

A Practical Guide to Selecting the Right Control Chart

Select the right control chart to improve manufacturing processes and product quality.

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Introduction

Control charts were invented in the 1920s by Dr. Walter Shewhart as a visual tool to determine whether a manufacturing process is in statistical control. If the control chart indicates the manufacturing process is not in control, then corrections or changes should be made to the process parameters to ensure process and product consistency.

For manufacturers, control charts are typically the first indication that something can be improved and warrants a root cause analysis or other process improvement investigation. Today, control charts are a key tool for quality control and figure prominently in Lean manufacturing and Six Sigma efforts.

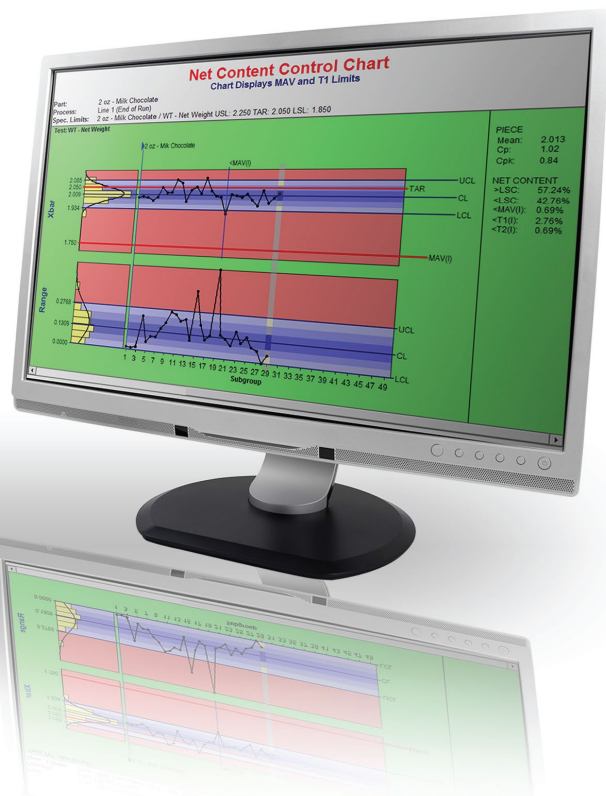
With over 300 types of control charts available, selecting the most appropriate one for a given situation can be overwhelming. You may be using only one or two types of charts for all your manufacturing process data simply because you haven't explored further possibilities or aren't sure when to use others. Choosing the wrong type of control chart may result in "false positives" because the chart may not be sensitive enough for your process. Or there may be ways to analyze parts and processes you thought weren't possible, resulting in new insights for possible process improvements.

This guide leads quality practitioners through a simple decision tree to select the right control chart to improve manufacturing processes and product quality. The guide focuses on **variables data**, not **attribute data**, and highlights powerful charting functionality that users often overlook.

You will learn which control chart is best for a given situation. InfinityQS® ProFicient™ software offers easy setup and display of a wide variety of control charts including the ones highlighted throughout this guide. In addition, ProFicient's quality hub gathers data from disparate sources, across multiple plants or production lines, using automated or manual sampling to present control charts in real time and alerting operators and quality engineers to take samples and initiate process improvements.

Variables Data – Measurements taken on a continuous scale such as time, weight, length, height, temperature, pressure, and so on. These measurements can have decimals.

Attribute Data – Measurements taken in discrete units that indicate the presence or absence of something such as number of defects, injuries, errors, and so on. This data cannot have decimals and cannot be used to calculate other information such as averages.



Part 1 – Control Charts and Basic Considerations

What IS and is NOT a Control Chart?

Just to make sure we're on the same page, let's first clarify what a control chart is.

A control chart is a real-time, time-ordered, graphical process feedback tool designed to tell an operator when significant changes have occurred in the manufacturing process. Control charts tell the operator when to do something and when to do nothing.

A control chart illustrates process behaviors by detecting changes in a process output's **mean** and/or **standard deviation** about the mean. Every process exhibits some normal levels of variation, but a control chart is designed to separate this normal or "common cause" variation from special cause variations.

Control charts indicate visually whether a process is in control (stable and predictable) or out of control (unstable and unpredictable). Typically, when the control chart indicates the process is out of control, an operator should take action to bring the process back under control or initiate an investigation into the root cause.

Even though a control chart analysis is NOT the same as a capability analysis (a process's ability to meet specifications), one should confirm that the process is in a state of statistical control before relying on the capability analysis results.

A control chart is also NOT useful for receiving inspection because the samples are not ordered in time of original production. Even though samples are taken, say 10 parts out of 100 in a box, there is no time ordering of the sampling like there is on a production line, so a control chart is not relevant for this type of data. However, box plots and histograms are perfectly suited for non-time-ordered data.

Control charts should NOT be confused with run charts, which are time-ordered but don't have control limits. In addition, pre-control charts are not control charts because these charts compare subgroup plot points with **specification limits**, not statistical limits.

Standard Deviation – An estimate of the variation from the mean for a larger population based on a given sample. The formula for estimated standard deviation is:

$$S = \sqrt{\frac{\sum(X - \bar{X})^2}{n - 1}}$$

S = estimated standard deviation

Σ = sum of

X = individual sample

\bar{X} = sample mean

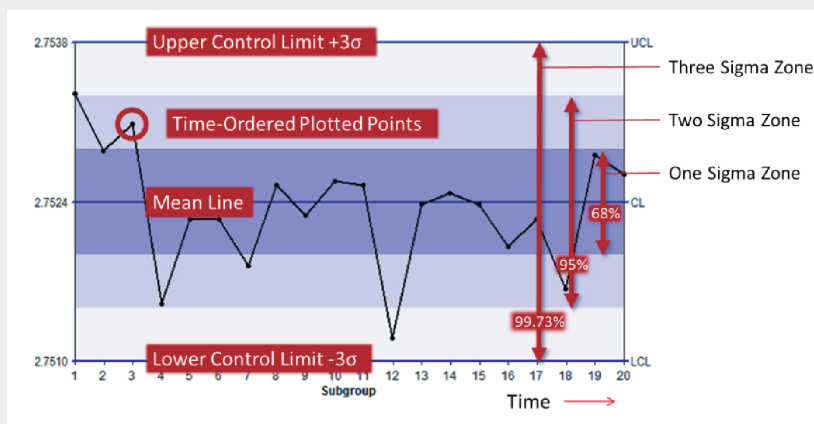
n = sample size

Mean – The average of a set of numbers such as sample data which indicates the "central" value. It is calculated by taking the sum of the samples and then dividing by the number of samples taken.

Specification Limits – Requirements for acceptability of a process output typically set by the customer or engineering. Typically given as a number – the target value – with upper and lower limits that define an acceptable range. The specification limit may also be given as a *not-to-exceed* number or a *not-less-than* number.

Components of a Control Chart

Control charts show time-ordered plotted points around a center line. The center line is determined by calculating the mean of the plot points, typically about 20 to 25 points. The upper control limits (UCL) and lower control limits (LCL) are typically set at ± 3 standard deviations of the plot points. The UCL and LCL show the *expected normal* (common cause) plot point variation. Control limits should be updated (recalculated) when the process *improves*. However, if you update the control limits when the process degrades, you are simply letting the process run with more variability. Updating the control limits only when the process improves promotes less variability and encourages continuous improvements over time.



Note: Control limits are based on observed process data, not on specification limits. Lines on a chart representing 75% of the specification limit are not statistical control limits. Control limits may not always be centered on target or within the specification limits.

Control charts are often divided into zones as shown. The 2 sigma and 1 sigma zones are sometimes used for early detection of an unstable process. Certain patterns within these zones may alert an operator to monitor more closely. For example, the operator may begin to see patterns such as more plot points than usual in the 2 sigma zone, causing him to increase sampling or initiate an investigation.

If the process is stable, 99.73% of the plot points should fall within the 3 sigma limits with half of the points above the centerline and half below; 95% should fall within the 2 sigma limits and 68% within the 1 sigma limits. Based on the **normal distribution**, control limits should be representative of 99.73% of a process' "normal" state. In statistical jargon, this means that when a plot point violates a control limit, there is only a 0.27% chance (0.135% above UCL and 0.135% below LCL) that it was NOT a statistically significant event. Therefore, an out-of-control plot point is a rare event when a process is behaving in a stable manner. Any points falling outside the control limits should be treated as a special cause of variation and worthy of investigation.

Normal Distribution – Variables data which has a Gaussian (bell-shaped and symmetrical) curve or frequency distribution. Control charts are only valid for data that follows a normal distribution.

Calculating these limits and zones sounds complicated, but InfinityQS's ProFicient software automatically computes the mean, control limits, and standard deviation zones based on the sample data and chart selected. The software displays the sample data in real time as each new plot point is written to the ProFicient database.

Basic Considerations for Selecting Control Chart Type

In this guide, we'll take a look at three basic factors or questions to consider when determining the most appropriate control chart for a given situation.

1. What is the sample size?
2. Do I need to group multiple process streams or part features on the same chart?
3. Do I need to combine multiple "like features" that have different target values on the same chart?

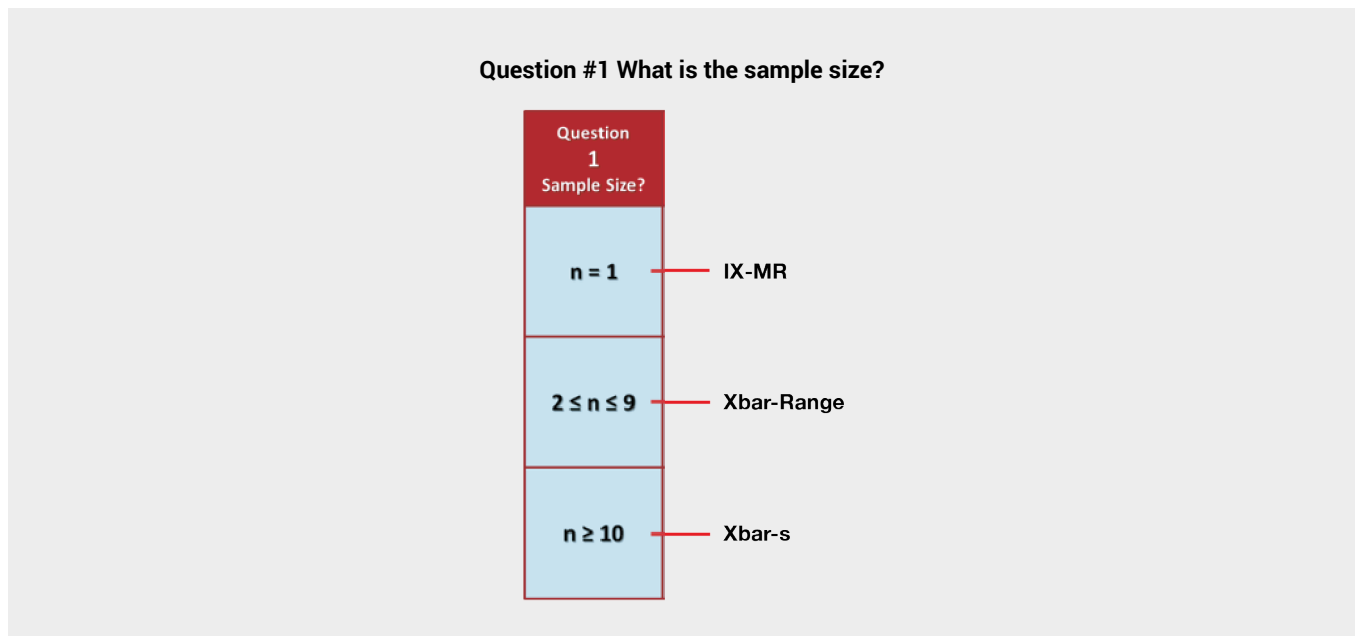
Your answers to each of these questions determine the most appropriate type of control chart to use for your situation. Simply use the decision tree shown here to guide your selection. Parts 2 through 3 in this guide provide more details for answering these questions, and the benefits and weaknesses of each type of control chart.

Variable Data Control Chart Decision Tree

Question 1 Sample Size?	Question 2 Grouping?	Question 3 Diff Targets?	
n = 1	Yes	Yes	Group Target IX-MR
		No	Group IX-MR
	No	Yes	Target IX-MR
		No	IX-MR
2 ≤ n ≤ 9	Yes	Yes	Group Target Xbar-Range
		No	Group Xbar-Range
	No	Yes	Target Xbar-Range
		No	Xbar-Range
n ≥ 10	Yes	Yes	Group Target Xbar-s
		No	Group Xbar-s
	No	Yes	Target Xbar-s
		No	Xbar-s

Part 2 – The Three Core Variables Charts: Using Sample Size to Determine Core Chart Type

In this section we'll address question one: What is the sample size?



Your answer to this question will lead you to a specific type of control chart as shown in the decision tree, with n being the sample size.

Sample Size Equals One: Individual X – Moving Range (IX-MR)

When your sample size is one ($n=1$), the chart to use is an **Individual X – Moving Range** chart (Individual X charts are also called X charts, I charts, IX charts, or individuals charts).

Examples of when to use a sample size of one include:

- › Accounting data
 - » daily overtime
 - » number of parts scrapped for a given time period
- › Homogeneous batches (e.g., chemicals, liquid foods) where variation from consecutive samples would not indicate product variation but only measurement error
- › Sampling is expensive and/or time-consuming, or destructive testing (automotive crash-testing)
- › Short production runs (e.g., five pieces in the entire run)
- › Process automation sending only one rational data value (PLC sends one value every five minutes for an oven temperature)

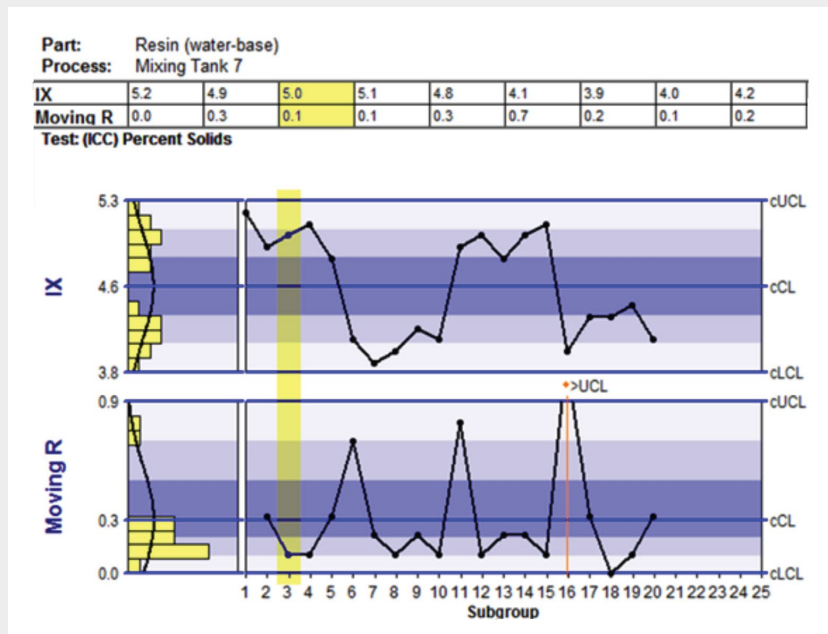
Individual X (IX) – The actual reading or measurement taken for quality control sampling purposes.

Moving Range – The absolute difference between two consecutive individual values (IX).

The IX-MR chart plots IX, the actual reading, and the Moving Range, which is the absolute difference between two consecutive IX plot points. The chart below represents several batches of resin, a homogeneous mixture, and we want to measure the percent solids of each batch.

Highlighted in yellow (the third plot point) in the ProFicient screen shot below, we see that the individual plot point on the IX chart is 5.0 and the Moving Range is 0.1. Notice that for subgroup 16, the moving range plot point exceeds the upper control limit of 0.9. This is an indication that the variability in resin % solids exceeds what would be considered “normal.” That is, a special cause of variation is present in our process and there exists a need for investigation and possible process adjustment.

Resin % Solids Traditional IX-MR



1st Plot Point

- › IX=5.2
- › MR=0

2nd Plot Point

- › IX=4.9
- › MR=0.3
- /4.9-5.2/

3rd Plot Point

- › IX=5.0
- › MR=0.1
- /5.0-4.9/

Note: Operators and others find these charts easy to read and understand, but for sample sizes greater than 9, they are not the most accurate indicators of process variability.

Benefits

- › Easy to Understand
- › Only 15-25 measurements needed to estimate control limits
- › Data can be plotted after each reading taken
- › Minimum calculations needed

Weaknesses

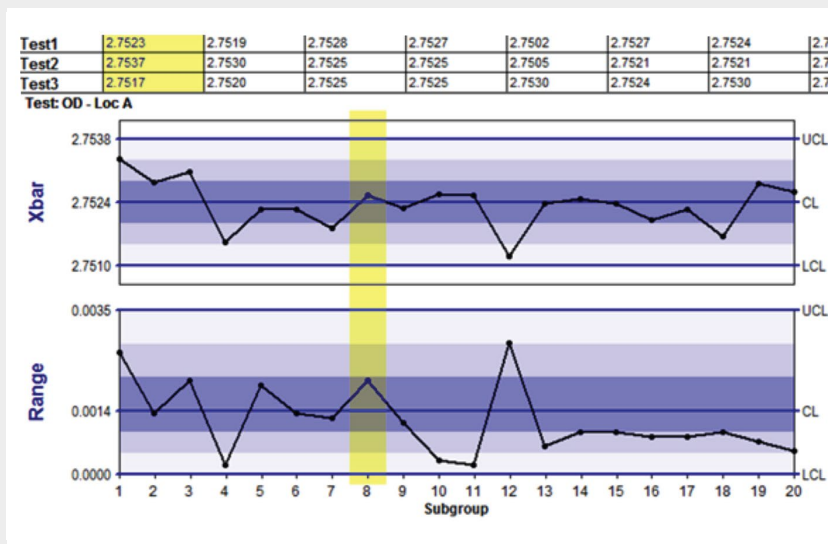
- › Does not independently separate variation in the average from variation in standard deviation
- › Not sensitive enough to detect small process changes

Sample Size is Between 2 and 9 (inclusively): Xbar – Range (Xbar-R)

When your sample size is between 2 and 9 ($2 \leq n \leq 9$), then use the Xbar – Range chart. Sample sizes between 2 and 9 (typically 3 or 5) are commonly used when at least a few parts are made every hour and data are available to be collected at a reasonable cost.

The Xbar chart plots subgroup means — that is, the average of the individual values in the subgroup. The R chart plots the subgroup **Range**, which is the difference between the maximum and the minimum individual values within the subgroup. In the example chart above, the average of subgroup 8, is 2.7526, which is well within the control limits. The range plot point is the difference between the highest and lowest values in the subgroup, 0.002, which is also well within the control limits. In fact, all plot points reside within the control limits indicating a consistent process where only common cause variation is present.

Range – The difference between the maximum and minimum individual values (IX) within a subgroup.



Xbar Plot Point

2.7523

2.7537 **HIGH**

2.7517 **LOW**

$8.2577 \div 3$

= 2.7526

Range Plot Point

$2.7537 - 2.7517$

= 0.002

Note: Operators and others find these charts easy to read and understand, but for sample sizes greater than 9, they are not the most accurate indicators of process variability.

Benefits

- › Separates variation in the averages from variation in the standard deviation
- › Most widely recognized control chart
- › Principles used as the foundation for most advanced control charts

Weaknesses

- › Must use separate chart for each characteristic on each part (the number of charts can add up quickly!)
- › No matter the sample size, only 2 individual values per subgroup are used to estimate the standard deviation for the range

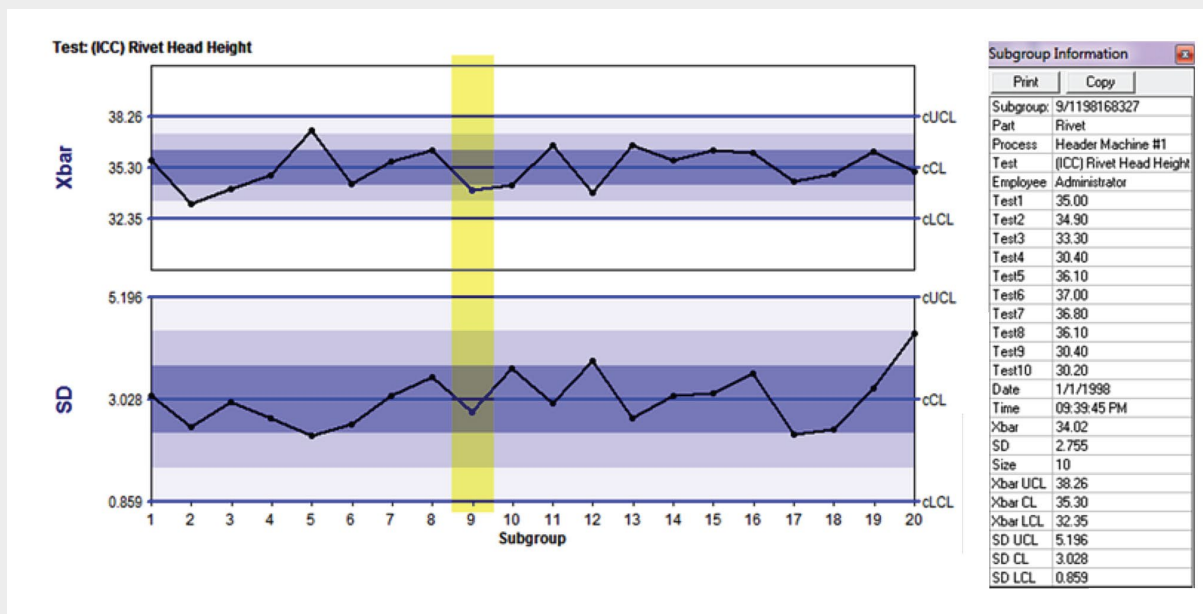
Sample Size is 10 or Higher: Xbar – Standard Deviation (Xbar-s)

When your sample size is 10 or higher ($n \geq 10$), then use the Xbar – Standard Deviation chart. The Xbar-Standard Deviation chart is often referred to as either an Xbar-s or Xbar-SD chart.

Using a sample size of 10 or higher is most common when lots of data is available and the cost for gathering the data is cheap. Examples include data from Programmable Logic Controllers (PLCs) or other automated data gathering devices. The Xbar-s chart is also commonly used for injection molding, multi-head filling operations, and continuous high speed production lines where it is possible to gather many measurements quickly and inexpensively.

The Xbar-s chart plots the mean (the average of the individual values in the subgroup) and the sample standard deviation of the individual values in the subgroup. In the chart below, subgroup 9 is highlighted. The average of the subgroup's 10 plot points is 34.02 and shown on the top Xbar chart, while the standard deviation is 2.755 and plotted on the lower SD chart.

InfinityQS's ProFicient software easily and quickly handles the data and calculations for the Xbar-s chart all in real time. Don't worry if the sample size changes with each subgroup; ProFicient can handle that too.



Note: If you are currently using the more popular Xbar-R chart for sample sizes of 10 or more, you will be better off using the Xbar-s chart to more accurately indicate process changes.

Benefits

- › Very sensitive to small changes in the mean
- › In most cases the standard deviation is a more accurate indicator of process variation than the range

Weaknesses

- › Large amounts of data need to be gathered. Assuming 20 plot points and $n=10$, then 200 values are needed to calculate control limits

Part 3 – Special Processing Options

In this section, we'll take a look at additional questions to ask related to grouping and combining data from processes, parts, and test characteristics. Group Charts and Target Charts will also be introduced. If we look back at our original questions, we'll be addressing questions 2 and 3 here.

2. Do I need to group multiple process streams or part features on the same chart?
3. Do I need to combine multiple "like features" that have different target values on the same chart?

Group Charts

Group charts address question 2 in our decision tree, "Do I need to group multiple data streams?" Group charts are used to display several parameters, characteristics, or process streams on one chart in order to assess the relative uniformity or consistency among the multiple streams of data. Examples include: measuring shaft diameter in 3 places; cash register reconciliations among multiple registers; temperature measurements at various locations in an oven; output from multiple fill heads.

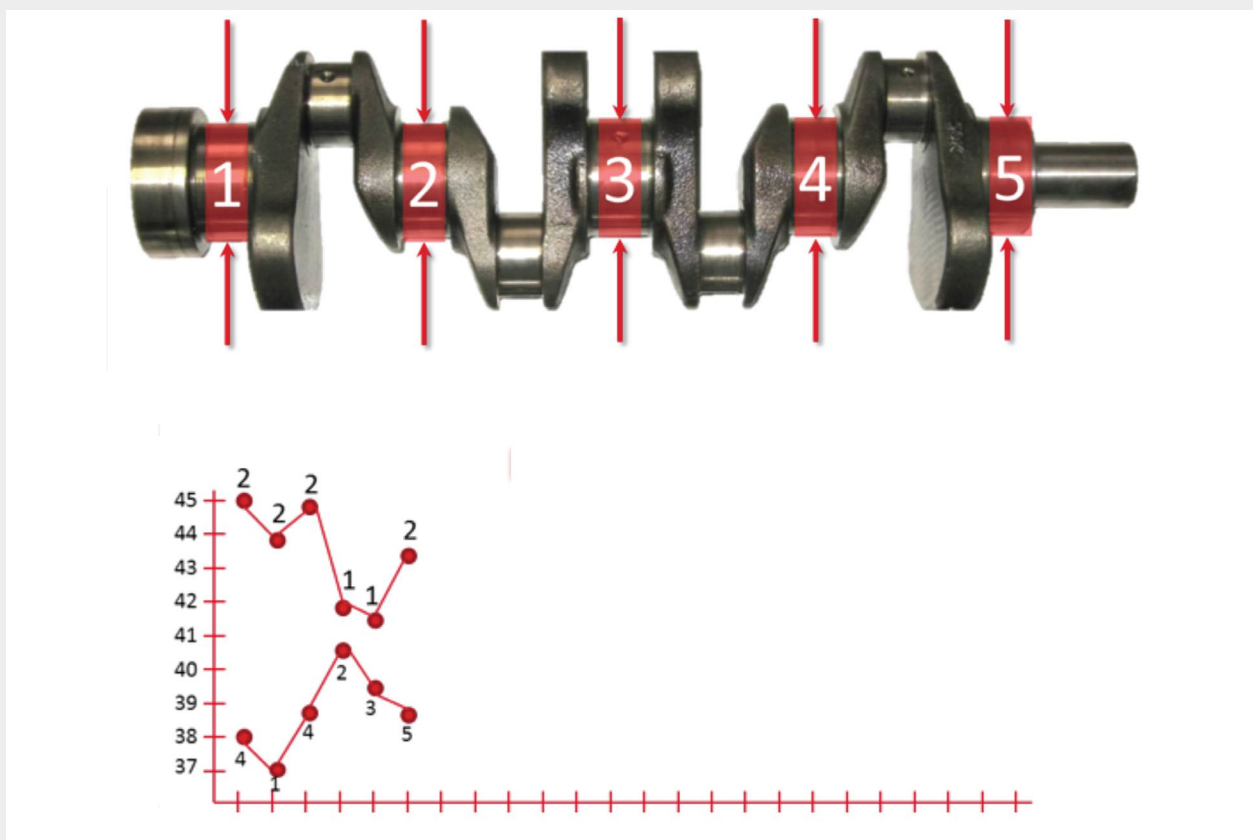
The power of a group chart is two-fold: one, to clearly and distinctly illustrate the extremes or lack of uniformity in a data set group; and two, to present the data to users so that opportunities for improvement are clearly detected.

Question #2 Do I need to group multiple process streams or part features on the same chart?

Question 1 Sample Size?	Question 2 Grouping?	
n = 1	Yes	Group IX-MR
	No	IX-MR
2 ≤ n ≤ 9	Yes	Group Xbar-Range
	No	Xbar-Range
n ≥ 10	Yes	Group Xbar-s
	No	Xbar-s

In the example below, we want to see how uniform five journal bearing diameters are from one crankshaft to the next and to each other. To chart these diameters, we could create five separate charts, one for each diameter, but that's a lot of charts and would make comparisons difficult.

Instead, we label each journal bearing diameter 1 through 5 and then combine all readings on the same Group chart. A Group chart plots only the minimum and maximum values from each group of diameters with the points labeled, identifying the diameter location. Of the 5 bearing diameters in the illustration, bearing 2 has the largest diameter at 1.7545 and bearing 4 has the smallest at 1.7538. The results from this crankshaft are plotted as the first MAX and MIN point on the chart. Notice that the chart's scale has been modified to only show the last two significant digits from each diameter (1.7545 = 45).



Note: The group chart is intentionally missing control limits because sometimes group charts are used for plotting **dependent data streams**.

Pooling dependent data values typically results in incorrect control limits. Besides, Group charts are more of a diagnostic and discovery tool than a traditional process control tool.

Dependent Data Streams – Two sets of process data which depend on each other: the values for one data set are in some way affected by or related to the other

- › Group charts are very sensitive and can easily detect differences among data streams. In our example, bearing 2 is the maximum value three consecutive times. The chance of this happening randomly is only 0.8% ($0.23=0.008$). Very quickly we see this may be worthy of investigation.
- › MAX and MIN lines that track each other indicate the data streams are dependent.
- › Converging lines suggest a decrease in within-part variation: closer lines = more uniformity. In our example above, the fourth crankshaft is the most uniform.
- › Diverging lines imply increasing within-part variation: farther spaced lines = less uniformity. In the example, the first three crankshafts are less uniform than the last three.
- › Patterns in plot point labels can also indicate issues with one stream and may warrant a closer look. If four of the same labels appear when there are five data streams grouped, then investigate further. In the example above, bearings 1 and 2 are always the largest diameters. This may indicate that there is a difference in how the left end of the crankshaft is being manufactured as compared with the right side.

ProFicient allows the user to group on tests (like in our example), processes, or parts. Grouping data, charting each data stream on different charts, or displaying data both ways at the same time is your choice. ProFicient makes Group charts easy to set up and simple to interpret.

Target Charts

Target charts address question 3 in our decision tree: Do I need to combine multiple “like features” that have different **target values**?

Target charts show multiple characteristics that have different nominal or target values all on one chart. For example, two parts may have different **specification limits**, but the same total **tolerances**.

Question #3 Do I need to combine multiple “like features” that have different target values on the same chart?

Question 1 Sample Size?	Question 2 Grouping?	Question 3 Diff Targets?	
n = 1	Yes	Yes	Group Target IX-MR
	No	No	Group IX-MR
2 ≤ n ≤ 9	Yes	Yes	Target IX-MR
	No	No	IX-MR
n ≥ 10	Yes	Yes	Group Target Xbar-Range
	No	No	Group Xbar-Range
	Yes	Yes	Target Xbar-Range
	No	No	Xbar-Range
	Yes	Yes	Group Target Xbar-s
	No	No	Group Xbar-s
	Yes	Yes	Target Xbar-s
	No	No	Xbar-s

Target Values – The historical mean for a quality measurement or the ideal value for a process output.

Specification Limits – Requirements for acceptability of a process output typically set by the customer or engineering. Typically given as a number – the target value – with upper and lower limits that define an acceptable range. The specification limit may also be given as a *not-to-exceed number* or a *not-less-than number*.

Tolerances – The upper and lower limits of a specification, typically shown as $\pm X$, which indicates the range for acceptance.

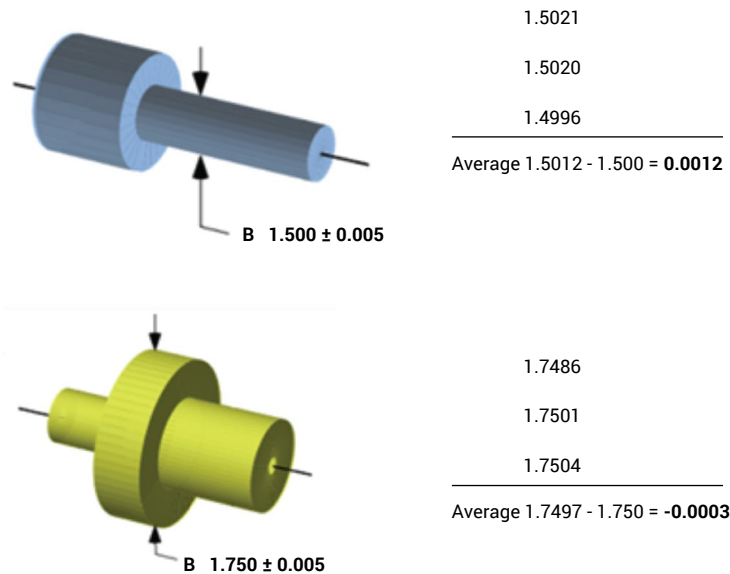
Target charts are ideal for monitoring the consistency of a production line making different parts in the same part family. Target charts are used frequently in food and consumer packaged goods processes. For example, a bakery might use a Target chart for its ovens, which bake muffins at 350°F and bread at 375°F. In the Target chart, they would be looking at deviation from target for these two temperature set points to assess how well the oven can maintain the temperatures.

Another example would be a paint line where different thicknesses of paint are applied; 3 mils for one part and 4 mils for another. Target charts are also ideal for assessing tool wear across multiple runs of different part numbers. By combining, in time order, data across the different part runs, the Target chart will expose tool wear patterns.

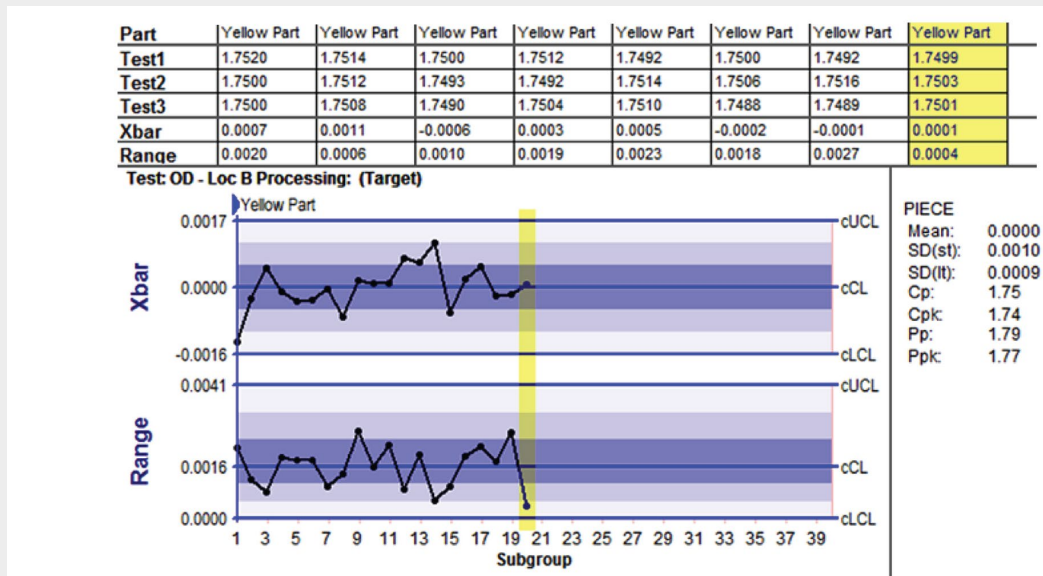
Target charts can also be useful for limited production runs because they allow you to combine enough short-run data sets to analyze process capabilities.

The Target chart plots the deviation from the specification limit target and then calculates a single shared set of control limits using the deviation from target values across multiple parts. In the example below, we have two parts: the blue part and the yellow part. Each has different specification limits, but identical total tolerances for the same Test (Outside Diameter B).

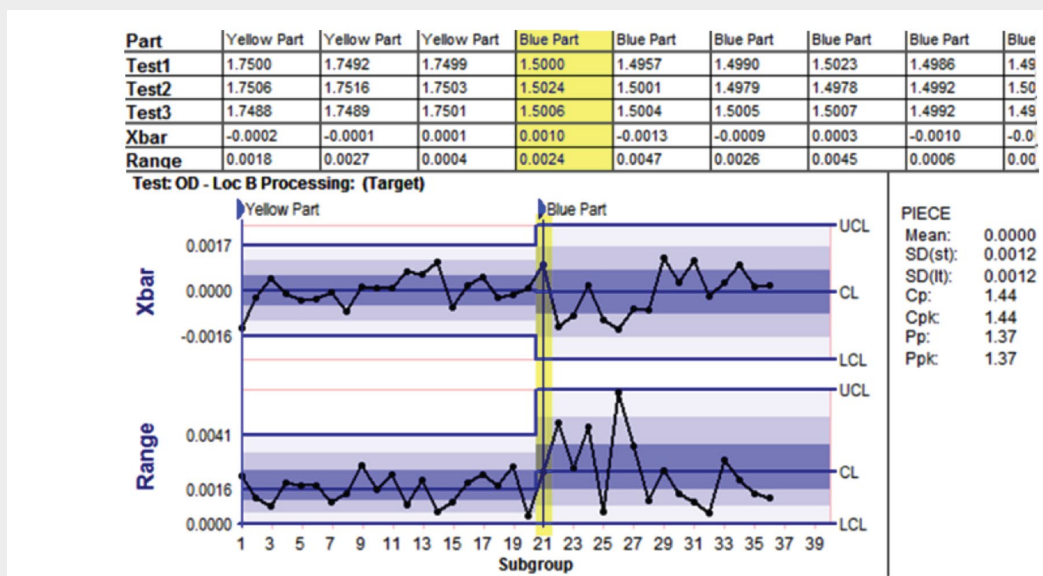
For each part we take three samples and calculate the average difference from the target value. As shown for the blue samples the average difference is 0.0012 and for the yellow samples the average difference is 0.0003. Charting the difference from target allows us to plot the two parts on the same chart.



If we first plot the yellow part as shown in the chart below, we use the Xbar-R chart — except that we're plotting the average difference from the target value instead of actual values. Highlighted subgroup 20 shows the average difference in the three samples is 0.0001. The plotted Range value is 0.0004, which is the calculated difference between the minimum and maximum values (1.7503 – 1.7499).



If we start making the blue part on the same machine, we can simply add the blue part data to our Target Xbar-R chart as shown below. ProFicient's "on the fly" processing option allows the user to easily combine data on the same chart and apply the deviation from target option at any time. The user can switch between Traditional and Target processing with the same set of data.

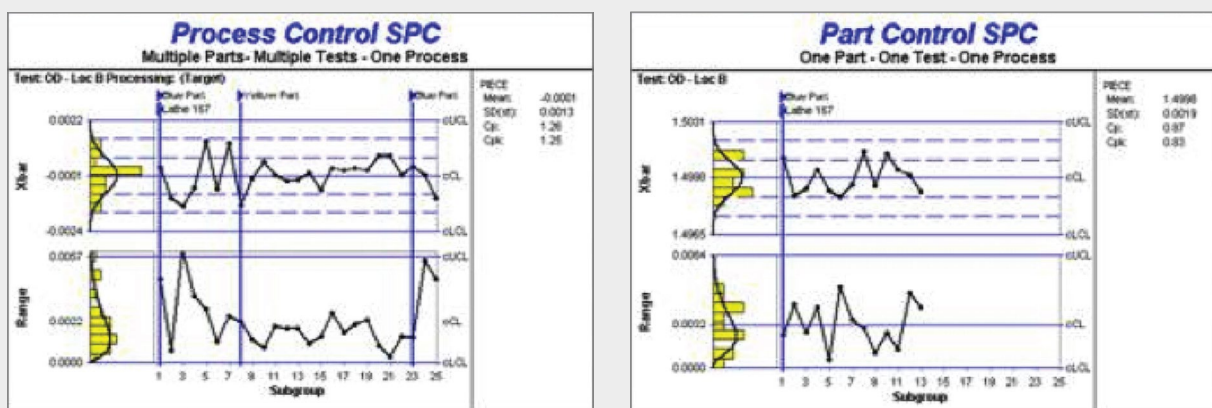


Process Control AND Part Control: Using the Same Data

When using conventional-logic Statistical Process Control (SPC) software, the user must make the choice between a strategy of either process control or part control. That's because data stored for process control requires a different type of data collection strategy than part control data.

But with ProFicient, you don't have to make that choice. Instead, both process control and part control strategies can be pursued. You can choose to display all data from a process across multiple parts or display data specific to a single part.

What makes this functionality amazing is that both options of analysis and display are managed using the same data. Switching between part control and process control requires only a simple right- click of the mouse.



Combining Chart Options

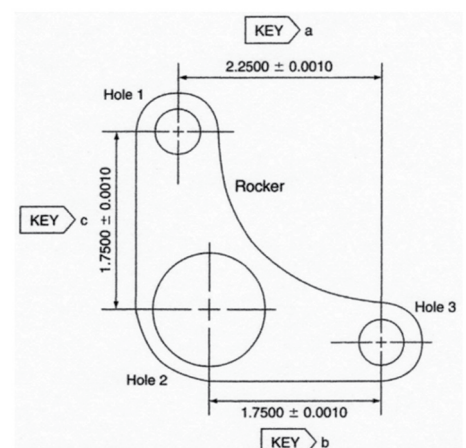
We've looked at traditional charts, Group charts, and Target charts. These are three distinct processing options suited for unique manufacturing and analysis needs. However, these options can be combined to provide even more flexibility to manage those situations where one might need to group data streams where the streams have different specifications.

For example, if we answered yes to question 2 and yes to question 3, and our sample size is 10, then a Group Target Xbar chart may be used as long as the measurements we're taking use the same units of measure.

Combining Group and Target charts is a good way to get statistically valid information for short runs of multiple process streams and puts everything onto one chart for better visibility of the process instead of individual parts and individual test characteristics.

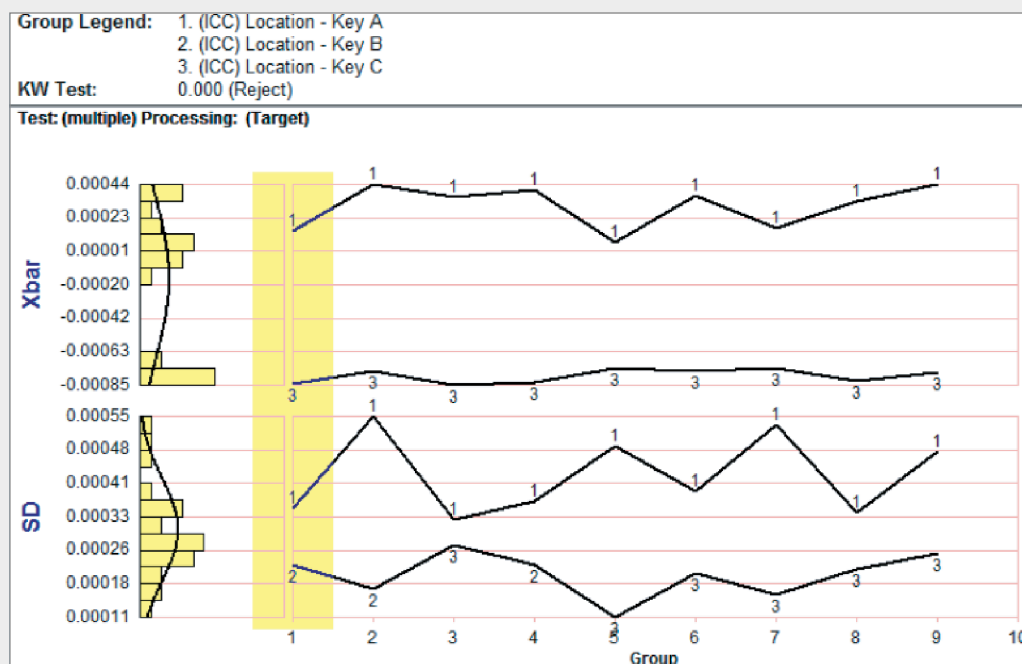
In the example below, we're taking three measurements on one part: Key A, Key B, and Key C. These measurements are all measured in inches, have the same total tolerance but different targets. Since the sample size is 10, we'll have a total of 30 data values from 10 consecutive parts. Using Target and Group processing options, we can overlay all three process streams — A, B, and C — on one chart.

Illustration and Sample Data Source,
Stephen A. Wise and Douglas C. Fair.
Innovative Control Charting.
ASQ Quality Press: Milwaukee 1998, p. 231.



Part	Rocker	Rocker	Rocker
Process	Bridgeport #5	Bridgeport #5	Bridgeport #5
Test	(ICC) Location - Key A	(ICC) Location - Key B	(ICC) Location - Key C
Employee	Administrator	Administrator	Administrator
Test1	2.24940	1.75010	1.74920
Test2	2.24940	1.74990	1.74930
Test3	2.25060	1.74990	1.74940
Test4	2.25040	1.74960	1.74930
Test5	2.25050	1.75020	1.74940
Test6	2.24990	1.74990	1.74910
Test7	2.24990	1.75040	1.74930
Test8	2.24960	1.75010	1.74910
Test9	2.25060	1.75050	1.74920
Test10	2.25040	1.75000	1.74930
Date	2/5/1998	2/5/1998	2/5/1998
Time	01:39:45 PM	01:39:45 PM	01:39:45 PM
Xbar	0.00007 HIGH	0.00006	-0.00074 LOW
SD	0.00049 HIGH	0.00026	0.00011 LOW
Size	10	10	10

Interpreting these charts is once again a matter of looking for patterns. In the chart below, we might investigate why Key A is always higher and has the most variability.



Now that you know about these new types of control charts, you'll want to use software that was built from the ground up to support these charts and many others.

With InfinityQS software, any data in the database can be combined and compared on any chart. Place any combination of parts, processes, and tests all on the same chart. We call this “million-way analysis.”

ProFicient’s unique method of storing and retrieving data from its fully-relational database provides for limitless queries, real-time combinations of any data, and over 300 types of charts.

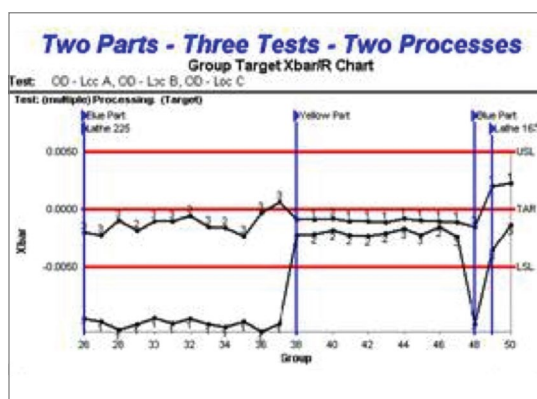
We are not talking about some third-party analysis tool. All this functionality is written by us right into ProFicient. Don’t worry if you started your data collection strategy down one path and find out after several subgroups that you need to make a change; every setting in the data entry configuration can be edited on a go-forward basis.

ProFicient can evolve at the speed of your thoughts.

Multiple Data Normalization Methods

It’s one thing to be able to display any data on any chart; it’s quite another to combine and compare dissimilar data entered at different times from different work stations — all on the same chart.

The trick is to normalize the data so they all can share the same scale. The normalization techniques used by ProFicient are the same ones pioneered -by the father of short run SPC, Davis Bothe of the International Quality Institute. If you want to chart all outside diameters created on a particular machine, regardless of feature size, no problem. If you want to display on a single box plot all the key characteristics from a particular part, regardless of feature type, size or unit of measure, no problem. ProFicient supports an amazing number of normalization techniques and processing options.



Subgroup Data (View) (SGRP_DCI)						
	SID	Create Date	Part	Process	Test	Value
981	942149918	1999/11/09 12:18:38	On Road Engine	Engine Assembly	Final Inspection - Engines	5.000000
982	983974146	2001/03/07 14:09:06	On Road Engine	Engine Assembly	Final Inspection - Engines	5.000000
983	941415705	1999/11/01 00:21:45	On Road Engine	Engine Assembly	Final Inspection - Engines	6.000000
984	979742644	2001/01/17 14:44:04	On Road Engine	Engine Assembly	Final Inspection - Engines	6.000000
985	956058240	2000/04/18 11:44:00	KJ-9987A	PCB Assembly - Line 2	PCB Final Test	10.000000
986	984015673	2001/03/08 01:41:13	3001950	Final Assembly	Final Inspection - Catheters	11.000000
987	956070284	2000/04/18 15:04:44	KJ-9987A	PCB Assembly - Line 1	PCB Final Test	12.000000
988	956058206	2000/04/18 11:43:26	KJ-9987A	PCB Assembly - Line 2	PCB Final Test	12.000000
989	956058218	2000/04/18 11:43:36	KJ-9987A	PCB Assembly - Line 2	PCB Final Test	13.000000
990	956138625	2000/04/19 10:07:05	KJ-9987A	PCB Assembly - Line 2	PCB Final Test	13.000000
991	984015631	2001/03/08 01:40:31	3001950	Final Assembly	Final Inspection - Catheters	13.000000
992	956058233	2000/04/18 11:43:53	KJ-9987A	PCB Assembly - Line 2	PCB Final Test	14.000000
993	956057942	2000/04/18 11:39:02	KJ-9987A	PCB Assembly - Line 1	PCB Final Test	17.000000
994	984015689	2001/03/08 01:41:29	3001950	Final Assembly	Final Inspection - Catheters	18.000000
995	984015644	2001/03/08 01:40:44	3001950	Final Assembly	Final Inspection - Catheters	19.000000
996	956058281	2000/04/18 11:44:41	KJ-9987A	PCB Assembly - Line 1	PCB Final Test	19.000000
997	984015586	2001/03/08 01:39:46	3001950	Final Assembly	Final Inspection - Catheters	21.000000
998	956057912	2000/04/18 11:36:32	KJ-9987A	PCB Assembly - Line 1	PCB Final Test	21.000000
999	956058265	2000/04/18 11:44:25	KJ-9987A	PCB Assembly - Line 1	PCB Final Test	23.000000
1000	945003798	1999/12/12 13:03:18	Wing	Deburring - Line 1	Section Weight	39.500000

Summary

With over 300 types of control charts available, we’ve only covered the tip of the iceberg in this guide. But we hope you see that the adage “If it ain’t broke, don’t fix it” does not apply when it comes to choosing a control chart.

If you are using a control chart just because it’s what you’ve always used or it’s what your predecessor used, there may be room for improvement. Step outside your comfort zone to try some of the charts we’ve discussed. Or maybe there’s a way to chart something you thought was not possible via combinations of chart types.

InfinityQS has seasoned SPC experts and application engineers with manufacturing experience who are available to discuss your situation and help you determine the best type of control chart. So please visit our website at infinityqs.com to learn more and contact us.

Sidebar – SPC for Very High Sampling Rates

What is high-speed data collection?

In most manufacturing facilities today, there is the capability to gather data at ultra-high-speeds. For example, PLC sensors can send data every second, or even multiple values per second. Because the data is being collected, the tendency is to want to plot all the values on SPC charts. The thinking is that with all this data streaming in so fast, plotting it on control charts will instantly show whether the process is in control and whether changes need to be made.

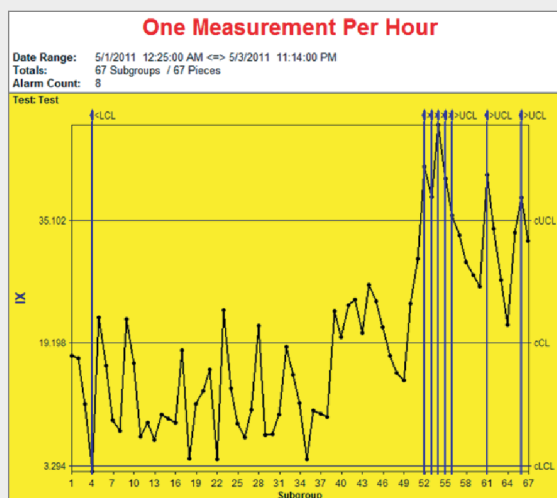
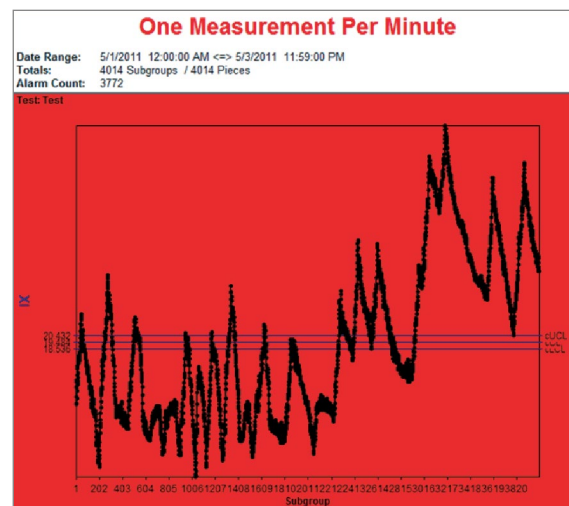
However, too much data can be problematic; plotting every data value is usually not in one's best interest.

Why plotting all the data can be problematic

When the time interval between each data point is uniform and 100% of the data is captured, the conventional wisdom is to simply plot each value using an IX-MR chart.

On an IX-MR chart, remember that control limits are based on variability between two consecutive samples. Because the average variation between two consecutive points is small, the resulting control limits on the IX chart will be absurdly tight compared to patterns that appear in the data over time. In other words, the tight control limits are focusing on the trees, but the chart is showing a picture of the forest.

When calculated properly, control limits separate the process noise (common cause variation) from the signals (special causes of variation), but in the chart below, the correctly calculated control limits are not serving any useful purpose other than to confirm that the variability over time (three days of data in this case) is far greater than the average variability exhibited between consecutive sampling periods (one minute in this case).



How to make the data meaningful

We can make ultra-high-speed data more meaningful by increasing the amount of time between plot points — **reducing the sampling rate**. We're not suggesting throwing data away, but rather that you plot only a portion of the data. Let the process "breathe" a little between plot points.

Consider the minute-by-minute data on the red chart; if we change the sampling rate to once per hour (plot every 60th point), using only 1.67% of the data, this creates more meaningful control limits. The hour-to-hour variation "relaxes" the control limits and detects only the prominent signals — the one's that could require process adjustments.

Notice the pattern is the same as the chart above, but now we will get appropriate alarms for special cause variations that require actions. For example, we can clearly see a process shift at plot point 50, so we would want to investigate why.

Limitations of Spreadsheet and Paper Methods

Many quality practitioners still rely on spreadsheets or even paper to collect and chart sampling data. However these manual methods have significant limitations that software and automated methods overcome.

If you are currently using manual methods for some or all of your analysis, consider the limitations listed below. An automated SPC software solution is simpler, more efficient, faster, easier to manage and less expensive. Isn't it time you take control by implementing an SPC software solution?

LIMITATIONS OF EXCEL	LIMITATIONS OF PEN AND PAPER
Not Real Time	Not Real Time
Manual Data Entry Prone to Error/Deletion	Highly susceptible to manual errors
Difficult to Compare and Consolidate Data	Impossible to Consolidate Data
Cumbersome to Manage Multiple Parts/Process Stream Data	Time Consuming Analysis and Reporting
Limited Visibility	Easily Lost or Misplaced, Extremely Limited Visibility
Lack of Security, Permissions, and Change History	Difficult and Costly to Maintain and Store
No Alert or Alarm Capability	No Alert or Alarm Capability



About InfinityQS International, Inc.

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Headquartered near Washington, D.C., with offices in Seattle, London, Beijing, and Shanghai, InfinityQS was founded in 1989 and now services more than 40,000 active licenses with more than 2,500 of the world's leading manufacturers, including Kraft Foods, Ball Corporation, Boston Scientific, Graham Packaging, and Medtronic. For more information, visit infinityqs.com.

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