University of Jordan
Chemical Engineering Department
905509 Statistical Quality Control

Causes of Variability & the Magnificent Seven

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Outline

- Introduction.
- Chance & assignable causes of variation.
- The magnificent seven
  1. Histogram
  2. Scatter plot
  3. Check sheet
  4. Pareto chart
  5. Cause and effect diagram
  6. Defect concentration diagram
  7. Control Chart

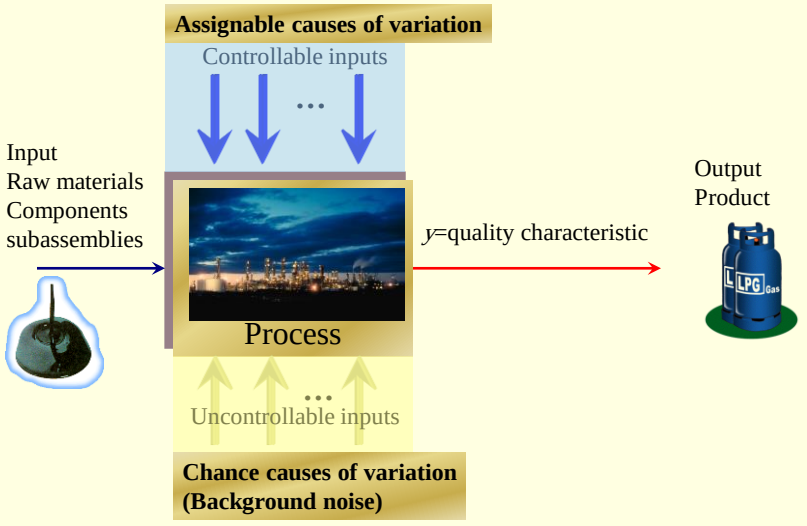
Motivation

- End products must comply to specifications, also components and materials used to fabricate products should adhere to specs.
- Rephrase this as : **the process must be capable of operating with minimal variability around the "target" product specification (quality characteristic).**
- The quality characteristic can be crystal size distribution, anti-caking agent concentration, impurity level etc.

Statistical Process Control (SPC)

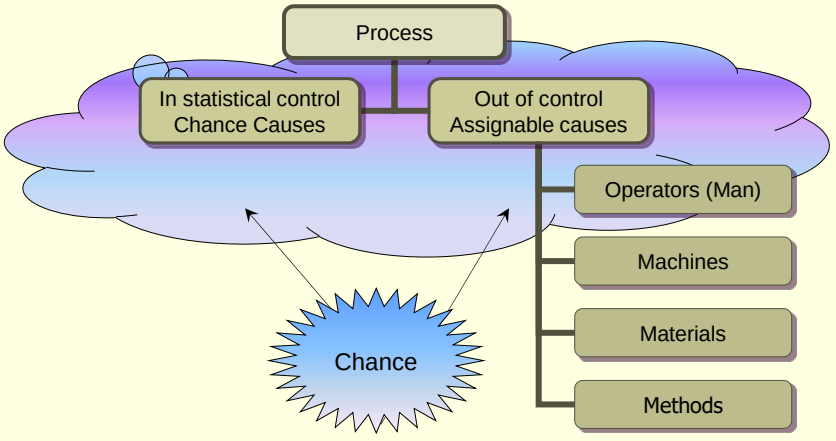
- Statistical Process Control (SPC) is a collection of statistically based problem solving tools that are used to:
  - Achieve process stability, and
  - Enhance or improve process capability.
- SPC achieves such improvement through the reduction of variability.

Process, Inputs and Outputs

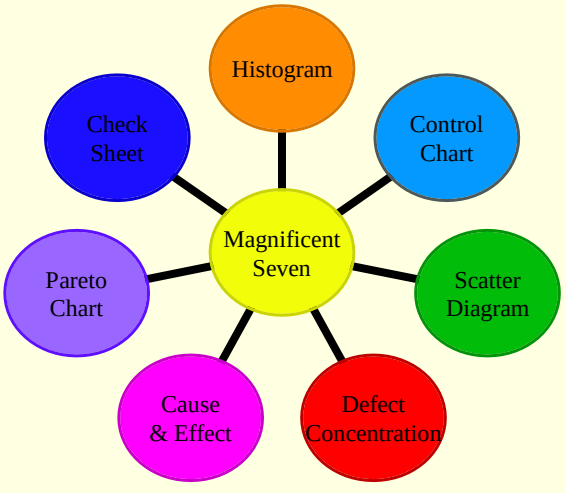


Statistically Controlled Processes

- All processes operate with less than 100% understanding and control.
- A process is
  - **in (statistical) control** if the only source of variation in that process is caused by **chance** (**common cause or background noise**).
  - **out of control** if we can find **assignable causes** to explain the malfunctioning or drifting of the process (**special causes**).
- SPC attempts to reduce variability due to assignable causes.

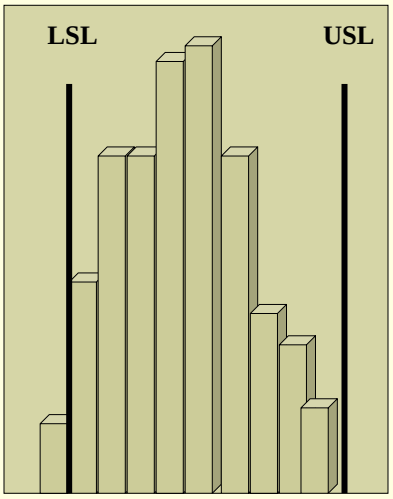


SPC's Magnificent Seven



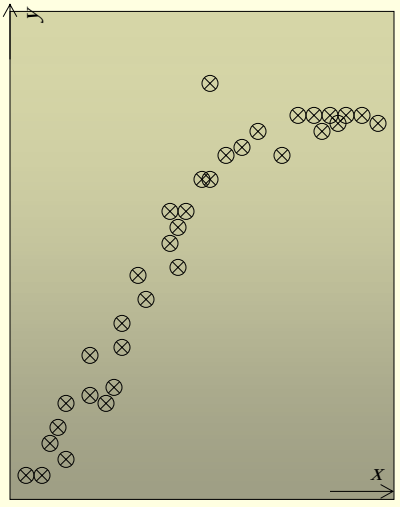
Histogram

- Nature of the distribution of the data is shown.
- Central tendency and variability are easily seen.
- Specification limits can be used to display the capability of the process.



Scatter Plot

- Identifies the relationship between two variables.
- The type of correlation can be seen: positive, negative, or no correlation.

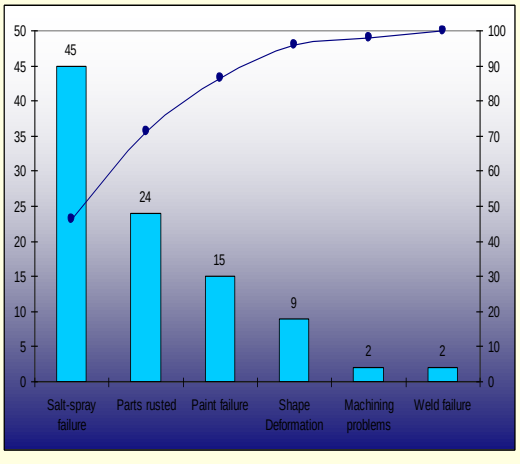


Check Sheet

- Usually constructed in the early stages of any SPC program.
- Concerns collecting historical and/or current operating data regarding the process under investigation.
- Spots problem areas by frequency of location, type, or cause.

Pareto Chart

- Identifies most significant problems to be worked first.
- Historically 80% of the problems are due to 20% of the factors.
- Shows the vital few.

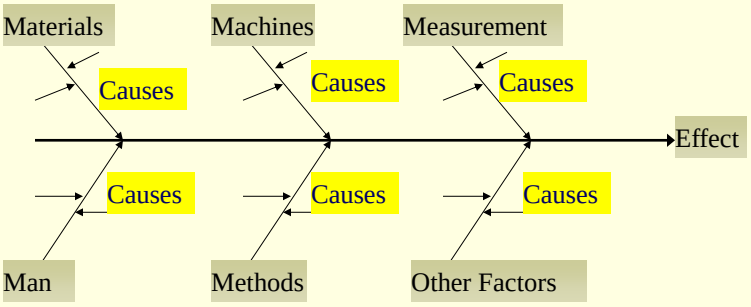


Cause & Effect Diagram

- If we identify a “defect”, “error”, or “problem”, we need to analyze our process for **causes** that generated such a disturbance.
- All contributing factors and their relationships are displayed.
- Identifies problem areas where data can be collected and analyzed.
- There is no generalized “one-size-fits-all” procedure to do this kind of reasoning.
- Team work and brainstorming is required to construct such diagrams.

Constructing a Cause & Effect Diagram

1. Problem definition (defect analyzed).
2. Form a team to uncover potential causes via brainstorming.
3. Draw the effect box and centerline.
4. Major potential cause categories
    1. Specify.
    2. Boxes connected to centerline.
5. Possible causes are identified.
6. Rank order the categories to identify those that seem most likely to impact the problem.
7. Take corrective action.

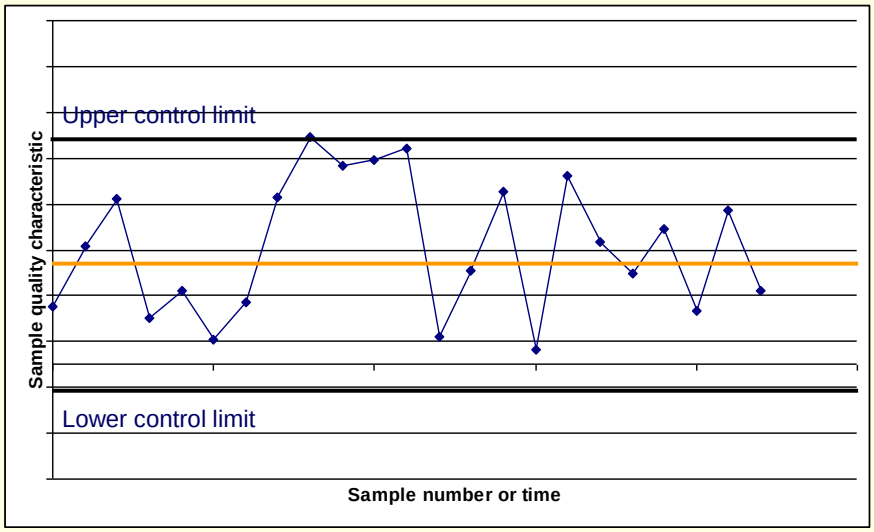


Defect Concentration Diagram

- Actual display of all relevant views of the unit/product.
- Types of defects are overlaid on the picture.
- It answers the question: does the **location** of the defects on the unit conveys any useful information about the potential causes of the defects.

Control Chart

- Graphical display of a quality characteristic that has been measured/computed from a sample versus the sample number or time.
- Contains three lines
  - Center line (CL) corresponds to the average of the characteristic corresponding to in-control state
  - Upper control limit (UCL), and lower control limit (LCL). These two lines are chosen such that nearly all of the sample points will fall between them.



Simple Interpretation of a Control Chart

- As long as the points fall within the control limits, the process is assumed to be in control and no action is necessary.
- A point falling outside the limits is interpreted as evidence that the process is out of control, and corrective action is necessary to eliminate the assignable causes that are responsible for such behavior.
- Even if all the points fall within the control limits, if they behave in a systematic or nonrandom manner, then this is an indication that the process is out of control.

Control Chart Types

- Many types, we focus our attention here on the mean and range charts.
- Advanced and related topics include
  - Standard Deviation Charts
  - CUSUM approach
  - Exponentially weighted average methods (EWMA).
- Can deal with
  - Variables
  - Attributes

Reasons for Using Control Charts