1 Nelson Rules for Interpreting Control Charts

- The eight tests used in statistical process control were developed by Lloyd S. Nelson, a process control expert. They are based on his determination that the identified patterns are very unlikely to occur in stable processes.
- Thus the existence of any of these patterns in an $\bar{X}$ chart indicates that the process may be unstable, and that one or more assignable causes may exist.
- The table on the next page contains examples of test failure for each of the eight tests, with a description for each graph as to what is required for the illustrated test failure.
- In practice, tests 1,2 and 7 are considered the three most useful.

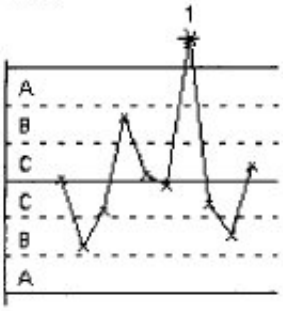
1.1 Descriptions of Tests

Test 1 - 3 sigma rule Identifies points outside of the control limits
Test 1 identifies points that are more standard deviations from the center line. Test 1 is universally recognized as necessary for detecting out-of-control situations. It has a false alarm rate of only 0.27%.

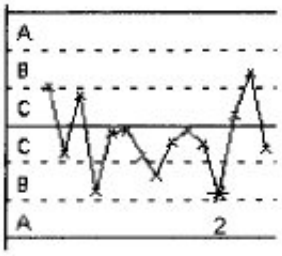
Test 2 Identifies shifts in the means
Test 2 signals when 9 points in a row fall on the same side of the center line. The use of Test 2 significantly increases the sensitivity of the chart to detect small shifts in the mean.

When test 1 and test 2 are used together, significantly fewer subgroups are needed to detect a small shift in the mean than are needed when test 1 is used alone. Therefore, adding test 2 helps to detect common out-of-control situations and increases sensitivity enough to warrant a slight increase in the false alarm rate.

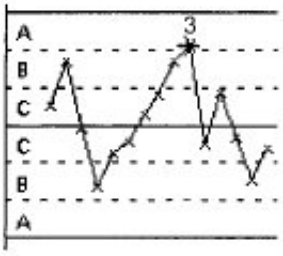
Test 1
One point more than 3 sigmas from center line



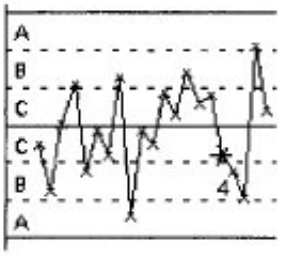
Test 2
Nine points in a row on same side of center line



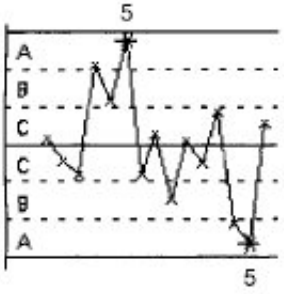
Test 3
Six points in a row, all increasing or all decreasing



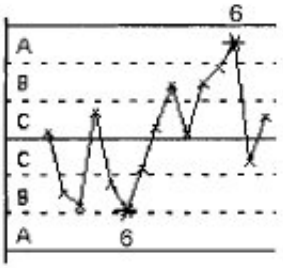
Test 4
Fourteen points in a row, alternating up and down



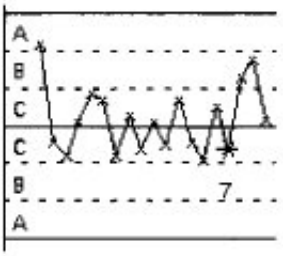
Test 5
Two out of three points in a row more than 2 sigmas from center line (same side)



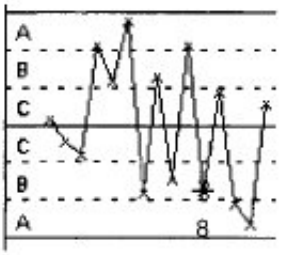
Test 6
Four out of five points in a row more than 1 sigma from center line (same side)



Test 7
Fifteen points in a row within 1 sigma of center line (either side)



Test 8
Eight points in a row more than 1 sigma from center line (either side)



Test 3 k points in a row, all increasing or all decreasing
Test 3 is designed to detect drifts in the process mean.
However, when test 3 is used in addition to test 1 and test 2, it does not significantly increase the sensitivity of the chart to detect drifts in the process mean.

Test 4 k points in a row, alternating up and down
Although this pattern can occur in practice, it is recommended to search for any unusual trends or patterns rather than test for one specific pattern.

Test 5 k out of k=1 points > 2 standard deviations from center line
This test is not quite as informative because it did not uniquely identify special cause situations that are common in practice.

Test 6 k out of k+1 points > 1 standard deviation from the center line
This test is not quite as informative because it did not uniquely identify special cause situations that are common in practice.

Test 7 Identifies control limits that are too wide
Test 7 signals when 12 or 15 points in a row fall within 1 standard deviation of the center line.
Test 7 is used only for the $\bar{X}$ chart when the control limits are estimated from the data. When this test fails, the cause is usually a systemic source of variation (stratification) within a subgroup, which is often the result of not forming rational subgroups.

Test 8 k points in a row > 1 standard deviation from center line (either side)
This test is not quite as informative because it did not uniquely identify special cause situations that are common in practice.