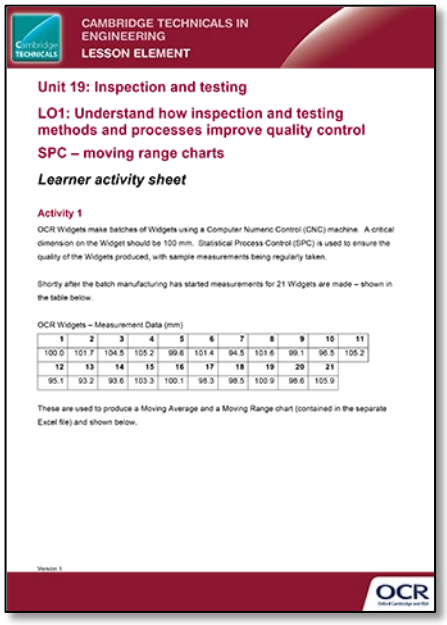
Unit 19: Inspection and testing

LO1: Understand how inspection and testing methods and processes improve quality control

SPC – moving range charts

Instructions and answers for teachers

These instructions should accompany the OCR resource 'SPC – moving range charts' *activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 19: Inspection and testing

LO1: Understand how inspection and testing methods and processes improve quality control

SPC – moving range charts

Learner activity sheet

Activity 1

OCR Widgets make batches of Widgets using a Computer Numeric Control (CNC) machine. A critical dimension on the Widget should be 100 mm. Statistical Process Control (SPC) is used to ensure the quality of the Widgets produced, with sample measurements being regularly taken.

Shortly after the batch manufacturing has started measurements for 21 Widgets are made – shown in the table below.

OCR Widgets – Measurement Data (mm)

1	2	3	4	5	6	7	8	9	10	11
100.0	101.7	104.5	105.2	99.6	101.4	94.5	101.6	99.1	96.5	105.2
12	13	14	15	16	17	18	19	20	21	
95.1	93.2	93.6	103.3	100.1	98.3	98.5	100.9	98.6	105.9	

These are used to produce a Moving Average and a Moving Range chart (contained in the separate Excel file) and shown below.

Version 1

OCR

The Activity:

Activity 1 presents a Moving Average and a Moving Range chart for a set of data.
Activity 2 requires learners to investigate a new set of measured data.

Suggested timings:

1-2 hours

Activity 1

Activity 1 presents a Moving Average and a Moving Range chart for a set of data shown below.

OCR Widgets – Measurement Data (mm)

1	2	3	4	5	6	7	8	9	10	11
100.0	101.7	104.5	105.2	99.6	101.4	94.5	101.6	99.1	96.5	105.2
12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
95.1	93.2	93.6	103.3	100.1	98.3	98.5	100.9	98.6	105.9	

Teachers could first introduce learners to the concept of Moving Average and Moving Range charts and how they can be produced using the following formulae:

Basic Formulae

$$n = number\ of\ measurements\ in\ moving\ average$$

$$MR = |current\ measurement - previous\ measurement|$$

$$\overline{R} = \frac{sum\ of\ MR\ values}{number\ of\ MR\ values}$$

$$\overline{X} = \frac{sum\ of\ measurements}{number\ of\ measurements}$$

Moving Average Control Limits

$$\sigma_c = \frac{\overline{R}}{1.128}$$

$$UCL\ (MA) = \overline{X} + 3\frac{\sigma_c}{\sqrt{n}} \qquad LCL\ (MA) = \overline{X} - 3\frac{\sigma_c}{\sqrt{n}}$$

Moving Range Control Limits

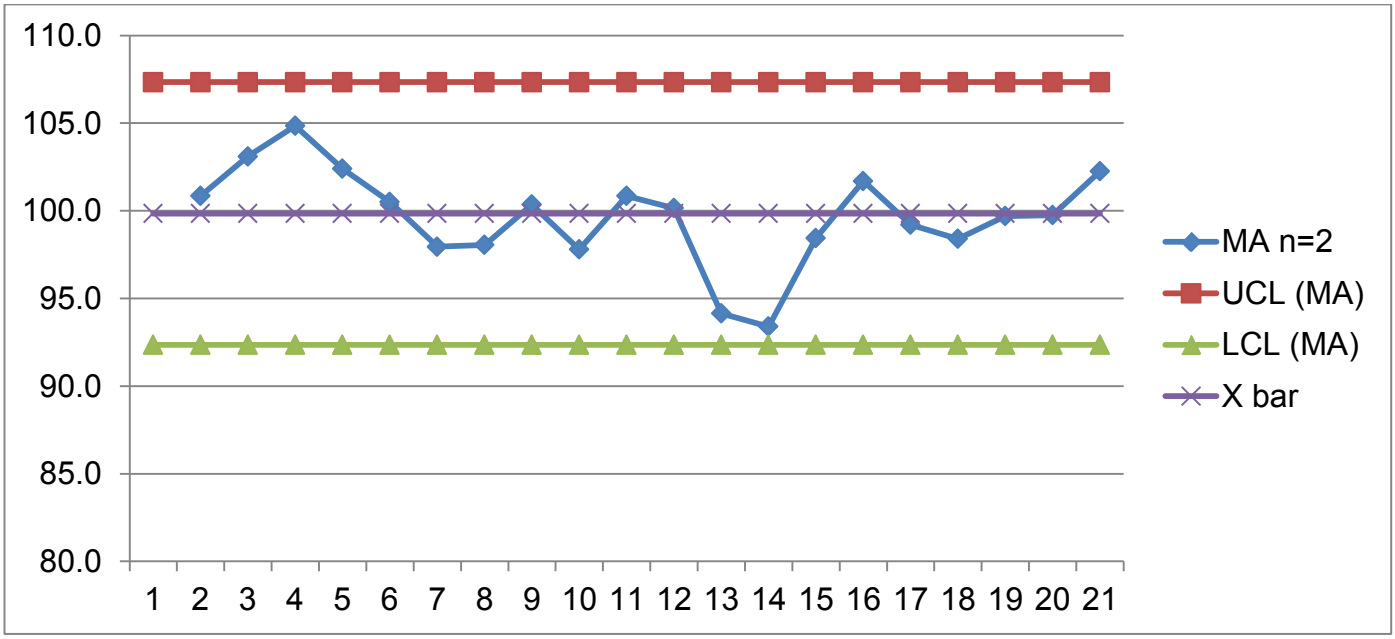
$$UCL\ (MR) = 3.267\ x\ \overline{R} \qquad LCL(MR) = 0$$

A spreadsheet has been developed to support this activity – and teachers may give this to learners or use it as a basis to explain Moving Average and Moving Range charts.

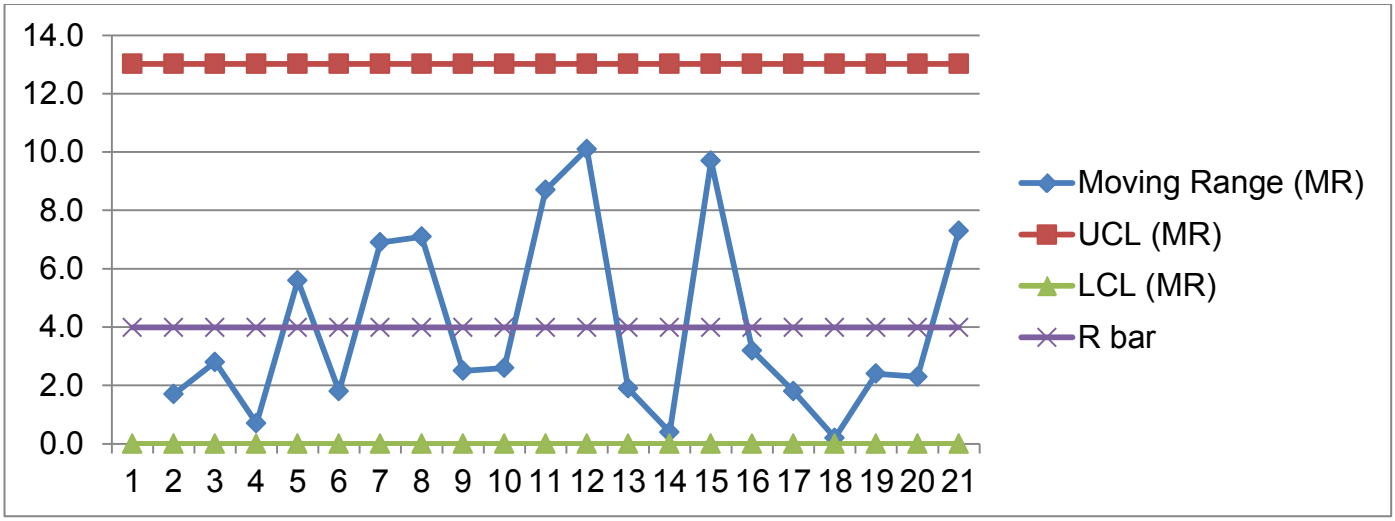
This activity could therefore be used for teaching purposes.

The following charts are produced using the spreadsheet:

Moving Average Chart:



Moving Range Chart:



The charts show the moving average and moving range data, the average value for moving range ($\bar{R}$), the average for moving average ($\bar{X}$), and the upper and lower control limits for each chart (UCL and LCL).

The formulae for averages and control limits shown above are calculated in the spreadsheet.

The charts show that, for the measured data, this sample is within the upper and lower control limits for both Moving Average and Moving Range, and can therefore be considered satisfactory.

Learners are required to answer the following questions.

Answers to questions

1. What do the Moving Average and Moving Range charts tell us about the quality of this batch of Widgets?

   The Moving Average and Moving Range charts show data is within the upper and lower control limits and it can therefore be assumed that the quality of this batch is satisfactory.

2. How are the Upper Control Limit (UCL) and Lower Control Limit (LCL) determined for each type of chart?

   The upper and lower control limits are determined using the formula above. It is perhaps beyond the scope of this unit to fully explain these formulae. In essence, the formulae for Moving Average represent a limit of 3 Standard Deviation either side of the mean value (3 SD). A similar problem was presented in Lesson Element 3 for Unit 1 which explains Standard Deviation.

   3 SD is taken, statistically, as the limit either side of the average value for which the sample fails or passes. This is a well accepted measure for quality.

   For the Moving Range chart the limits are determined as a result of a more complex theory based on statistical process control (SPC) beyond the scope of this unit.

3. Why is n=2 used to determine the moving average, and can this be changed?

n=2 represents that there are that the moving average is averaged over two consecutive samples, on a moving basis. It is feasible to average samples over more sample points e.g. n=3, n=4 etc. n=2 and n=3 are commonly used.

4. What are the advantages and disadvantages of a Moving Average Chart?

Advantages	• Good for situations where data is collected slowly or data is expensive to collect • Can bring trends to light more rapidly • Use a central limit theory to normalise the data (the centreline average and the 3 SD limits)
Disadvantages	• Adjacent points on the chart are not independent – they are an average • Difficult to be able to see quick changes – as there is a lag in the information on the chart

5. What are the advantages and disadvantages of a Moving Range Chart?

Advantages	• Sudden changes in data can be quickly identified • Complements the information shown in the Moving Average chart • Can show discontinuities in the data (i.e. missing sample values)
Disadvantages	• Not as good for trend analysis as shows instantaneous values

Teachers could analyse the construction of the spreadsheet. Good layout techniques have been used with fixed calculations being made at the head of the spreadsheet, and changing (measured) values being tabulated. Absolute and relative cell referencing (the $ symbol) have also been used. Graphs have been plotted using the data.

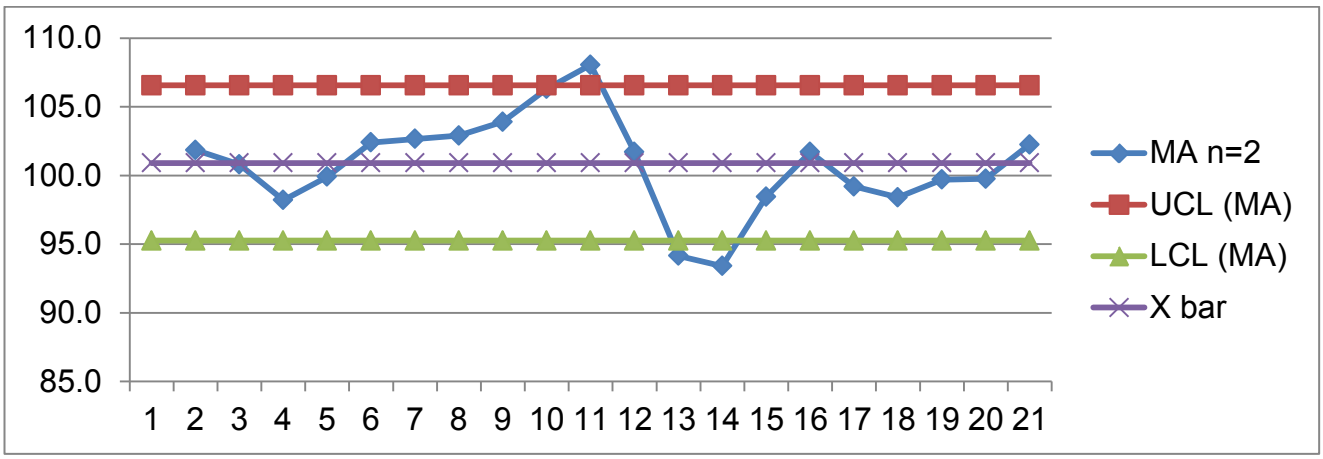
Activity 2

Activity 2 requires learners to investigate a new set of measured data shown below:

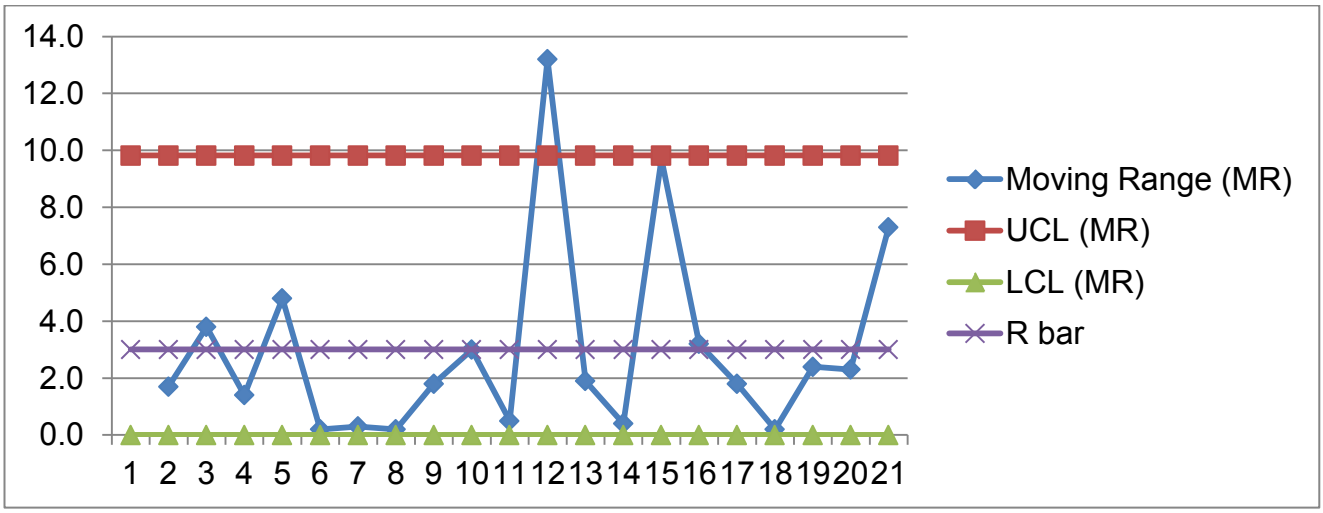
1	2	3	4	5	6	7	8	9	10	11
101.0	102.7	98.9	97.5	102.3	102.5	102.8	103.0	104.8	107.8	108.3
12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
95.1	93.2	93.6	103.3	100.1	98.3	98.5	100.9	98.6	105.9	

Moving Average and Moving Range plots for this data have been produced using the spreadsheet and are shown below:

Moving Average Chart:



Moving Range Chart:



Learners could develop their own spreadsheet in order to produce these plots, or could produce them manually using graph paper.

The plots show measured (sampled) data outside of the control limits at point 12, 13 and 14.

The Moving Range plot shows the instantaneous out of tolerance measurements, and the Moving Average shows this averaged between points 12, 13 and 14 (i.e. a trend).

This clearly indicates a problem with the CNC machine, its setup or its operation which requires further investigation.

Teachers could develop further problems involving Moving Average and Moving Range plots for learners to solve.