Shewhart’s View of SPC

Shewhart’s book - *Economic Control of Quality of Manufactured Product* (1931) - preface establishes the principles of SPC

1. Fundamental focus is on the process: "ways and means of satisfying human wants."

2. Overarching objective - economic process operation: "Reduce everything possible to routines requiring a minimum amount of effort."
3. Normal process operation - behavior w/in predictable limits: "It has been found possible to set up limits within which the results of routine efforts must lie if they are to be economical."

4. Deviations outside the limits signal presence of problems that are jeopardizing economic success: "Deviations in the results of a routine process outside such limits indicate that the routine has broken down and will no longer be economical."

5. Deviations outside the limits - find root cause of the trouble in the process and remove it: "The routine has broken down and will no longer be economical until the cause of trouble is removed."
Comments

- No mention of the product or conformance of the product to specifications.

- A controlled process is one where, based on experience, we can predict (within limits) future behavior.

- Special causes are sources of waste/inefficiency

- When a process is not in control (i.e., special causes present), it is no longer operating routinely/predictably, economic success is jeopardized.
Remember

- Only individual measurements may be compared to engineering specifications.

- Specs tell us about whether customer expectations are being met.

- Control charts tell us about process consistency, stability, or predictability. The presence of special causes means that our process is no longer consistent, stable, predictable, economical.
Var. Mgmt. w/ Control Charts

How to Detect Special Causes??

Since both mean and variability may be changing over time, need to collect samples & do calculations that tell us about centering ($\bar{X}$) and spread (R).
Detecting Special Causes

Circle the points that are "statistical signals" - special causes are present - process not routine / economical
Achieving Control

Let’s assume we take actions that eliminate the local faults manifested in the previous charts.
Control - is it enough??

Now what??
Summary

"Out-of-Control"  Control  Improvement

\[
\bar{x}, \text{ Range} \quad \bar{R} \quad UCL \quad LCL
\]
Process of Statistical Process Control

Uses of Control Charts

- Off-line. To identify when special/sporadic causes enter the process and to characterize the level of common-cause variability. Where to look for improvement opportunities. Help to formulate & assess effect of actions.

- On-line. To serve as a tool (provide a sound economic basis) for operators to make decisions at the machine as to when to adjust the machine (and when to leave it alone).
Control System View of SPC

- Observation: Data collection
- Diagnosis: Fault discovery
- Decision: Formulate action
- Implementation: Take action
- Process: Data analysis
- Evaluation: Data analysis
So, where do we stand??

Monitor changes in $\bar{X}$ and $R$ as a function of time.
Shewhart Control Chart Model

\[
\bar{x} = \mu_{\bar{x}}
\]

\[
3\sigma_{\bar{x}}
\]

\[
\begin{align*}
UCL_{\bar{x}} &= \bar{x} + 3\sigma_{\bar{x}} \\
LCL_{\bar{x}} &= \bar{x} - 3\sigma_{\bar{x}} \\
UCL_{R} &= R + 3\sigma_{R} \\
LCL_{R} &= R - 3\sigma_{R}
\end{align*}
\]
Control Chart - Hypothesis Test

Control limits depend, of course, on the risk level, $\alpha$. 
Where do we put the limits??

Centerline

Put the limits 3 standard deviations from the mean
Limits??

Centerline

Put the limits 3 standard deviations from the mean