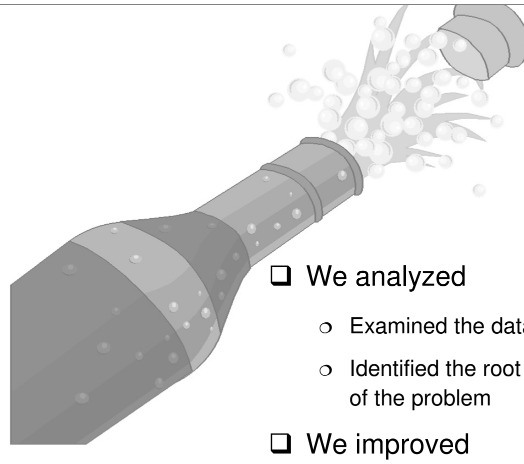
Introduction to Control and Control Plans

(Green Belt)

Module Objectives

- Develop a procedure for the control phase
  - Plan
  - Execute
- Discuss Project Transition Action Plans
- Explore Control Plans
- Introduce 4^{th} Generation Management Concepts

Six Sigma Summary



- ❑ What did we do?
- ❑ We measured
  - Clearly defined the problem
  - Found the critical outputs & inputs
  - Determined capability of the measurement systems and processes
- ❑ We analyzed
  - Examined the data
  - Identified the root cause of the problem
- ❑ We improved
  - Discovered y=f(x)
  - Optimized the process

Success right? What's Next?

Control Phase Questions

- ❑ What can be done to make sure the defects stay reduced?
- ❑ What actions can be taken by the team to ensure the improvement is permanent?
- ❑ What systems can be put in place to help the functional team maintain the gains routinely?
- ❑ Do I have buy-in from the important players?
- ❑ With whom do I leave the project?
- ❑ When does my role in the project end?

Control – Maintaining the Gains

- Brainstorming
  - Write down three actions that you will take to ***ensure*** that the gains from your project are ***permanently*** sustained, without ***your*** attention.
  - Be specific. Ask for suggestions, if necessary.

  1) ____

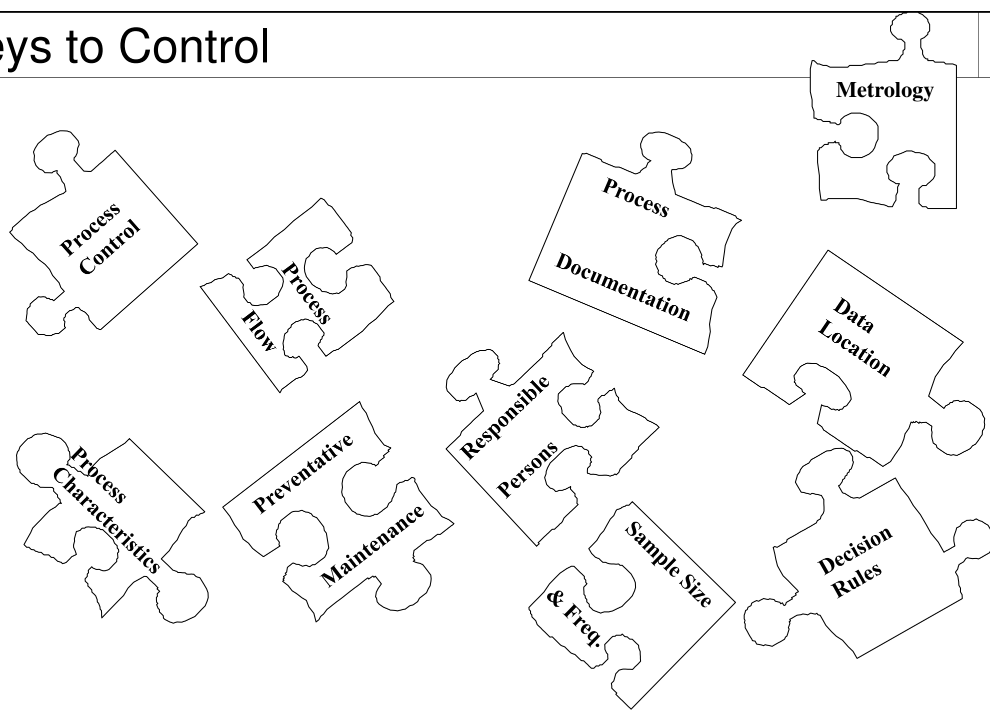
  2) ____

  3) ____

- Share one action with the class.
- You will need to explain how this action will **permanently** fix the problem.

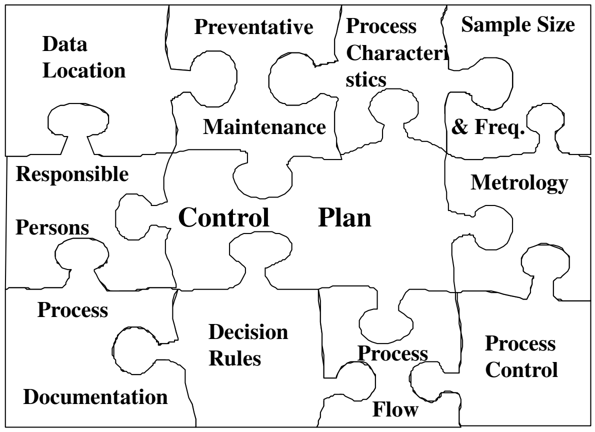
Document the actions of your classmates also

Keys to Control



Integrating the Keys

- A control plan integrates all of the keys to control.



Include all aspects of control in the control plan!

Process Control Plans. What's the Point?

- The intent of process control is:
  - Run the process on target
  - Minimize variation about the target
  - Minimize required adjustments and over-control
  - ALWAYS meet customer requirements
- The purpose of a control plan is:
  - Institutionalize process improvements
  - Highlight areas requiring extra education
  - Provide one-stop-shopping for control information

A Word About Decision Rules

- Critical elements to successful decision rules:
  - Who makes the decision?
  - What action does he take?
  - When to take action? When to elevate the decision?
  - Where to act? To what extent?
  - Where is the action recorded? By whom is it recorded?
  - Why is action necessary? Use data!
  - How effective was the action? Follow up!

Push the decision level as low in the organization as practical.

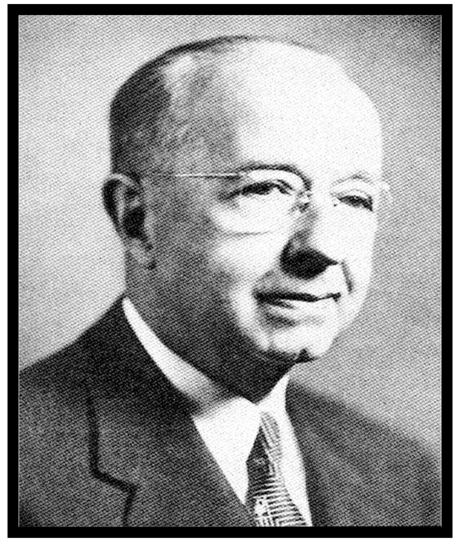
FOUNDATION OF YOUR SUCCESS

Statistical Process Control- Control Charts
(Green Belt)

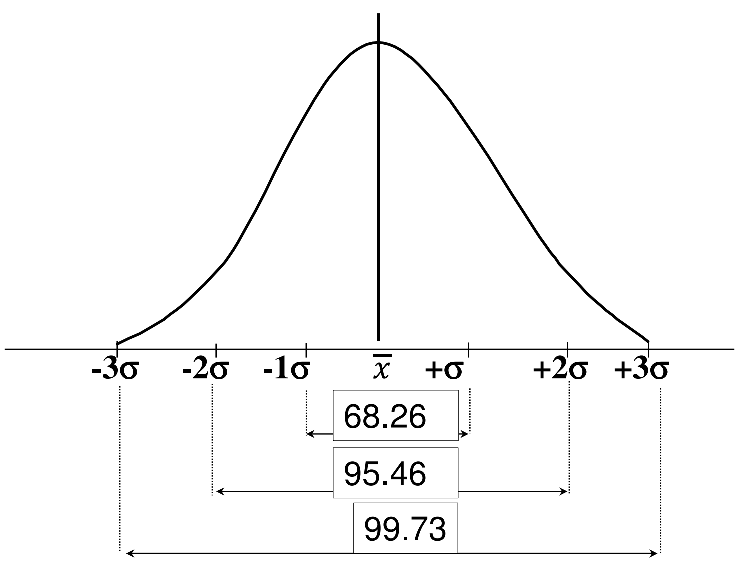
SPC – A Short History

When was SPC developed?
By whom?

- Dr. Walter Shewhart of Bell Labs developed a theory of Statistical Process Control in 1924.
- During the '20's Dr. Shewhart presented his theories in a series of lectures that were published in a book , *Economic Control of Quality Manufactured Product* (1931).
- SPC came into wide use during the 1940's as a result of war production efforts.

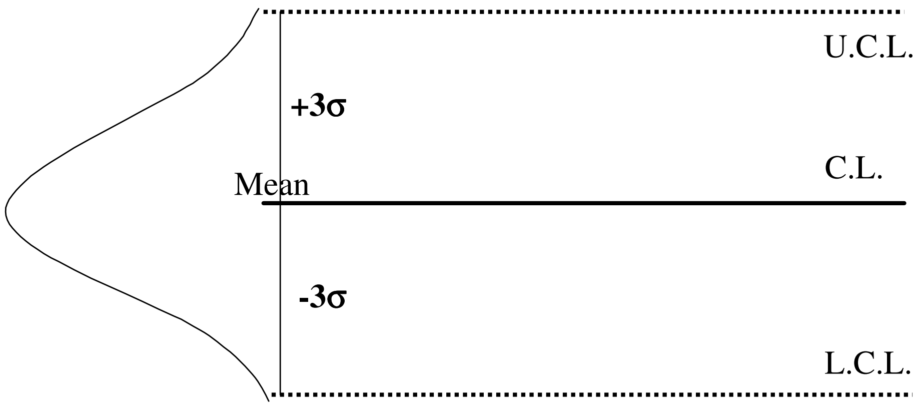


The Normal Curve



Control Charts

- Transformation of a normal distribution curve in the form of 3 parallel lines, where
  - The middle line indicates mean and called central line (C.L.)
  - The upper line indicates Mean +3 Sigma and called upper control limit (UCL)
  - The lower line indicates Mean -3 Sigma and called lower control limit (LCL)

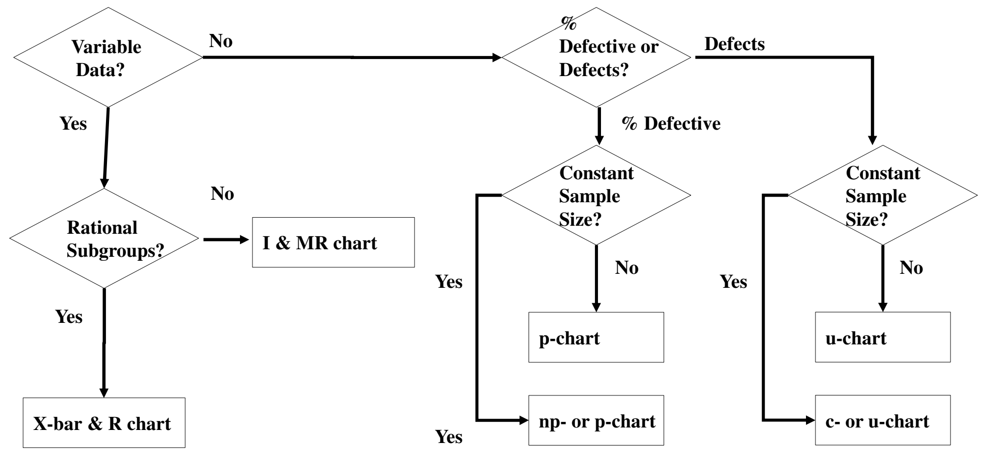


Benefits of Control Charts

- Properly used, control charts can:
  - Be used by operators for ongoing control of a process
  - Help the process perform consistently and predictably
  - Provide a common language for discussing the performance of the process
  - Distinguish between special and common cause variation
  - Serve as a guide for local action or action on the system
  - Allow the process to achieve
    - Higher quality
    - Lower unit cost
    - Higher effective capacity

The Green Belt should be in the forefront of instituting SPC in his/her area

SPC – Charts For All Occasions



A process control system is a Six Sigma project deliverable

Steps for Constructing an X-bar/R Chart

- Gather the Data
  - Select subgroup size
  - Select the frequency of collecting the subgroup data
  - Record the raw data
  - Calculate the average and range of each subgroup
  - Plot the subgroup averages and ranges on the control charts
- Calculate the Control Limits
  - Calculate the average range (R-bar) and the Process average (X-bar-bar)
  - Calculate the upper and lower control limits for the average and range charts

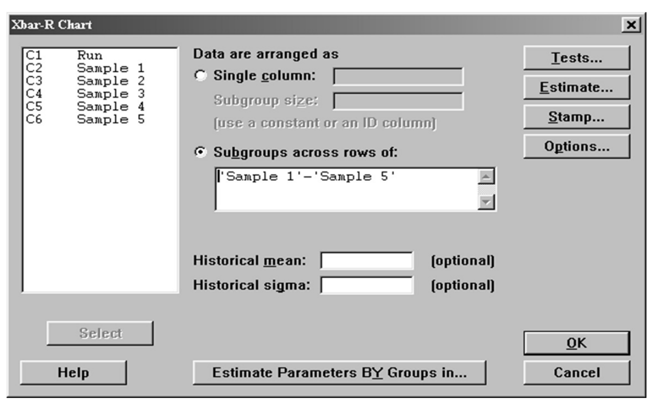
Constructing the chart is easy. Acting on the results is harder !

Step 1: Gather the Data

- ❑ Select subgroup size
- ❑ Select the frequency of collecting the subgroup data
- ❑ Record the raw data
- ❑ Calculate the average and range of each subgroup

Example – Constructing Charts in Minitab

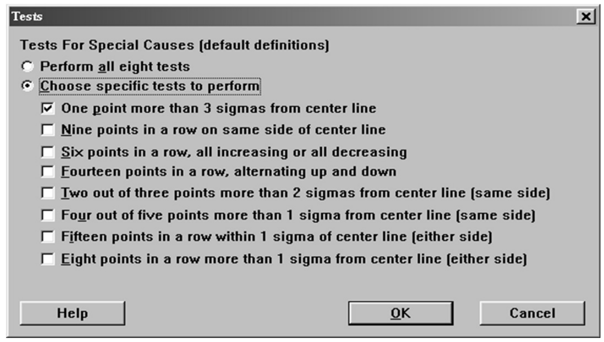
- ❑ In Minitab, open sample worksheet CCVar.mtw
- ❑ From the menu select Stat > Control Charts > Xbar-R…
- ❑ Select data columns C1-C5



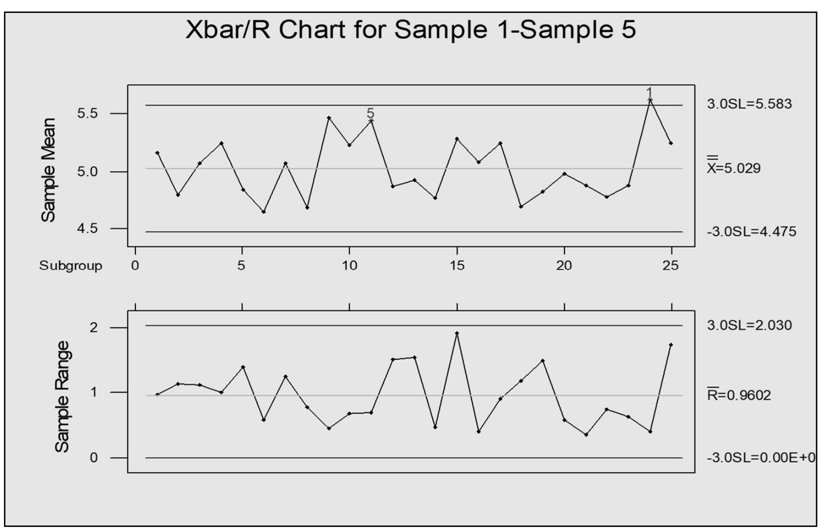
Minitab has automated the tasks for constructing control charts

Example: Control Chart Tests

- Press the Tests… Button
- Select the tests to run. Tests 1 & 5 are best when searching for gross special causes.
- Press the Help button for explanations of each of the tests



X-bar & R Chart – Minitab Output



Control Charts for Attribute Data

- Defective Data
  - Package does/does not leak
  - Lamp does/does not light
  - Go/no-go gauge data
  - Correct/Incorrect Shipment
- p- and np-charts
  - p-charts for proportion non-conforming units, sample size not necessarily constant
  - np-charts for proportion non-conforming units, sample size is constant
- Defect Data
  - Missing parts in a kit
  - Missed contract obligations
  - Errors on an invoice
  - Missed customer calls
- c- & u-charts
  - u-chart for the number of defects per inspection unit, sample size not necessarily constant
  - c-chart for the number of defects per inspection unit, sample size constant

p-Chart for Proportion Nonconforming

- When to use a p-chart
  - When it is difficult or uneconomical to make a numerical measurement
  - When it is desired to combine different types of defects into an overall proportion
  - When the available data are for attributes
  - When the data come from a binomial process
- Management summaries
  - Many management summaries are attribute forms and could benefit from control chart analysis.
  - Examples: scrap rates, quality audits, first-run yields, etc.

? ***Would you like to teach management to interpret trends on their charts?***

Notes on p-Chart Control Limits

- LCL
  - When the mean proportion defective is small, the LCL can be a negative number. In this case there is no LCL and $p=0$ is still within the control limits.
  - It is advantageous to pick a subgroup size that establishes a lower control limit. This way improvements can also be detected.
- Subgroup size
  - The previous formulae assume n is constant. As an approximation, if the subgroups are $\pm$ 25% of the mean then substitute n-bar, the mean subgroup size for n in the control limit formulae.
  - To minimize confusion it is best to have constant sample sizes whenever practical.
  - Minitab calculates p-chart control limits for each subgroup based on that subgroup's size.

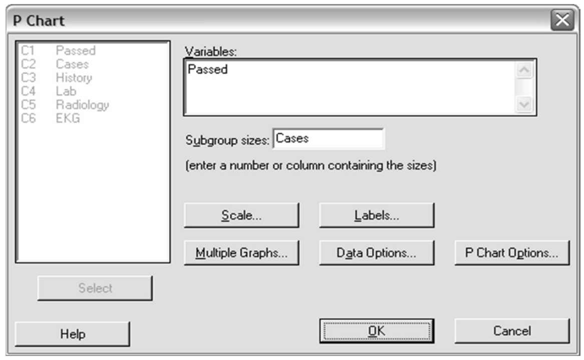
Minitab Example

- Pre-packaging tests are conducted for garments to determine readiness for shipment.
- Decision is taken on the basis of performance as compared to past shipments
- Construct a p-chart of the defective cases and evaluate whether the process is in control.

Constructing p Charts in Minitab

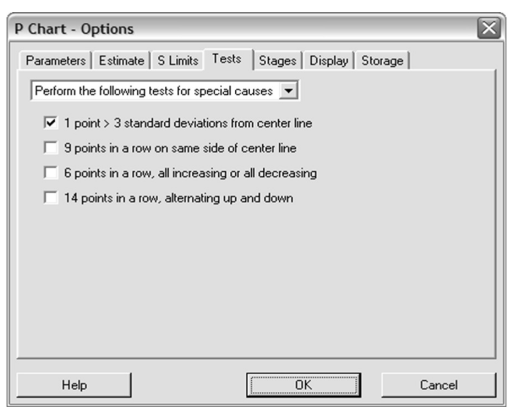
Pat.mtw

- ❑ Open Minitab file pat.mtw
- ❑ From the menu select Stat>Control Charts>Attributes Charts>P…
- ❑ Enter Passed for *Variables:*
- ❑ Enter *Cases* for Sub*groups Sizes:*



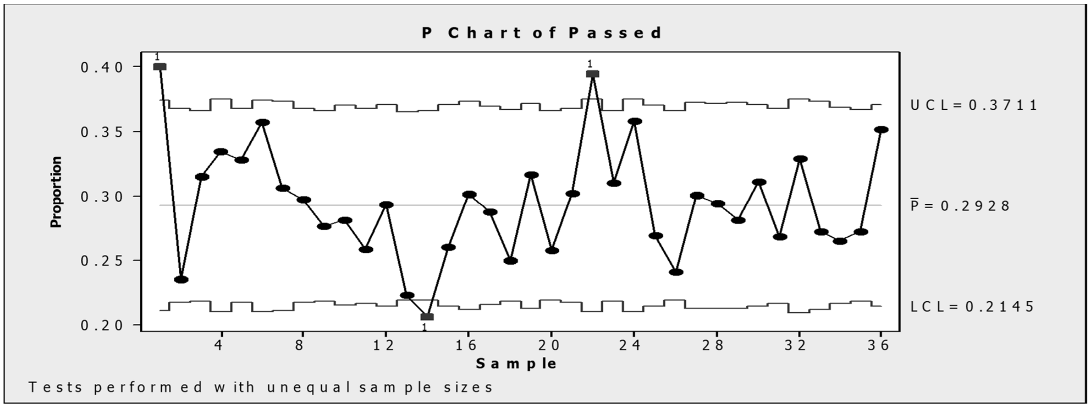
Interpreting p-Charts

- ❑ Attribute charts have fewer tests for special causes due to the lower information content of attribute data.
- ❑ A point outside the 3σ limit is assumed to be from special cause variation.
- ❑ When np<5, the likelihood of runs below p-bar increases. Take care when interpreting runs in these cases.



Unless the subgroups are equal sizes, only the first test is used.

Minitab p-Chart Output



Charts For Defects – c-Charts and u-Charts

- When to use c- or u-charts
  - When the data are attribute data of defects, not defectives
  - When the data come from a Poisson process
  - c-charts are charts constructed for *number of occurrences* for a constant exposure
  - u-charts are constructed for *rate of occurrence* for either constant or varying exposure
- Examples
  - Each month, 100 invoices are audited and the total number of mistakes is recorded.
  - In a molding process, there is a problem with pinholes in plastic bottles. Each day, a number of bottles are examined and the number of pinholes are recorded.
  - Each month, the number of accidents that occur in an organization are recorded.

Calculate c-Chart Control Limits

- For each subgroup
  - Record: c – the number of defects found

- Calculate $\bar{c}$ – the mean number of defects:

$$\bar{c} = \frac{c1 + c2 + \ldots + ck}{k}$$

- Calculate the control limits:

$$UCLc = \bar{c} + 3\sqrt{\bar{c}}$$
$$LCLc = \bar{c} - 3\sqrt{\bar{c}}$$