# How do I Choose the Appropriate Type of Control Chart?

Steven Wachs
Principal Statistician
Integral Concepts, Inc.

Proper control chart selection is critical to realizing the benefits of Statistical Process Control.  Many factors should be considered when choosing a control chart for a given application.  These include:

- The type of data being charted (continuous or attribute)
- The required sensitivity (size of the change to be detected) of the chart
- Whether the chart includes data from multiple locations or not
- The ease and cost of sampling
- Production volumes

For variable data, X-Bar and R (or Xbar and S) charts are very common, however there are cases when they are not appropriate.  For example, charts for multiple locations within the subgroup are utilized when a subgroup consists of measurements that may come from different distributions.  Examples include:

- Multiple measurements on the same unit (e.g. diameter in 3 places)
- Units produced during the same cycle from different cavities, machining locations, filling heads etc.

When sampling is costly, within-sample variation is negligible, or it is not required to detect "small" process changes, charts of individual measurements are often utilized.  EWMA and CUSUM charts are useful when charting individual measurements but the traditional Individuals/Moving Range charts do not provide adequate sensitivity (ability to detect process changes when they occur).

The following table may be utilized to help select an appropriate control chart for each application.  The charts are segregated by data type. Charts for variable data are listed first, followed by charts for attribute data.

| Data Type | Chart | Monitors | Applications |
|---|---|---|---|
| Variable | X-Bar and S | Process average and standard deviation | High volume, single characteristic<br>Sample size 2 or larger |
| Variable | X-Bar and R | Process average and range | High volume, single characteristic<br>Sample size between 2 and 6 |
| Variable | X and MR | Process average and moving range | Sensitivity not required<br>Sampling is costly<br>Long Cycle Time<br>Note: Normality of data must be considered |
| Variable | Deviation from Nominal | Process average and range (or standard deviation) | Short Production Runs (Multiple parts)<br>All parts have similar standard deviation |
| Variable | Standardized X-Bar and R<br>Standardized X-Bar and S | Process average and range<br>Process average and std dev | Short Production Runs (Multiple parts)<br>Part standard deviations differ |
| Variable | X-Bar, Rb, d | Process average, range between and difference between extreme locations | Multiple locations within subgroup<br>Location averages are statistically different |
| Variable | X-Bar, Rb, Rw<br>X-Bar, Rb, S | Process average, range (or std dev) within and range between subgroup | Multiple locations within subgroup<br>Variation within and between subgroups different<br>Location averages are not statistically different |
| Variable | CUSUM | Cumulative deviations from mean | Charts for individuals when X and MR are not sensitive enough |
| Variable | EWMA | Weighted moving average | Charts for individuals when X and MR are not sensitive enough |
| Attribute | np | Number of Defectives | Pass/Fail Data<br>Constant Sample Size<br>$n > 3/p$ |
| Attribute | p | Proportion Defective | Pass/Fail Data<br>Constant or Variable Sample Size<br>$n > 3/p$ |
| Attribute | standardized p | Standardized Proportion Defective | Pass/Fail Data<br>Variable Sample Size<br>$n > 3/p$<br>can be used for short production runs |
| Attribute | c | Number of Defects | Multiple types of defects on unit<br>Constant Sample Size<br>$n$ such that $c > 7$ |
| Attribute | u | Number of Defects per unit | Multiple types of defects on unit<br>Constant or Variable Sample Size<br>$n$ such that $c > 7$ |
| Attribute | standardized u | Standardized Number of Defects per unit | Multiple types of defects on unit<br>Variable Sample Size<br>$n$ such that $c > 7$<br>can be used for short production runs |