

CONTROL CHARTS SUMMARY

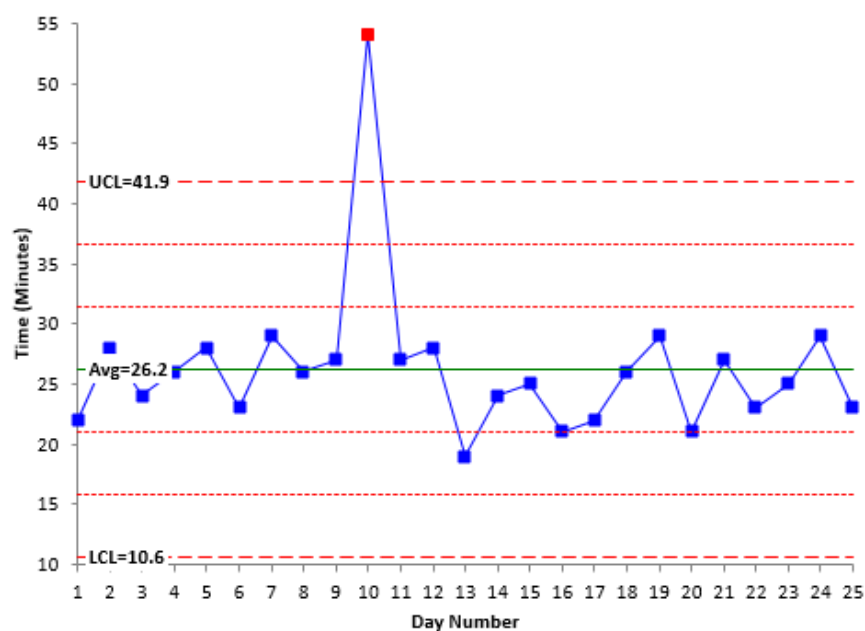
An effective way to separate common causes from special causes of variation is through the use of control charts.

A control chart monitors a process variable over time. The average is calculated after you have sufficient data. The control limits are calculated – an upper control limit (UCL) and a lower control limit (LCL). The UCL is the largest value you would expect from a process with just **common causes** of variation present. The LCL is the smallest value you would expect with just **common causes** of variation present. If all the points are within the limits and there are no patterns, only common causes of variation are present, the process is said to be **"in control."**

Figure 1 is an example of a control chart using a driving to work example.

Each day the time to get to work is measured. The data are then plotted on the control chart. The average is calculated. The average is 26.2 – which means it takes on average each day 26.2 minutes to get to work. The control limits are then calculated. The UCL is 41.9 minutes. This is the maximum time it will take to get to work when only common causes are present. The LCL is 10.6 minutes. This is the minimum time it will take to get to work when only common causes are present. If all the points are within the control limits and there are no patterns, then process is in statistical control.

Figure 1: Control Chart Example

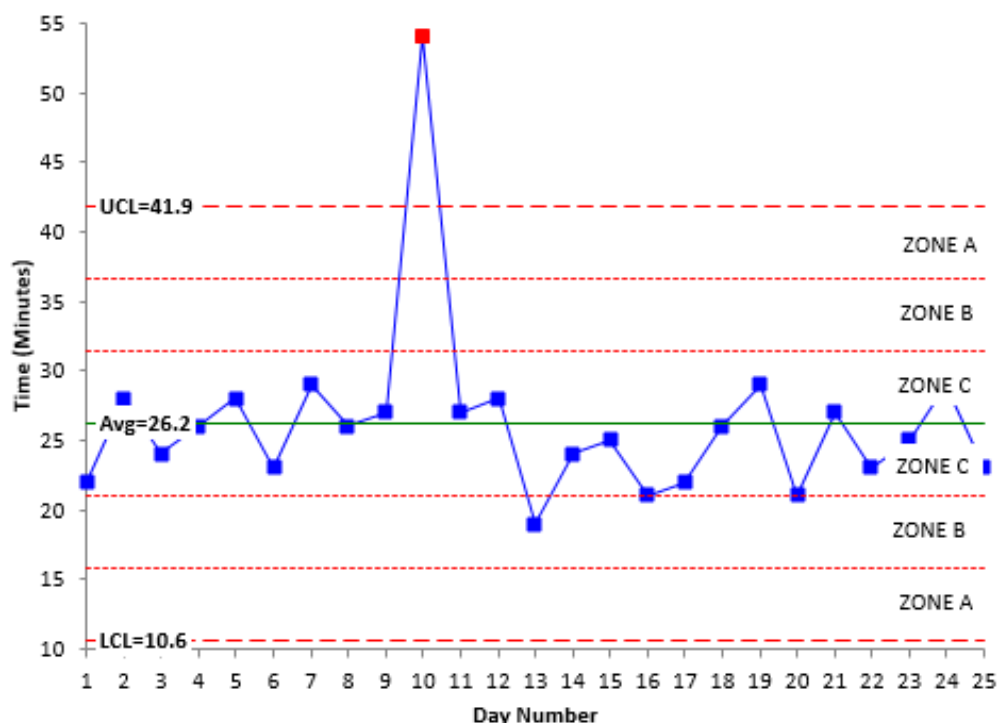


There is one point beyond the UCL in Figure 1. This is the first pattern that signifies an out of control point – a special cause of variation. One possible cause is the flat tire. There are many other possible causes as well – car break down, bad weather, etc.

Special causes of variation are detected on control charts by noticing certain types of patterns that appear on the control chart. The point beyond the control limits is one such pattern. You might see a pattern of 7 consecutive points above the average. This pattern indicates that something has happened to cause your process average to go up – a special cause is present. Recognizing patterns – and what they mean in your process – is one key to finding the reason for special causes. All the control chart rules are patterns that form on your control chart to indicate that special causes of variation are present.

Some of these patterns depend on “zones” in a control chart. To see if these patterns exist, a control chart is divided into three equal zones above and below the average. This is shown in Figure 2.

Figure 2: Control Chart Divided into Zones



Zone C is the zone closest to the average. It represents the area from the average to one sigma above the average. There is a corresponding zone C below the average. Zone B is the zone from one sigma to two sigma above the average. Again, there is a corresponding Zone B below the average. Zone A is the zone from two sigma to three sigma above the average – as well as below the average.

THE 8 CONTROL CHART RULES

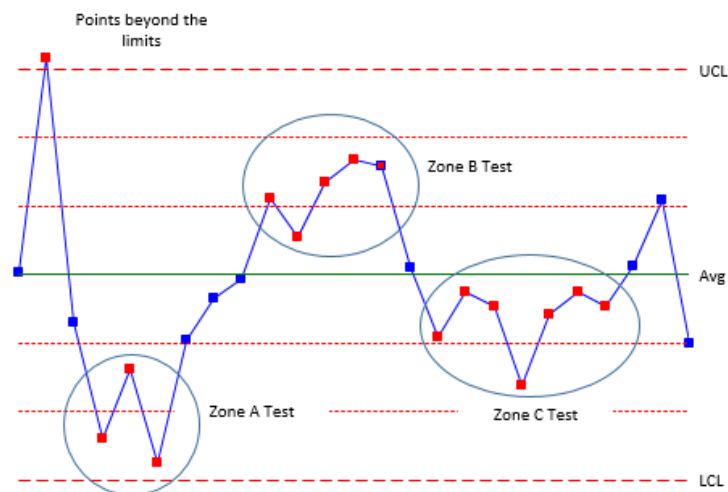
If a process is in statistical control, most of the points will be near the average, some will be closer to the control limits and no points will be beyond the control limits. The 8 control chart rules listed in Table 1 give you indications that there are special causes of variation present. Again, these represent patterns.

Table 1: Control Chart Rules

Rule	Rule Name	Pattern
1	Beyond Limits	One or more points beyond the control limits
2	Zone A	2 out of 3 consecutive points in Zone A or beyond
3	Zone B	4 out of 5 consecutive points in Zone B or beyond
4	Zone C	7 or more consecutive points on one side of the average (in Zone C or beyond)
5	Trend	7 consecutive points trending up or trending down
6	Mixture	8 consecutive points with no points in Zone C
7	Stratification	15 consecutive points in Zone C
8	Over-control	14 consecutive points alternating up and down

It should be noted that the numbers can be different depending upon the source. For example, some sources will use 8 consecutive points on one side of the average (Zone C test) instead of the 7 shown in the table above. But they are all very similar. **Figures 3 through 5** illustrate the patterns. **Figure 3** shows the patterns for Rules 1 to 4.

Figure 3: Zone Tests (Rules 1 to 4)



Rules 1 (points beyond the control limits) and 2 (zone A test) represent sudden, large shifts from the average. These are often fleeting – a one-time occurrence of a special cause – like the flat tire when driving to work.

Rules 3 (zone B) and 4 (Zone C) represent smaller shifts that are maintained over time. A change in raw material could cause these smaller shifts. The key is that the shifts are maintained over time – at least over a longer time frame than Rules 1 and 2.

Figure 4 shows Rules 5 and 6. Rule 5 (trending up or trending down) represents a process that is trending in one direction. For example, tool wearing could cause this type of trend. Rule 6 (mixture) occurs when you have more than one process present and are sampling each process by itself. Hence the mixture term. For example, you might be taking data from four different shifts. Shifts 1 and 2 operate at a different average than shifts 3 and 4. The control chart could have shifts 1 and 2 in zone B or beyond above the average and shifts 3 and 4 in zone B below the average – with nothing in zone C.

Figure 4: Rules 5 and 6

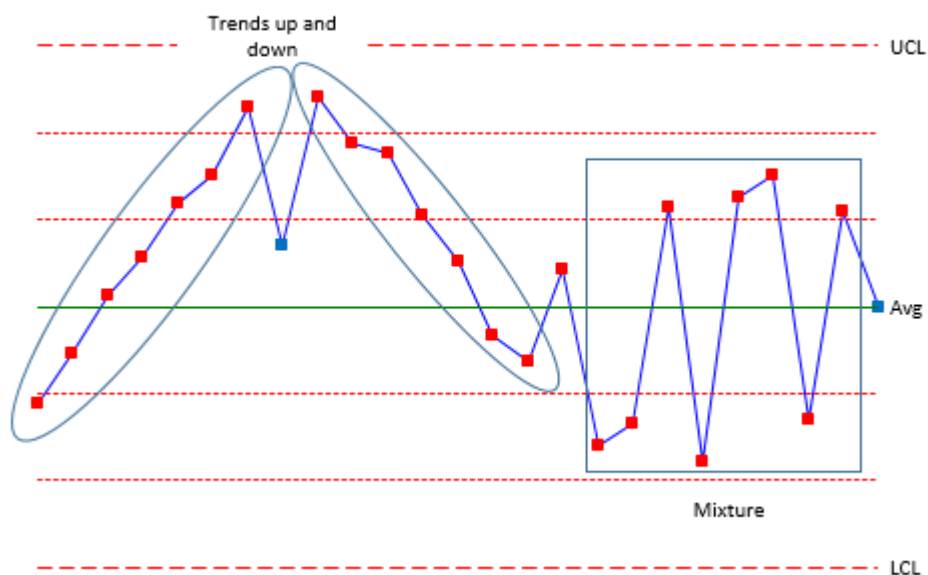


Figure 5 shows rules 7 and 8. Rule 7 (stratification) also occurs when you have multiple processes but you are including all the processes in a subgroup. This can lead to the data “hugging” the average – all the points in zone C with no points beyond zone C. Rule 8 (over-control) is often due to over adjustment. This is often called “tampering” with the process. Adjusting a process that is in statistical control actually increases the process variation. For example, an operator is trying to hit a certain value. If the result is above that

value, the operator makes an adjustment to lower the value. If the result is below that value, the operator makes an adjust to raise the value. This results in a saw-tooth pattern.

Figure 5: Rules 7 and 8

