

# MOVING AVERAGE CHARTS

## Advantages:

- In situations where data are collected slowly over a period of time, or where data are expensive to collect, moving average charts are beneficial.
- Moving average charts can help bring trends to light more rapidly than is possible with conventional charts.
- Moving average charts use the central limit theorem to make data approximately normal.

## Disadvantages:

- Adjacent points on the moving average chart are not independent. Therefore, runs tests are not valid.
- There is a tendency to forget that individual observations have more variability than do the averages.

Control Chart for AMA EXAMPLE

## AMA & MR CHARTS - Calculation Worksheet

$n =$  Number of Measurements in Moving Average  $= 2$

$MR = |$  Current Measurement  $-$  Previous Measurement  $|$

$$\bar{R} = \frac{\text{Total of MRs}}{\text{Total number MRs}} = \frac{79.7}{20} = 3.985$$

$$\bar{X} = \frac{\text{Total of Measurements}}{\text{Total number of Measurements}} = \frac{2096.8}{21} = 99.85$$

$$UCL_{MR} = 3.267 \times \bar{R}$$

$$LCL_{MR} = 0$$

$$= 3.267 \times 3.985$$

$$= 13.02$$

$$\sigma_c = \frac{\bar{R}}{1.128} = \frac{3.985}{1.128} = 3.53$$

$$UCL_{AMA} = \bar{X} + 3 \frac{\sigma_c}{\sqrt{n}}$$

$$LCL_{AMA} = \bar{X} - 3 \frac{\sigma_c}{\sqrt{n}}$$

$$UCL_{AMA} = 99.85 + 3 \frac{3.53}{\sqrt{2}}$$

$$LCL_{AMA} = 99.85 - 3 \frac{3.53}{\sqrt{2}}$$

$$UCL_{AMA} = 99.85 + 3(2.50)$$

$$LCL_{AMA} = 99.85 - 3(2.50)$$

$$UCL_{AMA} = 99.85 + 7.5$$

$$LCL_{AMA} = 99.85 - 7.5$$

$$UCL_{AMA} = 107.35$$

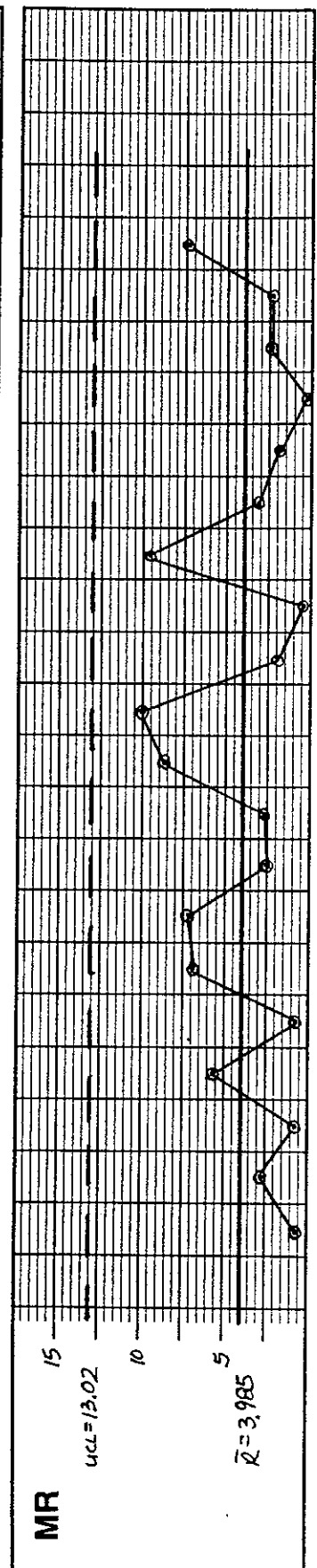
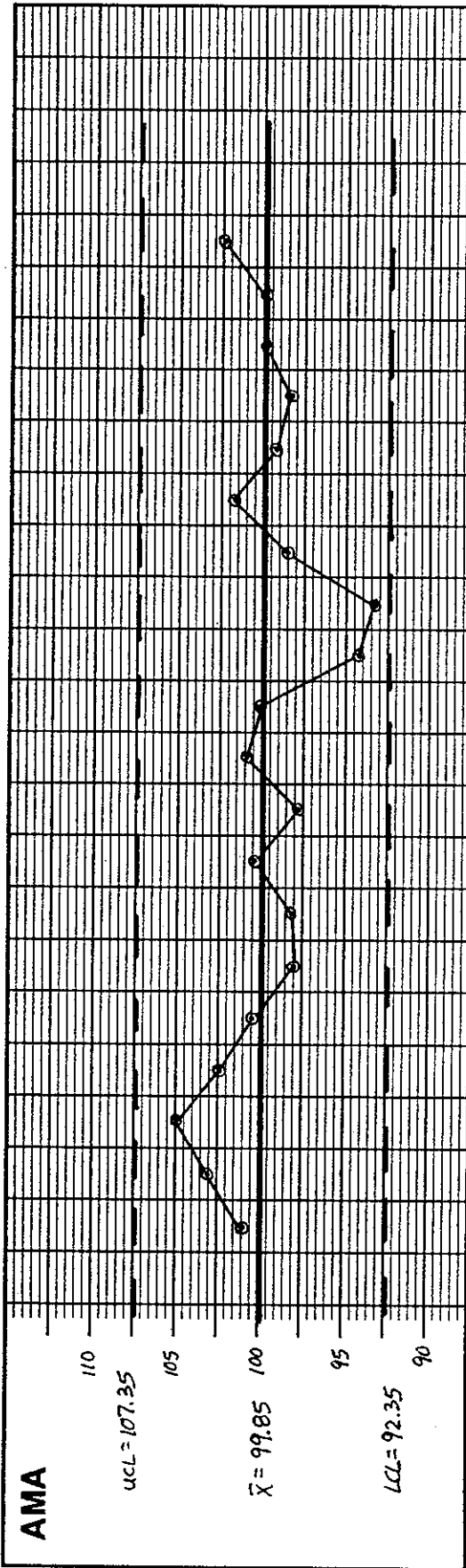
$$LCL_{AMA} = 92.35$$

**CONTROL CHART FOR  
AMA & MR**

AMA EXAMPLE

Frequency =

Date	Time	Operator	Measurement (X)	AMA	n = 2	Moving Range (MR)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
			100.8	101.7	104.5	105.2	99.6	101.4	94.5	101.6	99.1	96.5	105.2	95.1	93.2	93.6	103.3	100.1	98.3	98.5	100.9	98.6	105.9									
			-	100.9	103.1	101.9	102.4	100.5	98.0	98.1	100.4	97.8	100.9	100.2	94.2	93.4	98.5	101.7	99.2	98.4	99.7	99.8	102.3									
			-	1.7	2.8	0.7	5.6	1.8	6.9	7.1	2.5	2.6	8.7	10.1	1.9	0.4	9.7	3.2	1.8	0.2	2.4	2.3	7.3									



Moving Range Chart. When a Moving Range value falls outside the range control limits, it is an indication of a sudden change in the series of Individual Values. This identification of discontinuities in the original time series is the major contribution of any Moving Range Chart.

### 9.4 Control Charts for Moving Averages

Some authors suggest using Moving Average Charts with Periodically Collected Data. These are essentially ordinary Average and Range Charts constructed using a moving subgroup of size two or larger.

**EXAMPLE 9.4:** Moving Average and Moving Range Charts:

The weights of the first 45 sequential batches run during one week are shown below. (The time order sequence for these values is given by reading the values row by row.) These values will be used to obtain a Moving Average Chart.

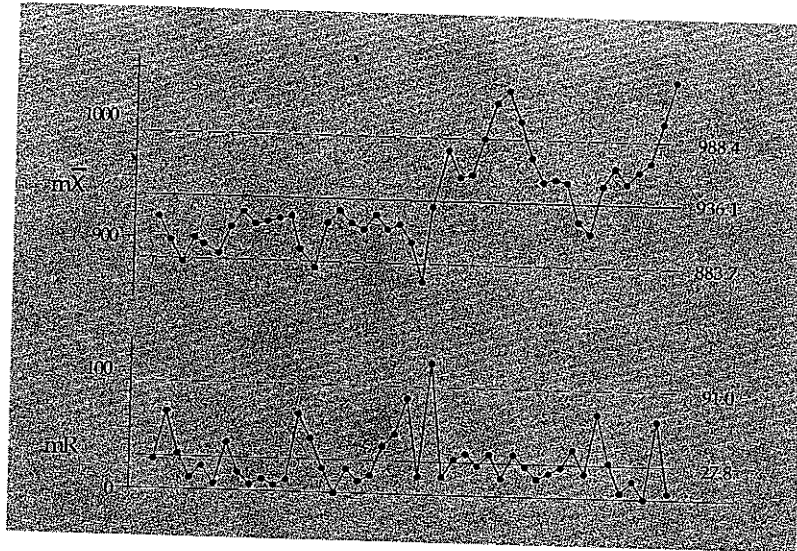
905	930	865	895	905	885	890	930	915	910	920	915	925	860	905
925	925	905	915	930	890	940	860	875	985	970	940	975	1000	1035
1020	985	960	945	965	940	900	920	980	950	955	970	970	1035	1040

The only unique aspect of the construction of a Moving Average and Moving Range Chart is the construction of the moving subgroups. The first 14 values are arranged into moving subgroups of size  $n = 2$  below—each value is written down twice on a diagonal so that it occurs in exactly two successive subgroups—then averages and ranges are computed for each "subgroup."

905	930	865	895	905	885	890	930	915	910	920	915	925	860	905
→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
905	905	930	865	895	905	885	890	930	915	910	920	915	925	860
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
905	930	865	895	905	885	890	930	915	910	920	915	925	860	905
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
$m\bar{X}$	917.5	897.5	880.0	900.0	895.0	887.5	910.0	922.5	912.5	915.0	917.5	920.0	892.5	...
$mR$	25	65	30	10	20	5	40	15	5	10	5	10	65	

With a Grand Moving Average of 936.08, and an Average Moving Range of 27.84, the limits for the Moving Average and Moving Range Chart are constructed just like those for an ordinary Average and Range Chart with subgroup size  $n = 2$ : (See Exercise 3.3 for the computations for these data.)

For an  $n$ -period Moving Average each value would be written down  $n$  times on a diagonal. When  $n$  values are stacked up they form a moving subgroup of size  $n$ . Then the average and range are computed for each subgroup and these values are plotted on a chart with the usual limits for subgroups of size  $n$ .



**Figure 9.6: Moving Average and Moving Range Chart**

*The chart in Figure 9.6 may be compared to that in Figure 9.4 on page 215. Both the Individuals Chart and the Moving Average Chart detect the lack of control in these data. The Moving Range Chart is the same as that in Figure 9.4 because both charts are based upon  $n = 2$ .*

Just as on the Moving Range Chart, successive Moving Averages are computed using some of the same Individual Values. This overlap in the data used for successive Moving Averages will undermine the use of detection rules which are based upon runs. For this reason, the authors do not recommend the use of Detection Rules Two, Three, or Four with the Moving Average Chart. It is best to use only Detection Rule One with Moving Average Charts and Moving Range Charts.

Moving Averages will, of necessity, lag behind any shift in the process. This makes the Moving Average Chart initially *less* sensitive to process changes than an *XmR* Chart. While the Moving Average Chart will eventually detect a sustained change or trend in the process, such changes are often seen more quickly on the Individuals Chart. Moreover, the Moving Average Chart will often obscure transitory phenomena. Before a Moving Average will detect a problem, that problem will have to persist for at least  $n$  time periods. Of course the Moving Range Chart is still available to detect sudden changes in the time series, but this sensitivity drops as the size of the moving subgroup increases.