

Example of X bar and R chart

Terms used

- n** Sample size (subgroup size).
- X** A reading (the data).
- \bar{X} Average of readings in a sample.
- $\bar{\bar{X}}$ Average of all the \bar{X} s. It is the value of the central line on the \bar{X} chart.
- R** The range. The difference between the largest and smallest value in each sample.
- \bar{R} Average of all the Rs. It is the value of the central line on the R chart.

UCL/LCL Upper and Lower Control Limits. The control boundaries for 99.73% of the population. They are not specification limits.

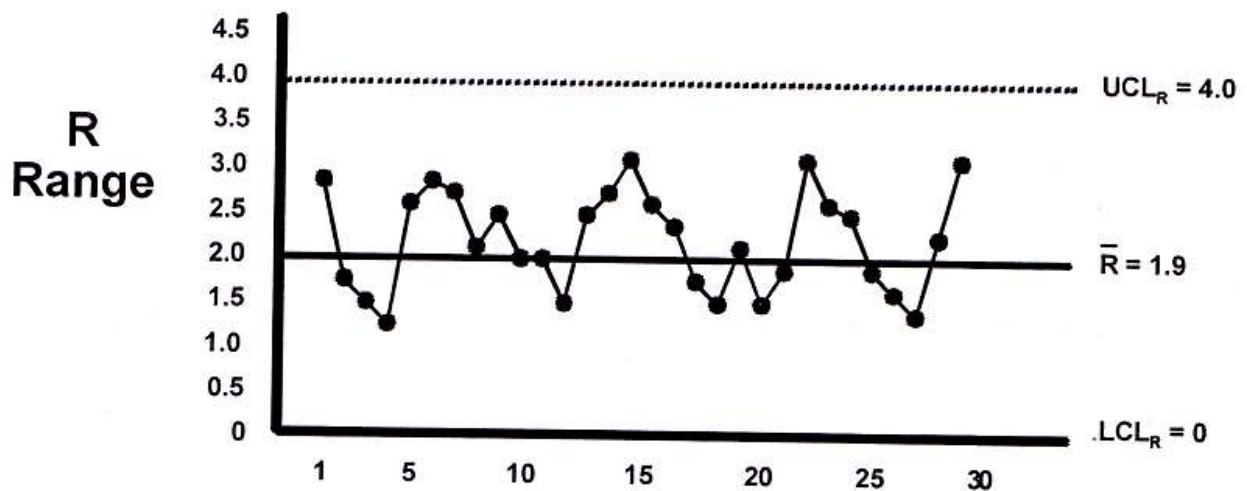
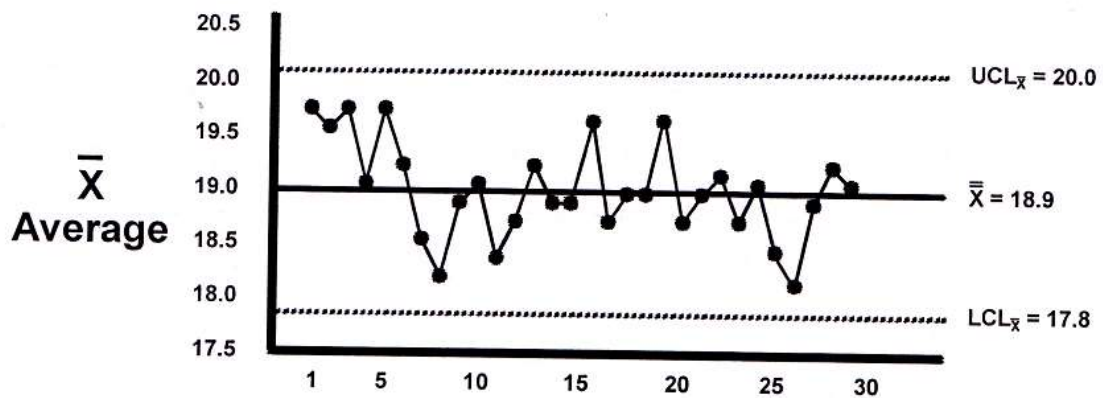


Figure 10.2 Typical \bar{X} - R Control Chart

Steps for Constructing \bar{X} - R Charts

1. Determine the sample size ($n = 3, 4, \text{ or } 5$) and the frequency of sampling.
2. Collect 20 to 25 sets of time sequenced samples (60 to 100 data points.)
3. Calculate the average for each set of samples, equals \bar{X} .
4. Calculate the range for each set of samples, equals R .
5. Calculate $\bar{\bar{X}}$ (the average of the \bar{X} values), this is the center line of the \bar{X} chart.
6. Calculate \bar{R} (the average of the R values). This is the center line of the R chart.
7. Calculate the control limits:

$$\bar{X} \text{ chart: } UCL_{\bar{X}} = \bar{\bar{X}} + A_2 \bar{R} \qquad LCL_{\bar{X}} = \bar{\bar{X}} - A_2 \bar{R}$$

$$R \text{ chart: } UCL_R = D_4 \bar{R} \qquad LCL_R = D_3 \bar{R}$$

Note: $A_2 \bar{R}$ can be shown to be identical in value to $3S_{\bar{X}}$

8. Plot the data and interpret the chart for special or assignable causes.

n	A_2	D_3	D_4	d_2
2	1.88	0	3.27	1.13
3	1.02	0	2.57	1.69
4	0.73	0	2.28	2.06
5	0.58	0	2.11	2.33
6	0.48	0	2.00	2.53

Common Factors used for \bar{X} - R Control Limits

\bar{X} - R Control Chart Data

Closure Removal Torque (in-lbs)

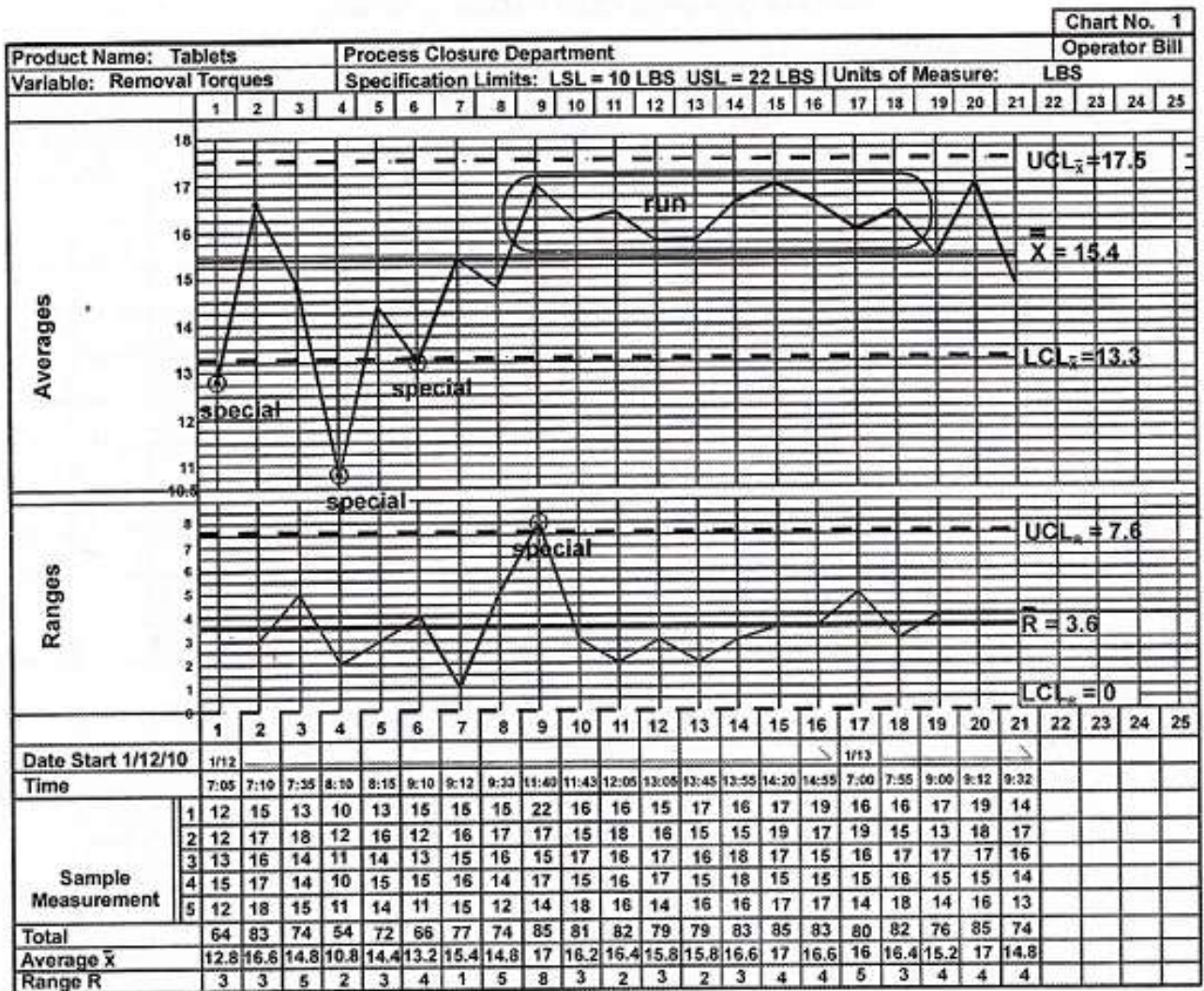
Sample	Measurements					Sample Avg. \bar{X}	Sample Range R
	1	2	3	4	5		
1	12	12	13	15	12	12.8	3
2	15	17	16	17	18	16.6	3
3	13	18	14	14	15	14.8	5
4	10	12	11	10	11	10.8	2
5	13	16	14	15	14	14.4	3
6	15	12	13	15	11	13.2	4
7	15	16	15	16	15	15.4	1
8	15	17	16	14	12	14.8	5
9	22	17	15	17	14	17.0	8
10	16	15	17	15	18	16.2	3
11	16	18	16	16	16	16.4	2
12	15	16	17	17	14	15.8	3
13	17	15	16	15	16	15.8	2
14	16	15	18	18	16	16.6	3
15	17	19	17	15	17	17.0	4
16	19	17	15	15	17	16.6	4
17	16	19	16	15	14	16.0	5
18	16	15	17	16	18	16.4	3
19	17	13	17	15	14	15.2	4
20	19	18	17	15	16	17.0	4
21	14	17	16	14	13	14.8	4
Totals						323.6	75
$\bar{\bar{X}}$						15.4	
\bar{R}							3.6

$$UCL_x = \bar{\bar{X}} + A_2 \bar{R} = 15.4 + (0.58 \times 3.6) = 17.5$$

$$LCL_x = \bar{\bar{X}} - A_2 \bar{R} = 15.4 - (0.58 \times 3.6) = 13.3$$

$$UCL_R = D_4 \bar{R} = 2.11 \times 3.6 = 7.6$$

$$LCL_R = D_3 \bar{R} = 0 \times 3.6 = 0$$



An \bar{X} - R Chart for Closure Removal Torques

This was a start up process. The process started smoothing out from data set number 10 on. If continued, the chart would need new control limits from that point.