

In the production of bank notes samples are taken at regular intervals and a number of measurements made on each note. The following table shows the width, mm, of the top margin in eight samples each of size 4. The target value is 9 mm.

Sample	1	2	3	4	5	6	7	8
	9.0	10.4	8.2	7.9	8.2	8.4	7.4	7.6
	8.1	9.0	9.2	7.7	9.0	8.1	8.0	8.5
	8.7	7.9	7.9	7.7	7.4	8.4	8.9	8.1
	7.5	7.2	7.7	9.3	8.6	8.7	9.8	8.8

- Calculate the mean sample range and, assuming a normal distribution, use it to estimate the standard deviation of the process.
- Use the estimate made in (a) to draw a control chart for means showing 95% warning limits and 99.8% action limits. Plot the eight means.
- Draw a control chart for ranges showing the upper and lower action and warning limits. Plot the eight ranges.
- Comment on the current state of the process.
- What action, if any, would you recommend in each of the following cases.

The next sample is

- 9.1, 10.2, 8.9, 9.7
 - 7.3, 6.9, 8.8, 7.1
 - 10.4, 10.1, 9.2, 6.8
 - 10.9, 9.8, 8.8, 11.1
 - 9.3, 9.2, 9.3, 9.3
- Suggest two methods, other than the one used in (a), to estimate the short term standard deviation of the process. Compare the relative merits of these three methods in the context of control charts.