AMERICAN MERIDIAN UNIVERSITY

Control Systems

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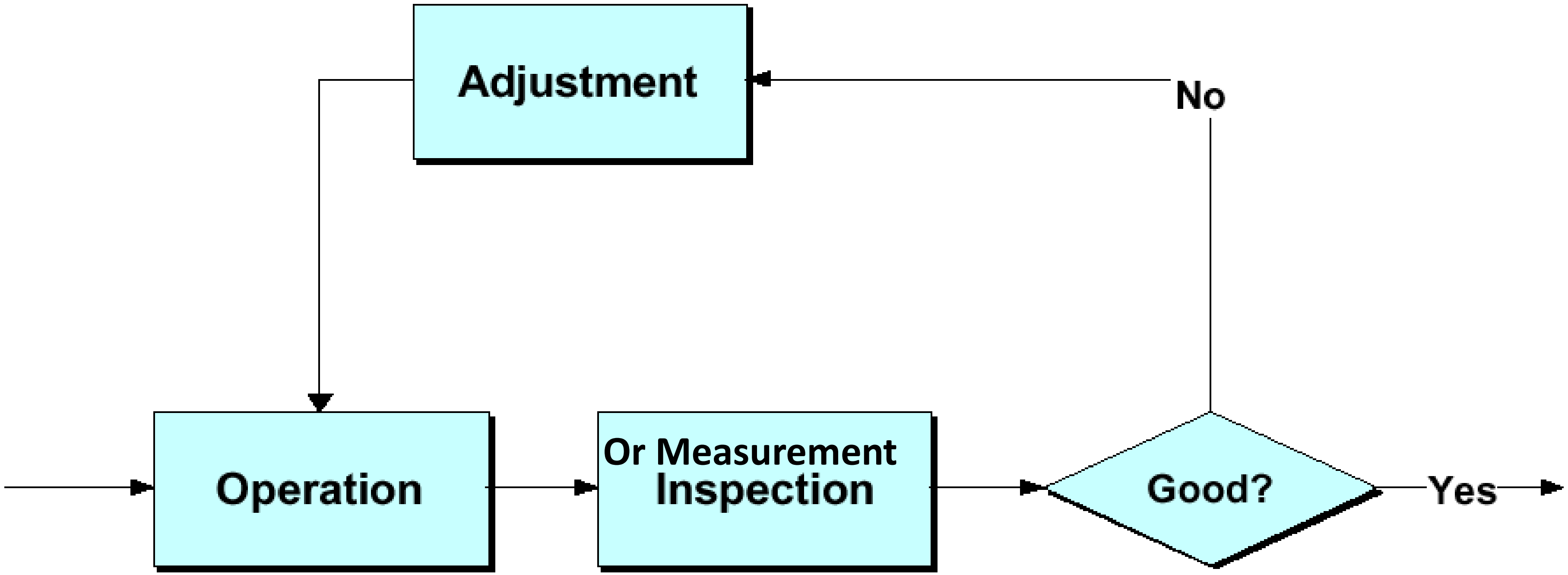
Agenda

- What is a control system
- Uses of a control system
- Types of control systems
- Review of SPC
- Integrating the control system into SPC

Control System Contents

- Control Systems contain:
  - Inputs and critical inputs
  - Desired outputs / performance levels
  - Capture and reporting of actual process performance measures
  - A feedback mechanism to report deviations in actual outputs from desired levels
  - Documented guidance on actions to take, based on the knowledge gained during Characterize on how process adjustments affect outputs
  - Adjustments to the process
- Can be Reinforcing (amplify the deviation) or balancing (bring back to equilibrium) - Balancing is normally what gets implemented

A Basic Control System



Control Lag = Time from Operation to when any applied adjustment takes effect

Control System Types

	Intent	Type	Time Lag	Action
Communication	Shared Knowledge	Open Loop	Short	Awareness
Reporting	Command and Control	One Way	Long	Variable Response
Control	Consistent Output	Closed Loop	Short	Preprogramme d Response

Control System Design Objectives

- Measure and adjust against the “controlling variables” or “Critical To Quality / Process”
- Minimize the control lag; have closely coupled feedback loops
- Have pre-defined responses
  - When to respond, and how (adjustment details)
  - When not to respond

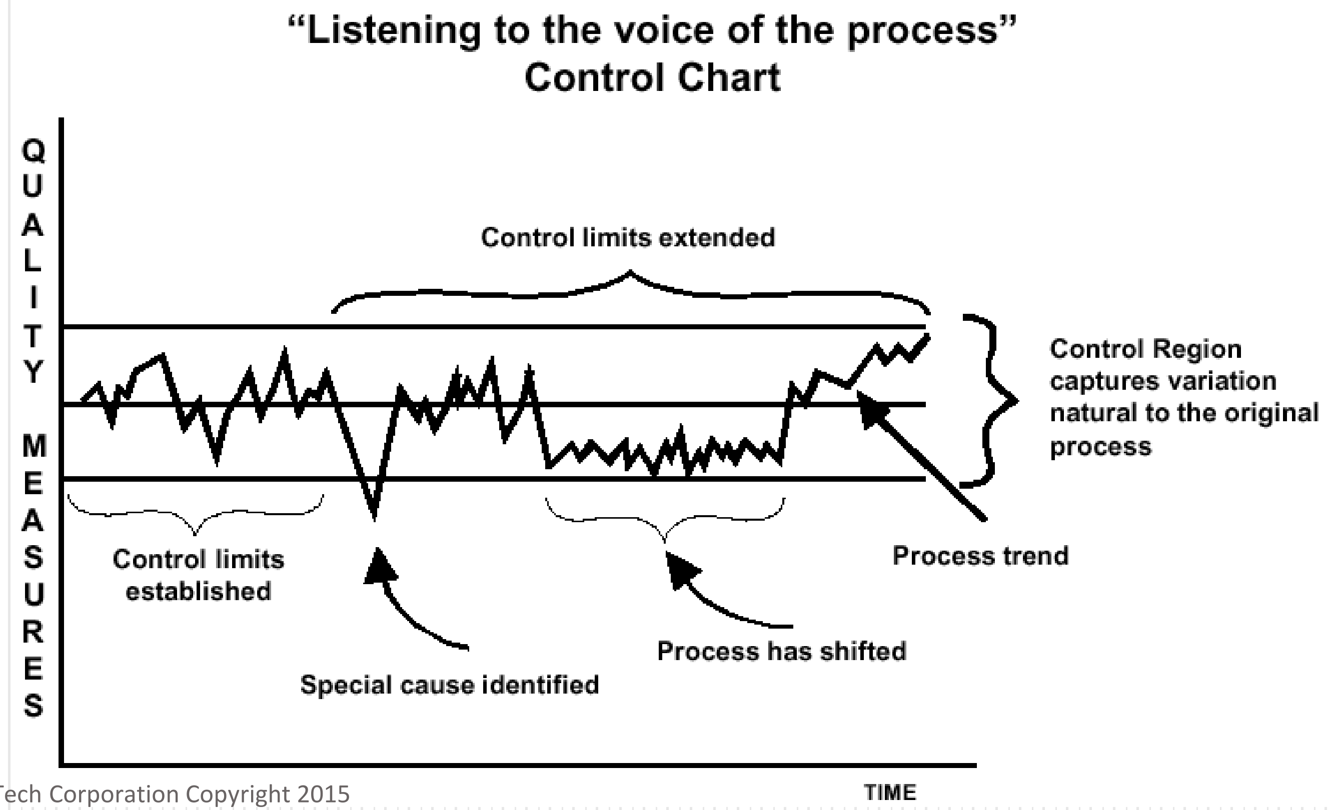
Types of Control Systems

- Control:
  - Causal Loop Diagramming - very good method to help design and document the control system
  - Control Charts (Statistical Process Control) - many variations / options for this
  - Prioritization - defines rules on work sequencing (e.g., FIFO, Rework first, etc.)
- Communication and Reporting:
  - Reporting of measures, status, etc.
  - Communication of information (two way)
- Control Charts will be discussed next

Control Charts (SPC)

SPC = Statistical Process Control

"The application of statistical techniques to understand and analyze variation in a process." – Juran



Review Purposes of SPC

- Analyze and characterize the outputs of a process
- Achieve and maintain a state of statistical control of that process
- Obtain a systematic reduction in the variability of key output characteristics of the process

Review Key Points of SPC

- Focuses attention on measuring and tracking process variation over time
- Distinguishes between special and common causes of variation
- Used as a tool for process control
- Drives a process towards improvements in quality, cost, and throughput
- Establishes a normative and uniform language for comparing performance among processes

Review Steps to SPC

- Determine where to use SPC
- Determine the control chart type, and then the sampling method
- Collect data
- Calculate statistics
- Track data, remove causes for out-of-control points, and recalculate statistics. Repeat until stable.
- Develop action plan for out-of-control conditions
- Run the process over time; create control charts by calculating control limits

Process vs. Product Measures

Input(s) → **Process** → **Output(s)**

Process

A set of ***cause & effects*** that transforms a set of ***inputs*** into a different set of ***outputs***. Processes are controlled & monitored using ***Process Parameters.***

Examples of ***Process Parameters:***
Wave Height
- Belt Speed
- Iron temperature
- Torque
- Temperature
- Humidity
- Pressure
- pH
- Feed Rates
- Speed
- Applied Voltage

Product

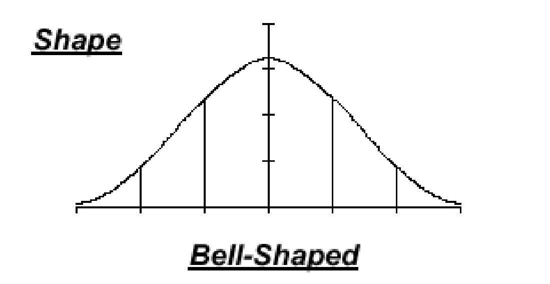
The ***tangible, observable*** set of ***outputs*** of a ***process***.
Products are controlled & monitored using ***Product Characteristics.***

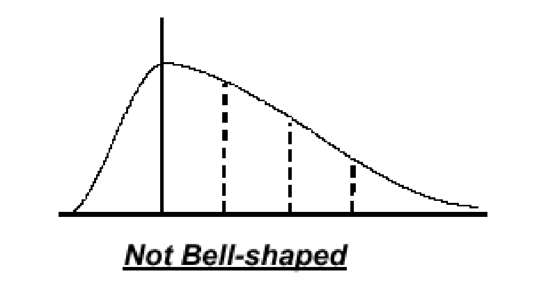
Examples of ***Product Characteristics:***
- Angle
- Hardness
- Resistance
- Capacitance
- Voltage
- Width
- Height
- Weight
- Diameter
- Thickness
- Conductivity

Review of Variation

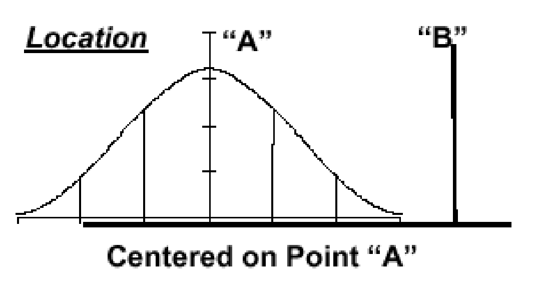
- Variation is the differences in outputs due to process input changes
- Customers don't "feel" the average; they feel the variation (the extremes)
- Common Cause: Effect of "natural" variation in a process that may or may not be controlled
- Special Cause: Effect of intermittent and uncontrolled variation; unpredictable and difficult to control
- Sources of variation tend to follow the Pareto principle
  - Find the driver, its Root Cause, and improve

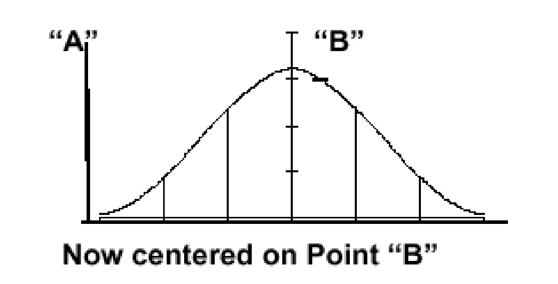
Pictures of Variation



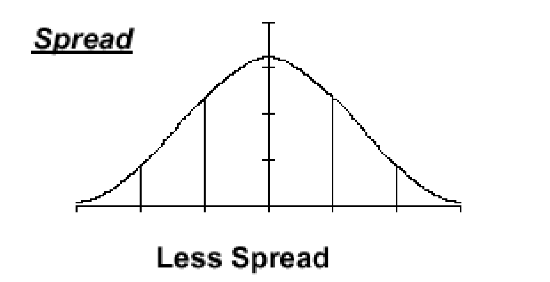


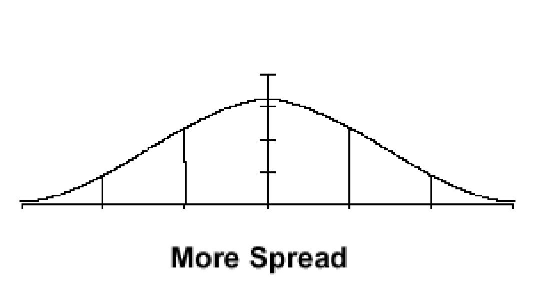
Most distribution patterns form a ***shape*** called the bell shaped curve***.*** Most things will gather close to the average.





The distribution may be a bell shaped curve, but it may have a different ***location.***





Although you may have a bell ***shape***, the curve could have different ***spreads***. The greater the spread of the distribution, the greater the ***variation***.

Collect Data and Calculate Statistics

- Run processes untouched
- Record data and note any unusual events
- Most statistical books provide details on the calculations, so not presented here
- Best resource: Control chart section in either: Memory Jogger II, BB Memory Jogger, or Six Sigma Memory Jogger

Sampling and Subgroups

- Subgroup: Grouping of units taken from a larger collection of units, used to determine information to support decisions about the larger set
- Selection and subgrouping determines what variation can be captured - e.g., within a product, piece-to-piece, etc.
- Rational subgroups: Sampling so that all common cause variation is captured, and special cause variation is indicated by differences between subgroups

Source of Variation	Subgroup Strategy
Within Piece	One unit measured in 4 places
Piece to Piece	4 units measured in same place
Lot to Lot	1 unit from 4 sequential lots measured in the same place
Time to Time	1 unit from 4 nonsequential lots measured in the same place

Causes for Patterns

- OUTLIERS
  - Wrong process settings, error in measurement, subgrouping or plotting, incomplete operation, machine and tool breakdowns, power surge.
- SHIFTS
  - Is the change sudden or gradual?
  - Introduction of a new material, machine, operator, inspector or test set, new process controls, maintenance, process changes, change in proportion of materials from different sources.
- TRENDS
  - Tool or fixture wear, deterioration of materials, aging, changes in maintenance or calibration, environmental factors, human factors, production schedules, gradual changes in materials or process, accumulation of waste products, machine warm-up.

Causes for Patterns

- CYCLES
  - Does the time period of the cycle suggest a cause?
  - Environmental factors, worn locations on tools or fixtures, human factors, gage changes, voltage fluctuations, shift changes, systematic rotation of equipment or materials, merging of subassemblies or processes.
- STRATIFICATION
  - Could each subgroup be a mixture of data from more than one source?
  - Non-random sampling, miscalculation, incorrect chart type, non-rational subgrouping, reduction in process variability, changes in inspection process.
- MIXTURES
  - Could subgroups be coming from two sources alternately?
  - Two or more different materials, operators, designs, or testers mixed in the process, over adjustments of the process, poor sampling procedures, control of two or more processes on the same chart

Implementation Notes

- Apply SPC where it will be of benefit
- Design the improvements and test them using SPC to help establish the SPC-based Control System (i.e., chart type, settings, limits, control plan)
- Train everyone on how to use the chart

Control Chart Dangers

- “In Control” does not necessarily mean “Capable”
- Takes time to identify and resolve problems
- Control charts signal problems but they still don’t indicate the reasons for the problems
- Data gathering and setting limits is not easy; use of past data that “happens to be available” may not be good enough
- Automated data gathering tools can miscalculate control limits

Control Chart Advantages

- Systematic and efficient method for turning data into actionable information
- Lets people make decisions from FACTS
- Highlights special cause impacts to a process
- Provides warning of degradation before making defect products / services
- Establishes controls for continuous improvement and shows evidence of improvements
- Involves everyone and builds worker knowledge of the process

Control Plans Summary

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