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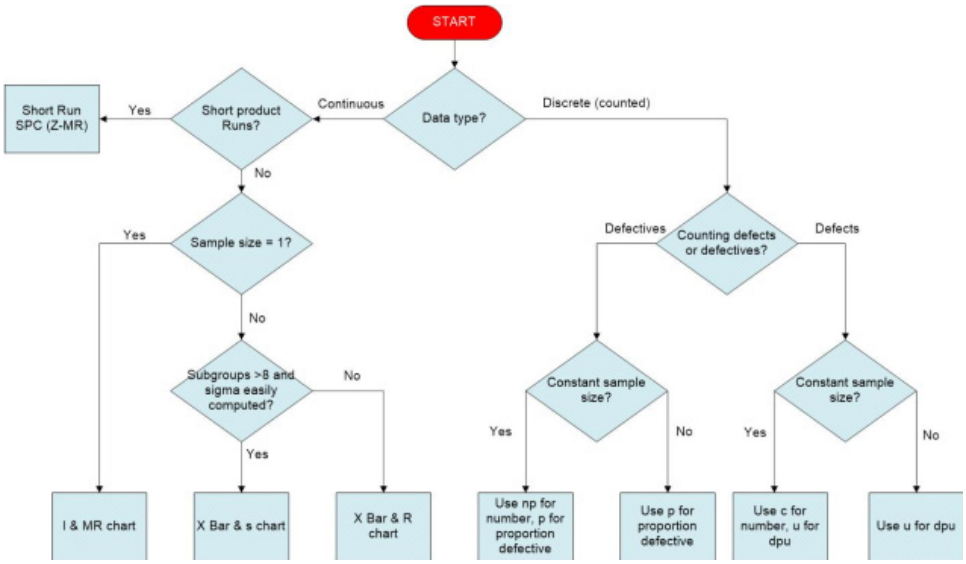
Control Charts in Minitab

Key Learning Points

1. Describe different types of Control Charts.
2. Explain how to create Control Charts.
3. Utilize Control Charts in improvement projects.

Selecting Appropriate Control Charts



Comparison of Common Control Charts

Statistical Measure Plotted	▪ Average (X-bar) and range (R) ▪ Average (X-bar) and standard deviation (s) ▪ Individual (I) and Moving Range (MR) ▪ Cumulative sum	▪ % defective p Number of ▪ defectives np	▪ Defects per unit u ▪ Number of defects c
Type of Data Required	Continuous data (measured values of a characteristic)	Discrete data (number of defective units of product)	Discrete data (number of defects per unit of product)
General Field of Application	Control of individual characteristics	Control of overall fraction defective of a process	Control of overall number of defects per unit

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Significant Advantages	1. Provides maximum utilization of information available from data 2. Provides detailed information on process average and variation for control of individual dimensions	1. Data required are often already available from inspection records 2. Easily understood by all personnel 3. Provides an overall picture of quality	Same advantages as p chart but also provides a measure of degree of defectiveness
Significant Disadvantages	1. Not understood unless training is provided—Can cause confusion between control limits and tolerance limits 2. Cannot be used with go no-go type of data	1. Does not provide detailed information for control of individual characteristics 2. Does not recognize different degrees of defectiveness in units of product 3. Requires large sample sizes	Does not provide detailed information for control of individual characteristics

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Sample Size	▪ Xbar-R: Minimum 2, usually 4 or 5 ▪ Xbar-S: Minimum 9 ▪ I&MR: 1, otherwise use Xbar-R or Xbar-S ▪ Cumulative Sum: Minimum 2, usually 4 or 5	Depends on rate of defectives, typically samples of 25 to 100	Any convenient unit of product such as 100 ft. of wire or one television set

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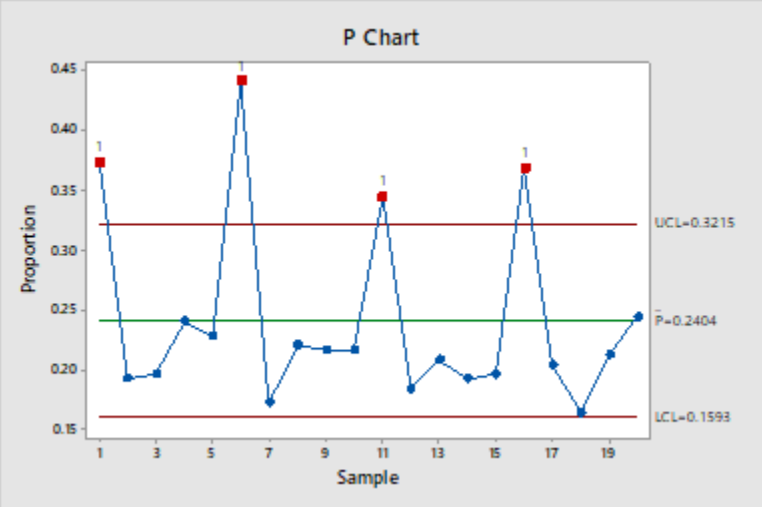
P Chart



The P chart plots the proportion of nonconforming units (also called defectives). While a unit may have many quality characteristics that can be evaluated, it is always considered as either conforming or nonconforming.

The P chart is the most widely used attribute control chart.

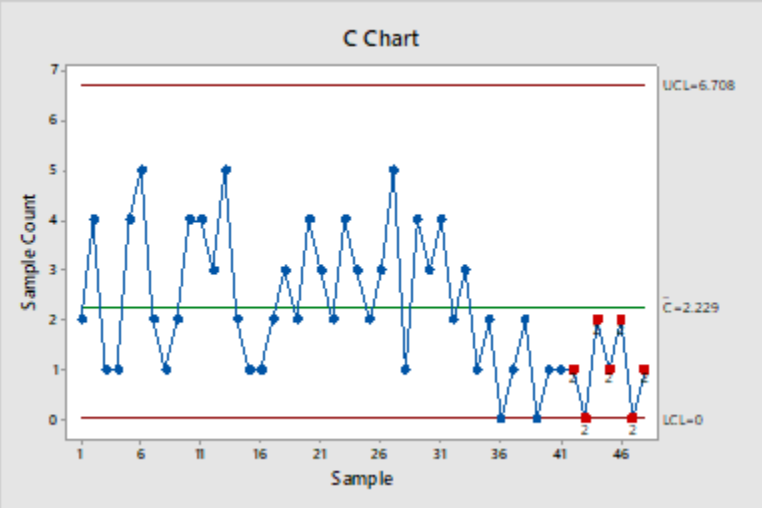
Upper Control Limits (UCL) and Lower Control Limits (LCL) help to determine if process variation is within expected process random variation.

The center line (p-bar) indicates the average proportion of errors of all data points. The red squares indicate out-of-control points. The numbers indicate which test failed.

For example, you can use a P chart to monitor the following:

- The proportion of flights that depart late
- The proportion of bicycle tires that are flat
- The proportion of printed logos that are smudged

C Chart



C charts are used to monitor the number of defects where each item can have multiple defects. You should use a C chart only when your subgroups are the same size. Use this control chart to monitor process stability over time so that you can identify and correct instabilities in a process.

In a C chart, the center line (c-bar) indicates the average number of defects in a set sample of product or process outputs.The red squares indicate out-of-control points and the number indicates what test failed.

For example, you can use a C chart to monitor the following:

- The hour-to-hour variation in the number of defects per 10 foot section of carpet.

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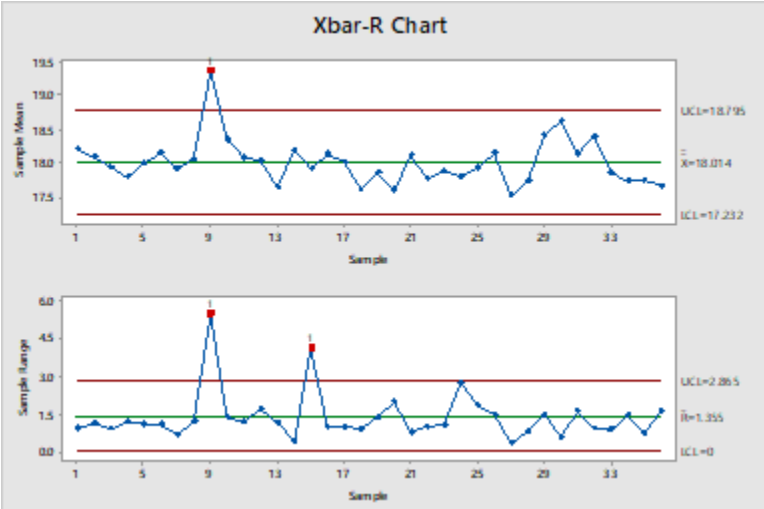
Averages and Ranges Chart (X-bar R)



Xbar-R Charts are used to monitor the mean and variation of a process when you have continuous data and subgroup sizes of 8 or less. Use this control chart to monitor process stability over time so that you can identify and correct instabilities in a process.

- Xbar charts show where the process is centered.
- If the Xbar chart shows natural variation, the center of the process is not shifting significantly.
- If the Xbar chart shows a trend, the center of the process is moving gradually up or down.
- If the Xbar chart is erratic and OOC, something is changing the center rapidly and inconsistently.
- Xbar charts can be affected by OOC conditions on the R chart.
- If the Xbar chart and R chart are both OOC, look first for the causes affecting the R chart.
- R chart uniformity or consistency:
  - If R chart is narrow, the product is uniform
  - If R chart is OOC, something is operating on the process in a non-uniform manner

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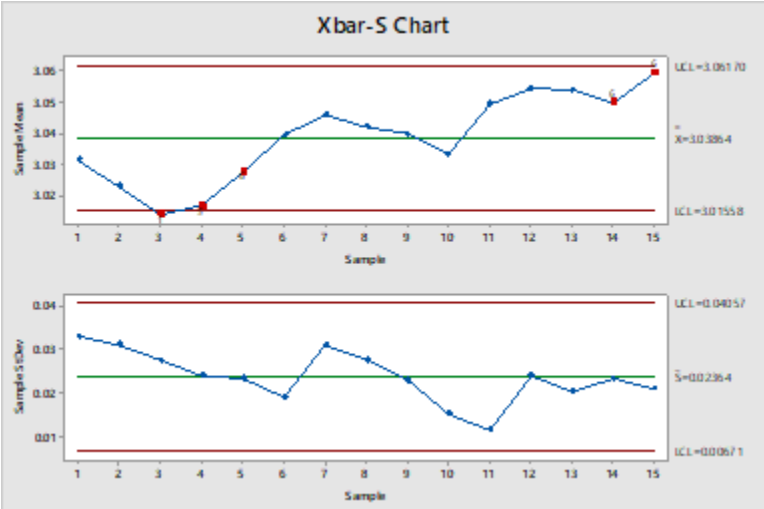
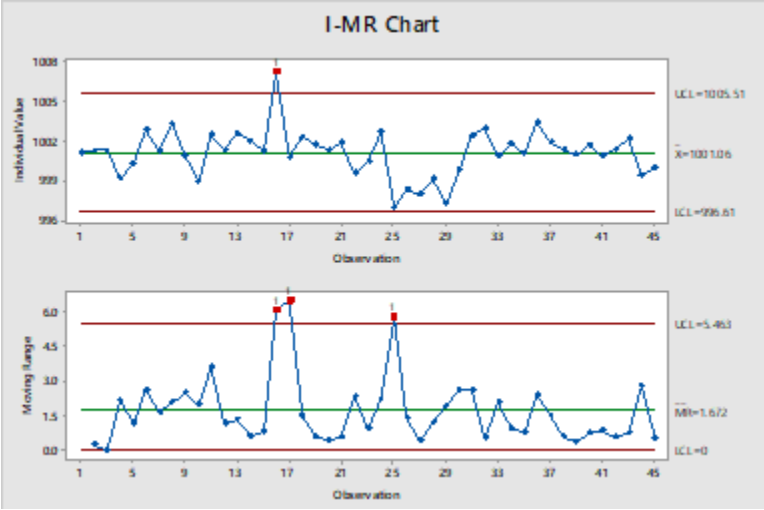
Averages and Ranges Chart (X-bar S)



Xbar-S Charts are used to monitor the mean and variation of a process when you have continuous data and subgroup sizes of 9 or more. Use this control chart to monitor process stability over time so that you can identify and correct instabilities in a process.

Individuals and Moving Range Chart (I&MR)



An Individuals and Moving Range chart plots individual observations (I chart) and moving ranges (MR chart) over time for variables data. Use this combination chart to monitor process center and variation when it is difficult or impossible to group measurements into subgroups. This occurs when measurements are expensive, production volume is low, or products have a long cycle time.
When data are collected as individual observations, you cannot calculate the standard deviation for each subgroup. The moving range is an alternative way to

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calculate process variation by computing the ranges of two or more consecutive observations.

The individuals' measurements should be tested for normality before using the calculated control limits based on the standard formulas. If the distribution is significantly not normal, e.g., pronounced skewness, then the control limits for individuals should be calculated based on transformed data.
Charts for individuals are not as sensitive to process changes as charts for averages. Care must be taken in interpretation of charts for individuals if the process distribution is not normal. Data transformation may be desirable in these cases. Charts for individuals do not isolate the piece-to-piece repeatability of the process. Therefore, in many applications it may be better to use a conventional Xbar and R chart with small subgroup sample sizes (2 to 4) even if this requires a longer period between subgroups.

Since there is only one individual item per subgroup, values of I and MR can have substantial variability (even if the process is stable) until the number of subgroups is 100 or more.

Using "Stages" to Prove Improvement

- After improvements have been implemented and the new process has stabilized, adding stages to control charts is a strong visualization of success.
- Tests of statistical significance should always accompany these types of control charts.

When Should A Control Chart Be Used?

Control charts are used after project completion to hold the gains from the improvement.

Pitfalls to Avoid

There are many different control charts for many different situations. It is very easy to use the incorrect control chart, which can lead to an incorrect interpretation about the process.

Control charts can also be perceived by employees as a judgement on their performance, even when this is not really the case. This can effect employee morale and performance. Proceed with caution.

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