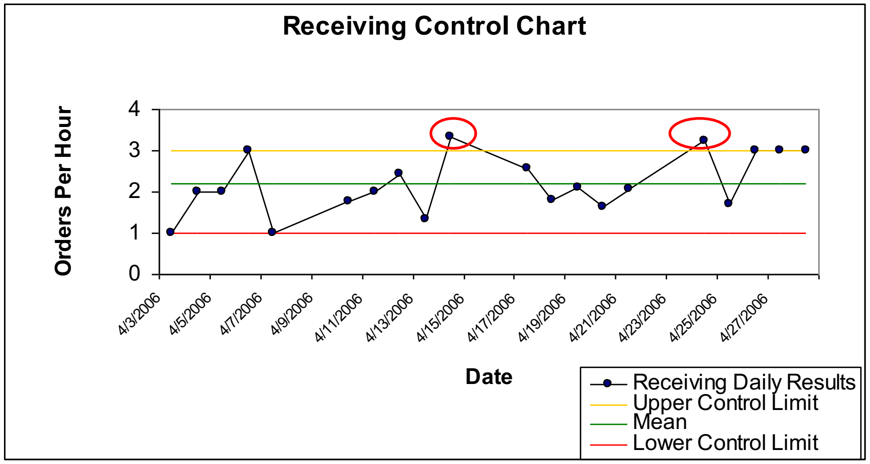
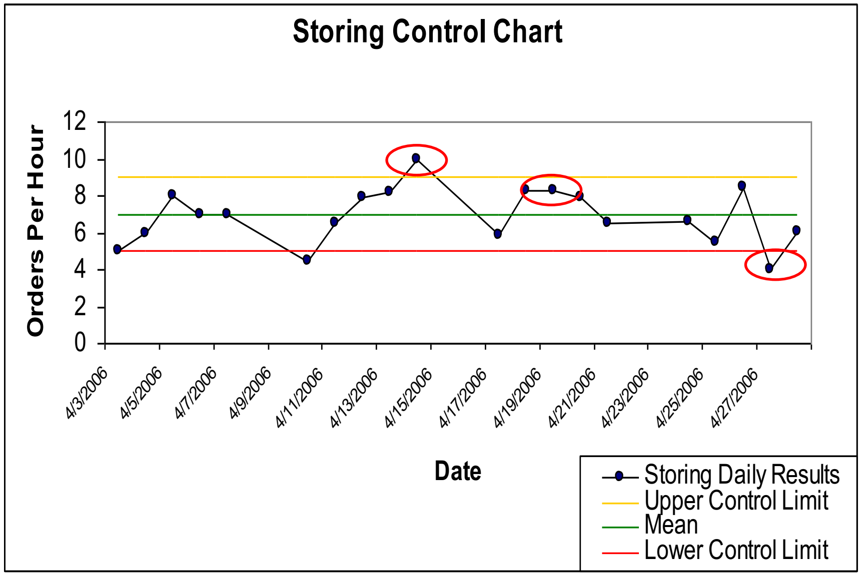
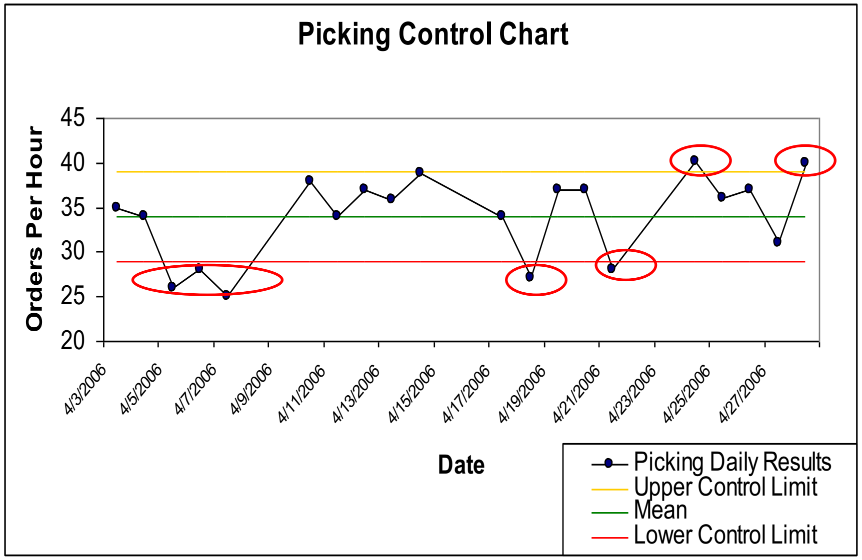


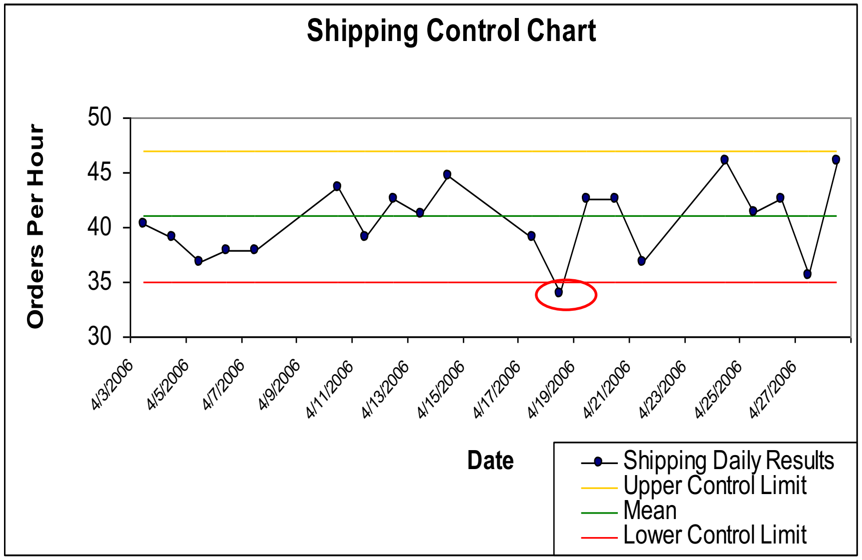

**FIGURE 6.6** Relationship of natural tolerance limits, control limits, and specification limits.

# Example:  Warehouse Operations



# Control Chart Methodology

**Phase I: Retrospective Analysis**

**Phase II: Process Monitoring**

## Define

- Quality characteristic
- Choice of charts
- Rational subgroups
- Parameters
  - Mean shift to detect
  - How fast to detect, ATS1*

## Measure

- Data
- Control chart calculations
  - Center line
  - Control limits
- Sample standard deviation
- Standard error of the mean

## Analyze

- Control chart assumptions
- Control chart assessment
  - Zone rules
  - Special cause investigations
- Average run length
- Average time to signal, ATS1

## Improve

- If acceptable, go to Phase II
  - No major assumption violations
  - In-control
  - ATS1 < ATS1*
- Otherwise, back to Define
  - Operating Characteristic (OC) Curves
    - k, n, $\beta$ tradeoffs

## Control

- Phase I centerline & control limits
- New data plotted as it arrives
- Zone rule #1 used
  - Too many false positives with other rules

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