Using SPC Charts

Prepared for:

American Society for Quality – *Columbus Section*
Spring Conference
March 24, 2011

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Outline

- Why SPC?
- What are SPC Charts
- Types of Control Charts
- Sampling and Rational Subgroups
- Constructing a Control Chart
- Using Control Charts
- Out-of-Control Conditions
- Control Chart Selector

Why SPC?

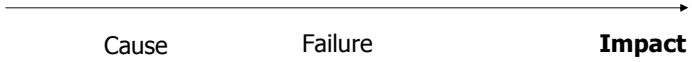
"A state of statistical control is NOT a natural state of a manufacturing process. It is instead an achievement, arrived at by eliminating one by one, by determined effort, the special causes of excessive variation"

Deming

Control Charts

- A control chart is a statistical device essentially used to study, control, and improve repetitive processes over time.
- Control charts:
  - Focus attention on detecting variation in a given characteristic over time
  - Differentiate between common and special causes of variation
  - Help in investigating trends for future improvements
  - Provide common language for communicating process performance

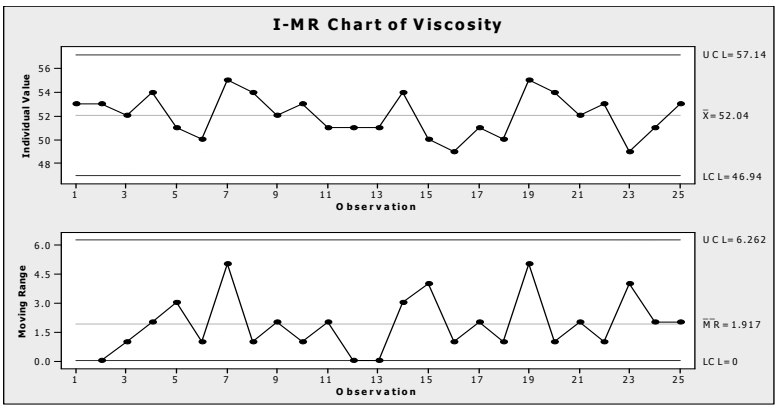
Problems, Causes, & Impacts



Introduction to Control Charts - Cont'd

- Every Control Chart consists of the following
  - Header information including characteristic name, unit of measure, process name/ID, part number, sample size, sampling frequency, among others.
  - Upper and lower control limits (UCL and LCL) generated from the process
  - Centerline or process average
  - Record or reference of process changes
  - Reaction plan (or reference) once an out-of- control condition has been identified

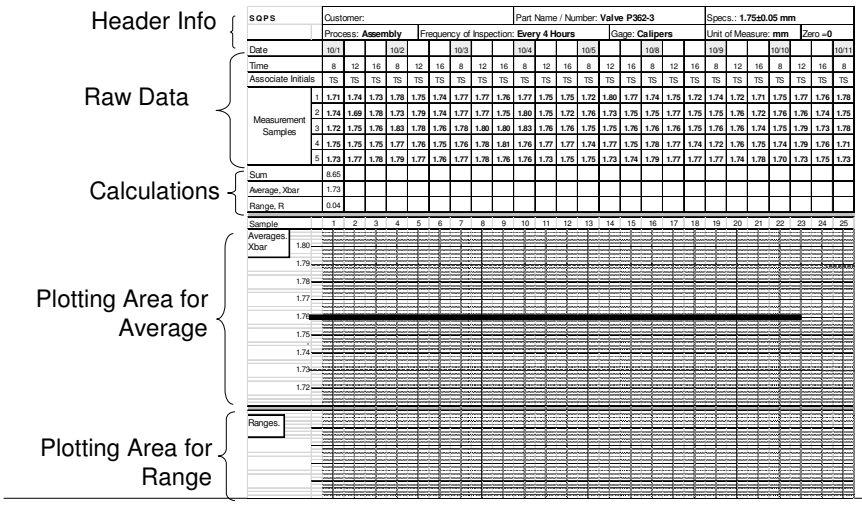
In seconds using Zahn cup



Types of Control Charts

- Control charts are of two main types
  - Attribute
  - Variable
- Attribute control charts are used when dealing with attribute data
- Variable control charts are used when dealing with continuous (or variable) data.
- Whenever feasible, variable control charts should be used

Typical Variable Control Chart



Sampling and Rational Subgroups

- A sample is taken at an appropriate interval to check the performance of the process
- Sampling must be made at the appropriate frequency so that:
  - No extra samples are taken – minimize cost
  - Enough samples for the control chart are taken to be most reliable for detecting out of control conditions

Sampling Frequency & Subgroups - Cont'd

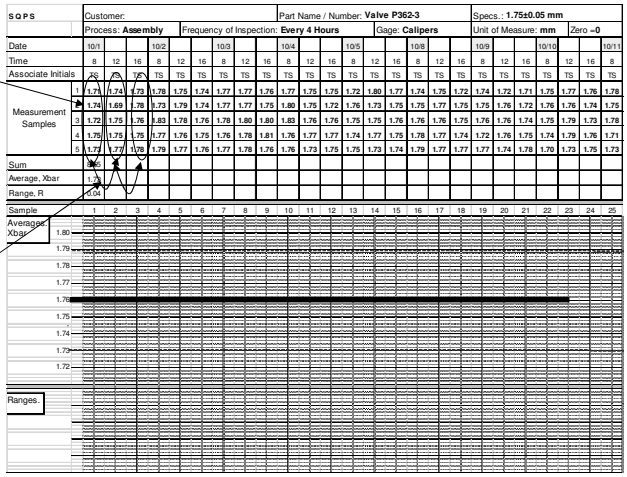
- "Rational Subgroups" is an important concept in collecting data for control charts
- The subgroups or samples should be selected so that if special (assignable) causes are present, then:
  - The chance for differences between subgroups will be maximized
  - The chance for differences due to these assignable causes within a sample should be minimized

Sampling and Rational Subgroups- Cont'd

- Approach for variable control charts
  - Take a sample of units produced at the same time or as close to each other as possible to minimize the chance of detecting differences within a sample due to assignable causes
  - The interval between samples should be selected to maximize the chance of variability between samples if assignable causes are present
  - This approach is considered a "snapshot" of the process and provides a better estimate of the standard deviation

Sampling and Rational Subgroups- Cont'd

The units within a sample (or subgroup) must be selected as close to each other as possible with regard to their production **>>** minimize variation within sample



Time between every two consecutive samples (or subgroups) should be long enough to detect variability (special causes) when present

Sampling and Rational Subgroups- Cont'd

- How do we determine sampling frequency?
  - First, select the subgroup size. If using an X-Bar and R chart, 3 to 5 is appropriate. A sample size of 5 is common.
  - How consistent is your process? Any changes to the process with regard to:
    - Equipment settings
    - Materials
    - Methods
    - Personnel
    - Environment

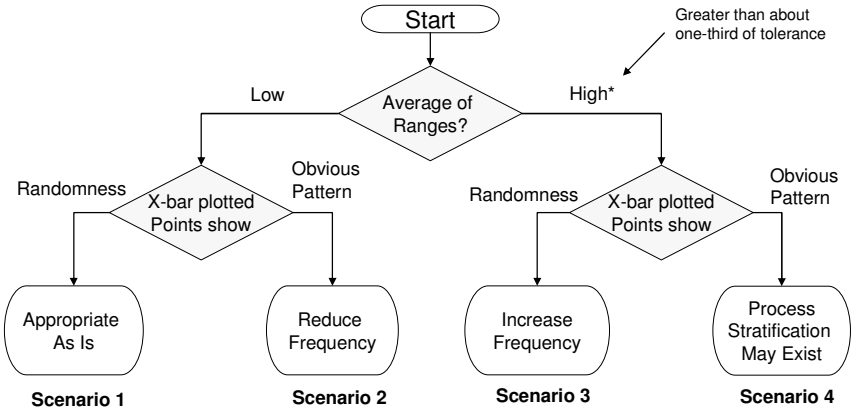
Sampling and Rational Subgroups- Cont'd

- How do we determine sampling frequency?
  1. First, select the subgroup size.
     - As mentioned before, using an X-Bar and R chart, 3 to 5 is appropriate. A sample size of 5 is common.
     - In case an X-Bar and S (standard deviation) is used, a sample size of at least 10 should be selected
     - For an individual and moving range chart (I & MR), we take only one point at a time and there is no option there

Sampling and Rational Subgroups- Cont'd

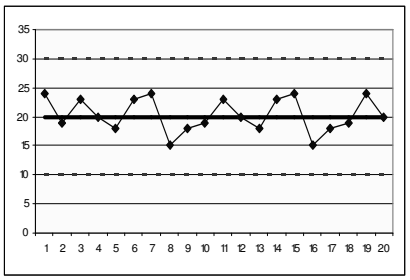
- How do we determine sampling frequency?
  2. Sample at least 3 times within consistent "homogeneous" conditions keeping the same time interval between samples
  3. Keep sampling through normal changes in the process such as shift changes, material changes, before and after equipment maintenance, etc.
  4. Plot points and check for patterns in both charts (X-Bar and Range)

Determining Frequency



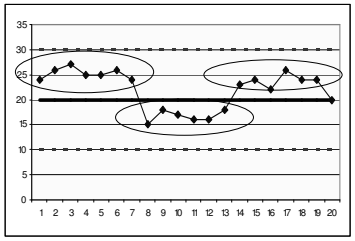
Determining Frequency

- Scenario 1
  - Range average is low (lower than one-third of specification tolerance)
  - Average chart shows random variation (no obvious non-random patterns **>>**See Graph**>>**
  - Current sampling frequency is, therefore, **Appropriate**



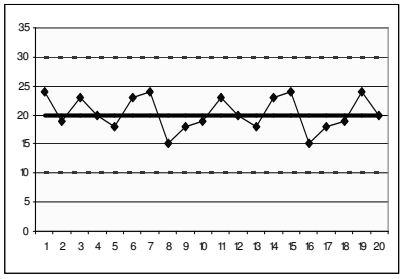
Determining Frequency

- Scenario 2
  - Range average is low (lower than one-third of specification tolerance)
  - Average chart shows obvious non-random patterns **>>**See Graph**>>**
  - Shortest run at same level appears to consist of 6 samples
  - Sampling frequency should, therefore, **Be Reduced**
  - Possibility by 6. For example, we could go from once every hour to once every 6 hours



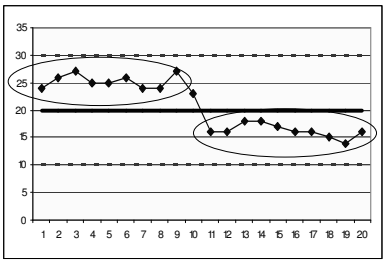
Determining Frequency

- Scenario 3
  - Range average is High (higher than one-third of specification tolerance)
  - Average chart shows random variation (no obvious non-random patterns **>>**See Graph**>>**
  - Sampling frequency should, therefore, **Be Increased**
  - Start over



Determining Frequency

- Scenario 4
  - Range average is high (higher than one-third of specification tolerance)
  - Average chart shows obvious non-random patterns with long runs **>>**See Graph**>>**
  - Stratification analysis of the process should be conducted before deciding on frequency
    - Data could be coming from different processes
    - Troubleshoot process and correct
  - Start Over

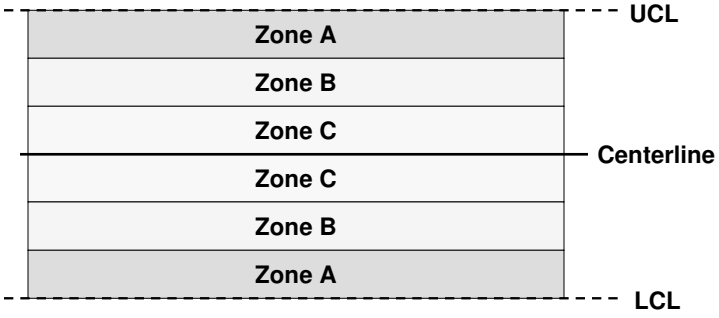


Exercise: Determining Frequency

- In a process, a dimensional characteristic to be plotted has a tolerance of 3.0 mm and an average of ranges of 0.5. The initial chart (every 15 minutes) showed cycles of 4 to 5 points each. Approximately how often should we sample?

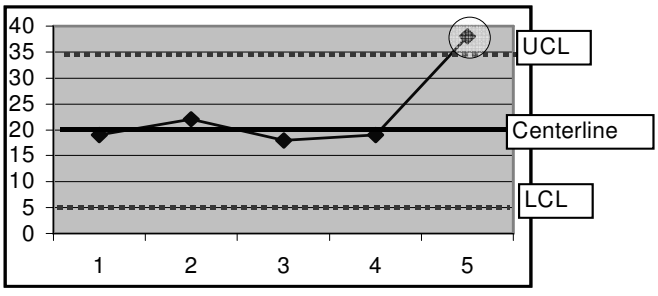
Out-of-Control Conditions

The control chart should be divided into 6 zones – 3 on each side- (see below)



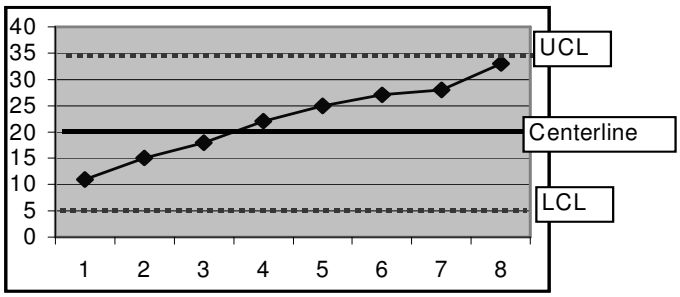
Out-of-Control Conditions - Cont'd

1. One or more points fall outside the control limits



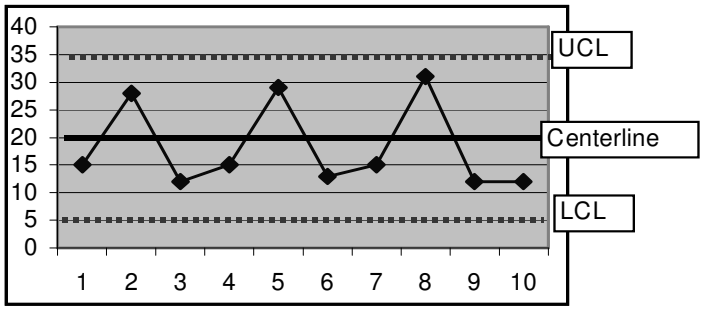
Out-of-Control Conditions - Cont'd

2. Six consecutive points increasing or decreasing (trend)



Out-of-Control Conditions - Cont'd

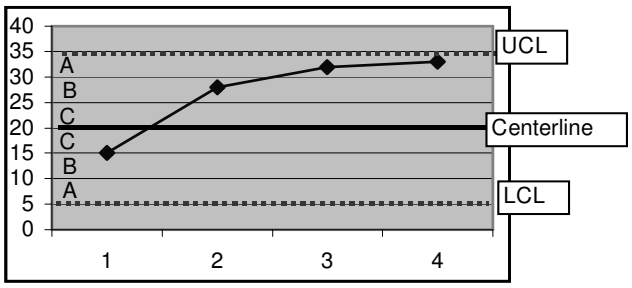
3. Cycles (3 or more obvious cycles)



Out-of-Control Conditions - Cont'd

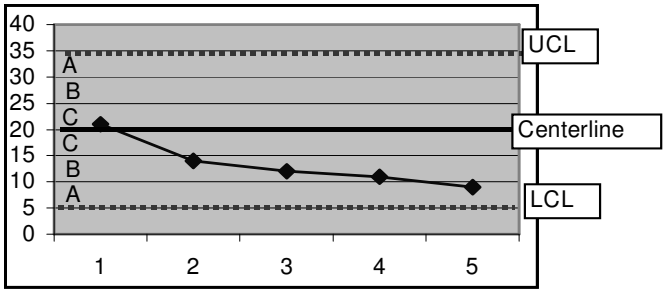
4. Process Shift

4a Two Points out of 3 consecutive points are on the same side of the centerline (Average) in region A or beyond



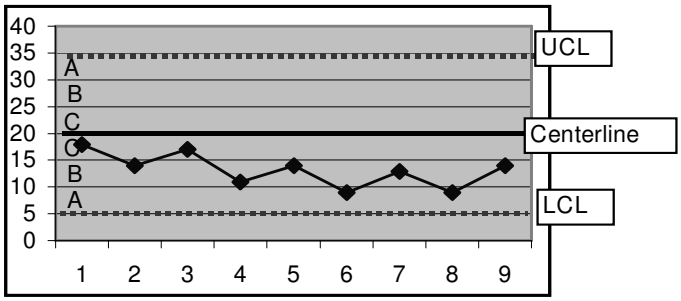
Out-of-Control Conditions- Cont'd

4b Four out of five consecutive points are on the same side of the centerline (Average) in zone B or beyond



Out-of-Control Conditions- Cont'd

4c Nine consecutive points are on the same side of the centerline (Average)



Out-of-Control Conditions- Cont'd

- When an out-of control condition is observed:
  - Verify data entry and calculations
  - If still out-of-control, contain suspect samples since last in-control
  - Follow your reaction plan. This might range from notifying the supervisor to stopping production until a corrective action is implemented and verified

Out-of-Control Conditions- Cont'd

- Possible Causes
  - One point beyond control limits: Possible causes include sudden change in the process elements
  - Trends: Possible cause(s) include Gradual deterioration (improvement in R chart or attribute charts if downward trend is observed)
  - Cycles; Possible cause(s) include Recurring pattern due to shift changes or environmental changes. It could also be periodic replacement of tool.
  - Concentration of points on the same side of centerline: Possible cause(s) include shift in the process average due to change in one of the process elements

Out-of-Control Conditions- Cont'd

- After plotting each point, the out-of-control conditions must be checked.
- Control limits must be updated to reflect the current status of the process.
  - Wider limits --- more variation
    - Determine root cause(s)
    - Reduce variation
  - Narrower limits --- less variation
    - know why!
    - Apply in other areas

Control Chart Selector

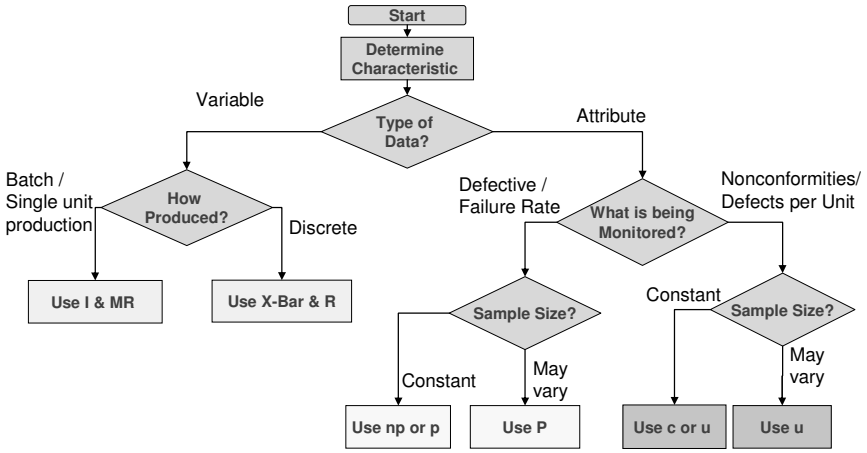


Chart Selection Exercise

1. A company produces metal washers at a rate of 250,000 each day. The critical characteristic is the inner diameter
2. An physician office is interested in reducing the additional waiting time (beyond appointment time) to no more than 5 minutes. What control chart might be helpful to so?

Thank You!

Questions and Inquiries:

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