IE 361 Module 32

Patterns on Control Charts Part 2 and Special Checks/Extra Alarm Rules

Reading: Section 3.4 *Statistical Methods for Quality Assurance*

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Another phenomenon that can produce strange-looking patterns on Shewhart control charts is something early users called the occurrence of **mixtures.** These are the combination of two or more distinct patterns of variation (in either a plotted statistic Q, or in an underlying distribution of individual observations leading to Q) that get put together on a single chart. Where an underlying distribution of observations has two or more radically different components, depending upon the circumstances a plotted statistic Q can be *either* unexpectedly variable or surprisingly consistent.

Patterns on Control Charts

Mixtures (Large Variation)

Consider first the possibility of unexpectedly large variation. Where blunders like incomplete or omitted manufacturing operations or equipment malfunctions lead to occasional wild individual observations and correspondingly wild values of Q, the terminology **freaks** is often used to describe the mixture of normal and aberrant observations. The next figure shows both a plot over time and a corresponding histogram of a series of values Q that fit this description.

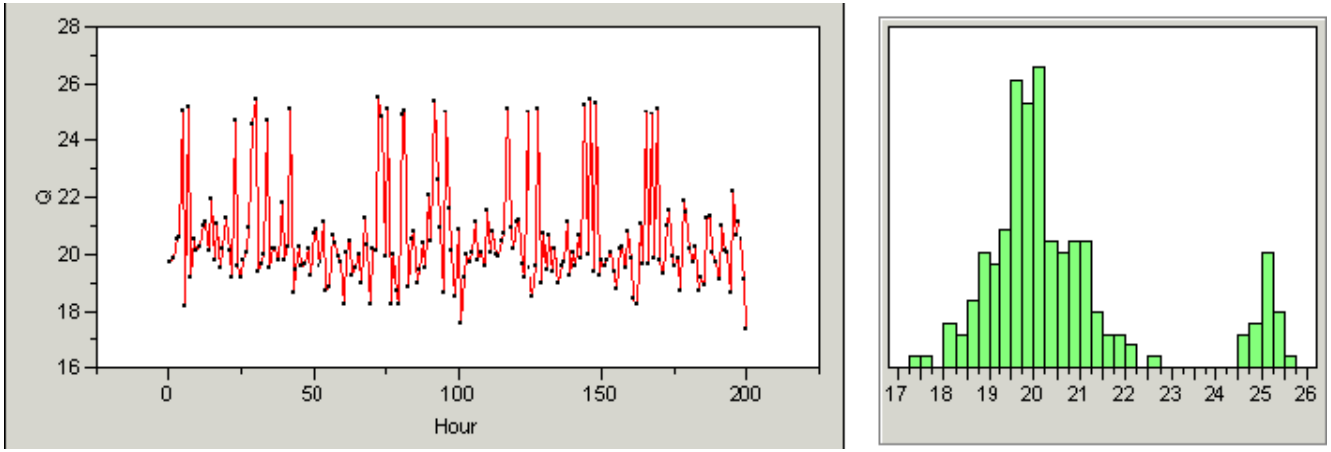

Figure: An Example of a Pattern that Could be Described as Exhibiting "Freaks" (and the Corresponding Histogram)

Patterns on Control Charts

Mixtures (Large Variation)

Where individual observations or values of Q of a given magnitude tend to occur together in time, the terminology **grouping** or **bunching** is common. (Different work methods employed by different operators or changes in the calibration of a measurement instrument can be responsible for grouping or bunching.) The next figure shows this kind of pattern.

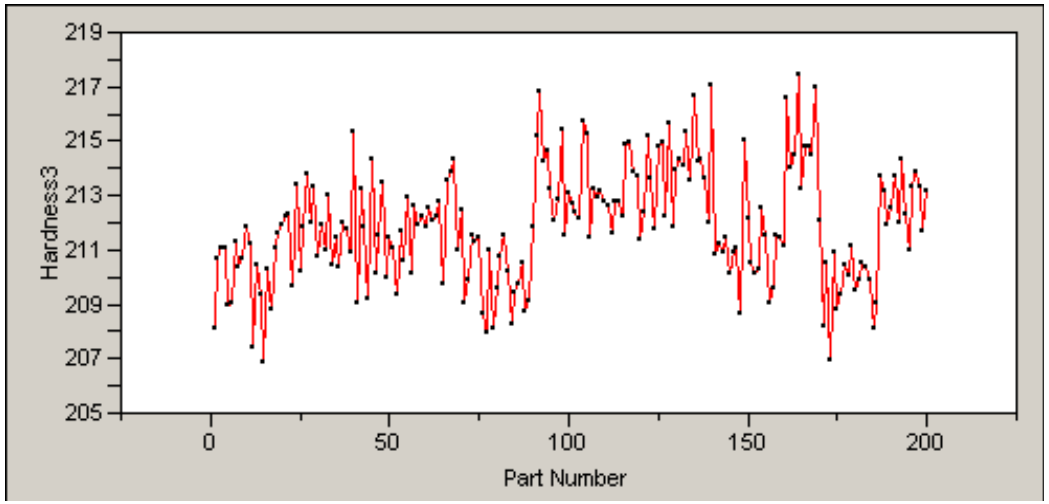

Figure: A Run Chart Showing Grouping/Bunching

Patterns on Control Charts

Mixtures (Small Variation and "Stratification")

How a mixture can lead to unexpectedly small variation in a plotted statistic (as portrayed below) is more subtle. It involves a phenomenon known as **stratification**, in which an underlying distribution of observations has radically different components, each with small associated variation, and these components are sampled in a systematic fashion. One might, for example, be sampling different raw material streams or the output of different machines and unthinkingly calling the resulting values a single "sample" (in violation the notion of rational subgrouping!!).

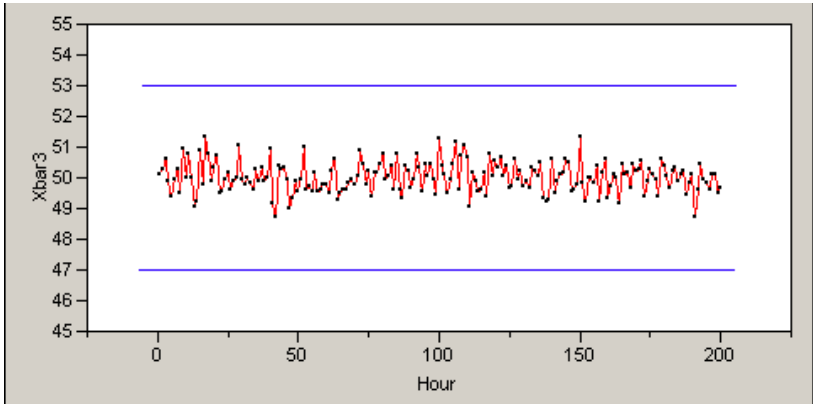

Figure: Small Variation on an $\bar{x}$ Chart, Potentially Due to Stratification

Consider, for example, the case of a hypothetical 10-head machine that has one completely bad head and 9 perfect ones. If the items from this machine are taken off the heads in sequence and placed into a production stream, "samples" of 10 consecutive items will have fractions defective that are *absolutely constant* at 10%. A Shewhart p chart for the process will look unbelievably consistent about a center line at .10. (A similar hypothetical example involving $\overline{x}$ and R charts can be invented by thinking of 9 of the 10 heads as turning out widget diameters of essentially exactly 5.000, while the 10th turns out widget diameters of essentially exactly 55.000. Ranges of "samples" of 10 consecutive parts will be unbelievably stable at 50.000 and means will be "unbelievably consistent" around 10.000.)

"Special Checks"/"Extra Alarm Rules" for Patterns on a Control Chart

Once one begins to look for patterns on Shewhart control charts, the question arises as to *exactly* what ought to be considered the occurrence of a pattern. This is important for two reasons. In the first place, there is the matter of consistency within an organization. Further, there is the matter that without a fair amount of theoretical experience in probability and/or practical experience in using control charts, people tend to want to "see" patterns that are in actuality very easily produced by a stable process.

Since the "one point outside control limits" rule is blind to the interesting kinds of patterns discussed here and there is a need for standardization of the criteria used to judge whether a pattern has occurred, many organizations have developed sets of "special checks for unnatural patterns" for application to Shewhart charts. These are usually based on segmenting the set of possible Q's into various "zones" defined in terms of multiples of σ_Q above and below the central value μ_Q.

"Special Checks"/"Extra Alarm Rules" for Patterns on a Control Chart

"Zones" on Shewhart Charts

The following figure shows a generic Shewhart chart with typical zones marked on it.

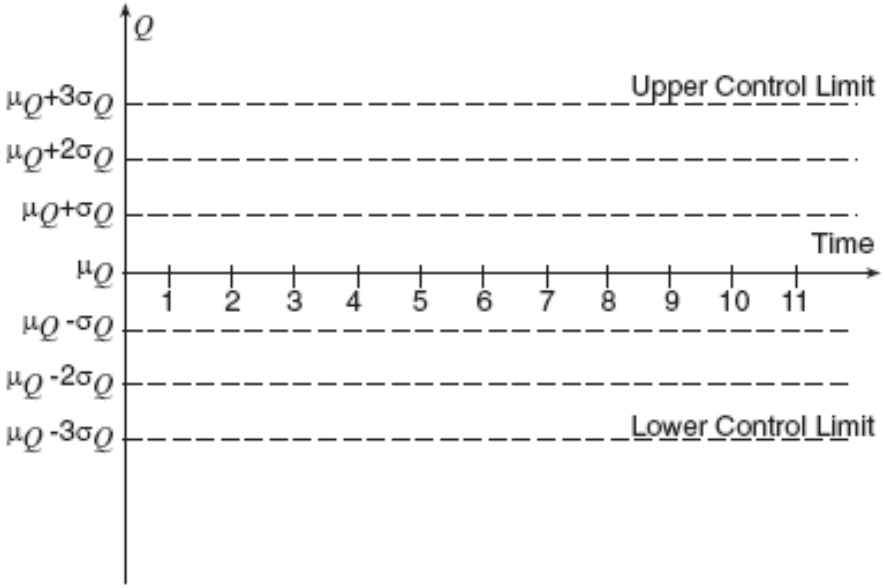

Figure: A Generic Shewhart Chart With "Zones" Marked on It

Western Electric Rules

By far the most famous set of special checks is the set of "Western Electric Alarm Rules" given below. They are discussed extensively in the *Statistical Quality Control Handbook* published originally by Western Electric and later by AT&T.

Western Electric Alarm Rules
A single point outside 3 sigma control limits
2 out of any 3 consecutive points outside 2 sigma limits on one side of center
4 out of any 5 consecutive points outside 1 sigma limits on one side of center
8 consecutive points on one side of center

One should be able to see in this set of rules an attempt to provide operational definitions for "patterns" of the type just discussed. It is not obvious whether this set or some other set of checks should be used, or even what are rational criteria for comparing them to the many other sets that have been suggested. But the motivation for creating them should be clear.