Applied Technology

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Control Chart Runs Tests

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The technique used in statistical process control to determine if the process has become unstable is runs or pattern tests. If the process data shows a pattern that suggests with high probability that the mean and/or variance of the process has changed (assuming independent events), then the practitioner should conclude that the process has become unstable. There are infinitely many ways a process might exhibit instability, but the practitioner requires a small set of tests that are simple to apply and can be easily understood by operators on the floor. Dr. Shewhart gave us the original $\pm 3\sigma$ test and over the years many other pattern tests have been added. The landscape is now fairly muddled with tests, some of which are reasonable, and others that should be discarded. For example, ASQ publications and some prominent consultants continue to advocate the use of the six points increasing or decreasing test even though this test has been shown to be statistically very weak [Davis, 1988].

Table 1 provides a list of the most well known pattern tests and my suggestion for a simple yet reasonable reduced set.

Table 1. Pattern Tests for Instability of Mean or Individuals Charts

	Type of Instability
Shewhart (1931)	
1. A single point beyond ± 3 sigma	change in μ or σ
Western Electric (1956)	
1. A single point beyond ± 3 sigma	change in μ or σ
2. Two out of three consecutive points beyond ± 2 sigma on the same side of CL	change in μ or σ
3. Four out of five consecutive points beyond ± 1 sigma on the same side of CL	change in μ or σ
4. Eight consecutive points on the same side of the centerline	change in μ
Nelson (1984)	
1. A single point outside the control limits Applies to any distribution, continuous or discrete	change in μ or σ

2. A run of nine points above or below the centerline — change in μ
   Applies to any symmetric distribution, continuous or discrete

3. A run of six points in a row increasing or decreasing — change in μ
   Applies to a continuous distribution (This is a weak test [Davis 1988])

4. Fourteen points in a row alternating up and down — systematic or mixture
   Applies to a continuous distribution
   (Dr. Trietsch recommends thirteen points [Trietsch, 1997])

5. Two out of three points outside ± 2 sigma on the same side of CL — change in μ or σ
   Applies to any distribution, continuous or discrete

6. Four out of five points outside ± 1 sigma on the same side of CL — change in μ or σ
   Applies to any distribution, continuous or discrete

7. A run of fifteen points within ± 1 sigma of the centerline — mixture or change in σ
   Applies to any distribution, continuous or discrete
   (Dr. Trietsch recommends thirteen points)

8. Eight points in a row on both sides of CL but none within ± 1 sigma — mixture or change in σ
   Applies to any distribution, continuous or discrete
   (Dr. Trietsch recommends five points)

Flaig (1997)

1. Use Nelson's rules 1 and 2 — change in μ or σ
2. Any pattern that repeats itself eight times in succession — non-random pattern

Davis, R. B. and Woodall, W. H. (1988). Performance of the Control Chart Trend Rule Under Linear Shift. Journal of Quality Technology, Vol. 20, No. 4. pp. 260-262.

Trietsch, D. and Hwang, F. C. (1997). Notes on Pattern Tests for Special Causes. Quality Engineering, Vol. 9, No. 3.

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