Control Chart for Mean using Range

SESSION 2

Structure

2.1 INTRODUCTION

In Lab Session 1, you have learnt how to prepare the control chart for mean in MS Excel 2007 when process variability is known. But the value of process variability is not known in practice. Therefore, we estimate it from the samples or subgroups taken when the process is thought to be in control. You have studied in Unit 2 of MSTE-001 (Industrial Statistics-I) that we express process variability in terms of standard deviation in quality control. We use sample range or sample standard deviation as an estimator of the process standard deviation (σ).

In this lab session, you will learn about the construction of control chart for mean in MS Excel 2007 **when process variability is unknown**. We shall consider the **sample range** as an estimator of process standard deviation (σ) to demonstrate control chart for mean using a specific problem. In the next lab session, you will learn how to use **sample standard deviation** for estimating the process standard deviation.

Prerequisite

- Lab Sessions 1, 3 and 6 of MSTL-001 (Basic Statistics Lab).
- Lab Session 1 of MSTE-002 (Industrial Statistics Lab).
- Unit 2 of MSTE-001 (Industrial Statistics-I).

Objectives

After performing the activities of this session, you should be able to:

- prepare the spreadsheet in MS Excel 2007;
- determine the control limits for control chart for mean using sample range to estimate the unknown process variability;
- construct the control chart for mean using sample range to estimate the unknown process variability;
- obtain the revised control limits for control charts for mean using sample range; and
- interpret the control chart.

2.2 PROBLEM DESCRIPTION

For this lab session, we consider the data given in Lab Session 1.

Suppose the quality control inspector of the juice manufacturing company needs to develop $\bar{X}$-chart to check whether the process of bottling is under control or out-of-control **when process variability is unknown**. Suppose he/she also needs to compute the revised control limits if the process is out-of-control.

Therefore, the problem for this session is to construct the control chart for mean using sample range to estimate the process variability.

2.3 PROCEDURE FOR THE CONSTRUCTION OF $\bar{X}$-CHART

In Sec. 2.4 of Unit 2 of MSTE-001, you have learnt various formulae and procedure of constructing the $\bar{X}$-chart when we estimate (σ) using sample range. Therefore, in this lab session, we will briefly revise the procedure of computing the centre line, upper and lower control limits using sample range to estimate the process standard deviation (σ). The main steps involved in the construction of $\bar{X}$-chart are as follows:

Steps 1-3: The first three steps are the same as explained in Sec. 1.3 of Lab Session 1.

Step 4: We calculate the sample range for each subgroup or sample, say, $R_1, R_2, \ldots, R_k$ where R_i is the sample range for i^{th} sample or subgroup given by

$$R_i = \max\left(X_{i1}, X_{i2}, \ldots, X_{ik}\right) - \min\left(X_{i1}, X_{i2}, \ldots, X_{ik}\right) \quad \ldots(1)$$

Step 5: We find the mean of all sample ranges given by

$$\bar{R} = \frac{1}{k}\left(R_1 + R_2 + \ldots + R_k\right) = \frac{1}{k}\sum_{i=1}^{k} R_i \quad \ldots(2)$$

Step 6: The control limits for $\bar{X}$-chart when σ is estimated by $\bar{R}/d_2$ are given by

- ✓ Centre line (CL) $= \bar{\bar{X}}$ ...(3)
- ✓ Upper control limit (UCL) $= \bar{\bar{X}} + A_2\bar{R}$ ...(4)
- ✓ Lower control limit (LCL) $= \bar{\bar{X}} - A_2\bar{R}$ ...(5)

where $A_2 = \dfrac{3}{d_2\sqrt{n}}$ is a constant and depends on the size of the sample. It is tabulated for various sample sizes in the Appendix given at the end of this lab course.

Step 7: Interpretation of the $\bar{X}$-chart.

2.4 STEPS INVOLVED IN THE CONSTRUCTION OF $\bar{X}$-CHART IN EXCEL 2007

We now apply the steps explained in Sec. 2.3 and construct the $\bar{X}$-chart for controlling process mean when process variability is estimated by the sample range for the given data. It is similar to the procedure we have explained in Lab Session 1. The main steps involved in this method are as follows:

Step 1: We calculate the sample mean for all 25 samples. To calculate sample means ($\bar{X}$), we repeat Steps 1-5 of Sec. 1.4 of Lab Session 1. To compute the grand sample mean ($\bar{\bar{X}}$) of the given 25 samples, we repeat Step 6 of Sec. 1.4. We get the output shown in Fig. 2.1.

	A	B	C	D	E	F
1		Juice Volume (in ml)				
2	Sample No.	Obs 1	Obs 2	Obs 3	Obs 4	Sample Mean
3	1	497.32	500.62	498.68	497.82	498.610
4	2	504.76	500.00	498.32	500.32	500.850
5	3	499.24	497.18	498.12	498.68	498.305
6	4	499.26	496.32	498.88	497.82	498.070
7	5	502.32	503.62	504.56	503.12	503.405
8	6	502.12	500.32	501.38	500.94	501.190
9	7	499.34	498.32	497.32	497.62	498.150
10	8	499.38	498.12	500.62	498.12	499.060
11	9	501.26	502.38	500.68	501.38	501.425
12	10	498.60	497.62	499.25	498.56	498.508
13	11	502.44	500.00	501.32	499.38	500.785
14	12	501.26	502.32	500.76	502.68	501.755
15	13	497.32	498.50	497.18	499.38	498.095
16	14	499.56	498.00	498.76	501.12	499.360
17	15	502.24	500.32	503.12	501.25	501.733
18	16	501.76	500.50	502.68	501.12	501.515
19	17	500.65	497.82	494.06	496.25	497.195
20	18	501.12	501.26	500.44	502.76	501.395
21	19	501.00	500.50	501.56	501.76	501.205
22	20	497.50	498.82	499.76	497.82	498.475
23	21	503.44	500.62	500.00	501.26	501.330
24	22	499.38	498.38	497.56	498.56	498.470
25	23	501.56	499.56	498.00	499.82	499.735

X Bar Chart

F28 =AVERAGE(F3:F27)

	A	B	C	D	E	F
25	23	501.56	499.56	498.00	499.82	499.735
26	24	498.32	497.32	499.56	498.62	498.455
27	25	499.50	501.12	502.50	500.38	500.875
28					Average	499.918
29						

Fig. 2.1: Partial screenshot of the spreadsheet for the given data.

Step 2: We calculate the sample range (R) for all 25 samples. In Column G, we determine the range for each sample. For this, we type "=Max(B3:E3)–Min(B3:E3)" in Cell G3 and then drag down Cell G3 up to Cell G27. We get the ranges for all 25 samples as shown in Fig. 2.2.

G3 =MAX(B3:E3)-MIN(B3:E3)

	A	B	C	D	E	F	G	H
1			Juice Volume (in ml)					
2	Sample No.	Obs 1	Obs 2	Obs 3	Obs 4	Sample Mean	Sample Range	
3	1	497.32	500.62	498.68	497.82	498.610	3.300	
4	2	504.76	500.00	498.32	500.32	500.850		
5	3	499.24	497.18	498.12	498.68	498.305		
6	4	499.26	496.32	498.88	497.82	498.070		
7	5	502.32	503.62	504.56	503.12	503.405		

DRAG IT DOWN

	A	B	C	D	E	F	G	H
1			Juice Volume (in ml)					
2	Sample No.	Obs 1	Obs 2	Obs 3	Obs 4	Sample Mean	Sample Range	
3	1	497.32	500.62	498.68	497.82	498.610	3.300	
4	2	504.76	500.00	498.32	500.32	500.850	6.440	
5	3	499.24	497.18	498.12	498.68	498.305	2.060	
6	4	499.26	496.32	498.88	497.82	498.070	2.940	
7	5	502.32	503.62	504.56	503.12	503.405	2.240	
8	6	502.12	500.32	501.38	500.94	501.190	1.800	
9	7	499.34	498.32	497.32	497.62	498.150	2.020	
10	8	499.38	498.12	500.62	498.12	499.060	2.500	
11	9	501.26	502.38	500.68	501.38	501.425	1.700	
12	10	498.60	497.62	499.25	498.56	498.508	1.630	
13	11	502.44	500.00	501.32	499.38	500.785	3.060	
14	12	501.26	502.32	500.76	502.68	501.755	1.920	
15	13	497.32	498.50	497.18	499.38	498.095	2.200	
16	14	499.56	498.00	498.76	501.12	499.360	3.120	
17	15	502.24	500.32	503.12	501.25	501.733	2.800	
18	16	501.76	500.50	502.68	501.12	501.515	2.180	
19	17	500.65	497.82	494.06	496.25	497.195	6.590	
20	18	501.12	501.26	500.44	502.76	501.395	2.320	
21	19	501.00	500.50	501.56	501.76	501.205	1.260	
22	20	497.50	498.82	499.76	497.82	498.475	2.260	
23	21	503.44	500.62	500.00	501.26	501.330	3.440	

X Bar Chart

Fig. 2.2

Step 3: To determine the average range ($\bar{R}$), we type "=Average(G3:G27)" in Cell G28 as shown in Fig. 2.3. We get the value of $\bar{R}$ (shown in the box, Fig. 2.3).

G28 =AVERAGE(G3:G27)

	A	B	C	D	E	F	G
25	23	501.56	499.56	498.00	499.82	499.735	3.560
26	24	498.32	497.32	499.56	498.62	498.455	2.240
27	25	499.50	501.12	502.50	500.38	500.875	3.000
28					Average	499.918	2.736

Fig. 2.3

Step 4: We type the values of k and n in Cells F30 and F31, respectively, as shown in Fig. 2.4. Note that we have also put the value of A_2 for n = 4 in Cell F32 from the Appendix given at the end of this lab course.

	C	D	E	F
30			k	25
31			n	4
32	A_2 Value from Table (for n = 4)			0.729

Fig. 2.4

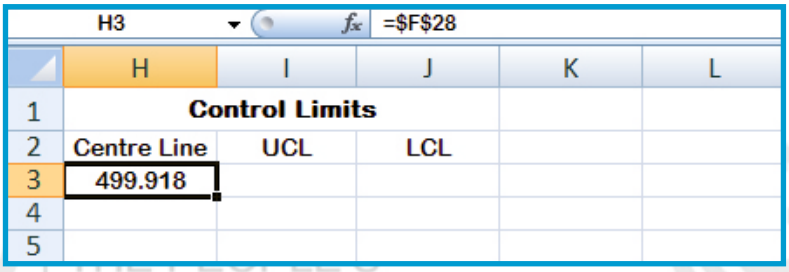
Step 5: We use the method for computing centre line and both control limits described in Step 8 of Sec. 1.4 in Lab Session 1. Here we shall use Columns H, I and J for putting the values of centre line, upper and lower control limits, respectively. We compute the centre line, upper and lower control limits as follows:

i) The formula for centre line is $(CL) = \overline{\overline{X}}$ and $\overline{\overline{X}}$ is given in Cell F28 (see Fig. 2.3). So we type "=$F$28" in Cell H3 as shown in Fig. 2.5a to obtain the centre line.

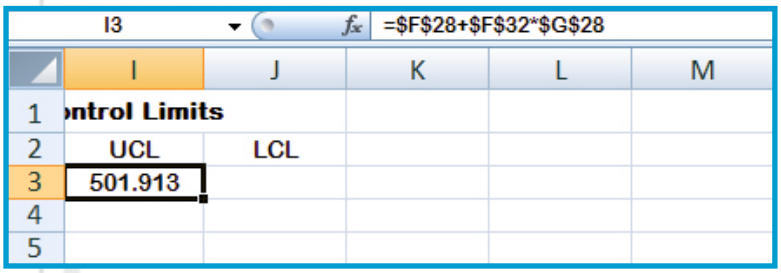
The formula with dollar sign ($) isused for an absolute references.

ii) To calculate upper control limit, the formula is $UCL = \overline{\overline{X}} + A_2\overline{R}$. Since the values of $\overline{\overline{X}}$, A_2 and $\overline{R}$ are given in Cells F28, F32 and G28, respectively (see Figs. 2.3 and 2.4), we type "=$F$28+$F$32*$G$28" in Cell I3 as shown in Fig. 2.5b.

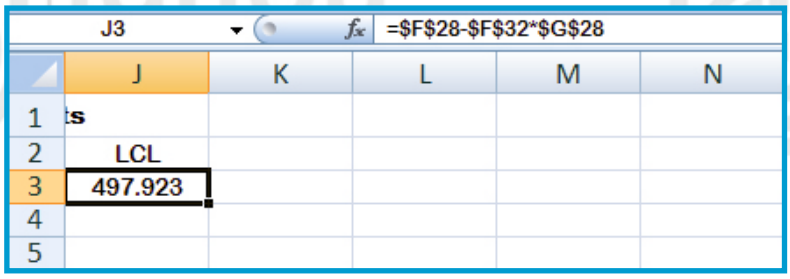
iii) Similarly, we calculate the lower control limit $LCL = \overline{\overline{X}} - A_2\overline{R}$ by typing "=$F$28-$F$32*$G$28" in Cell J3 as shown in Fig. 2.5c.



(a)



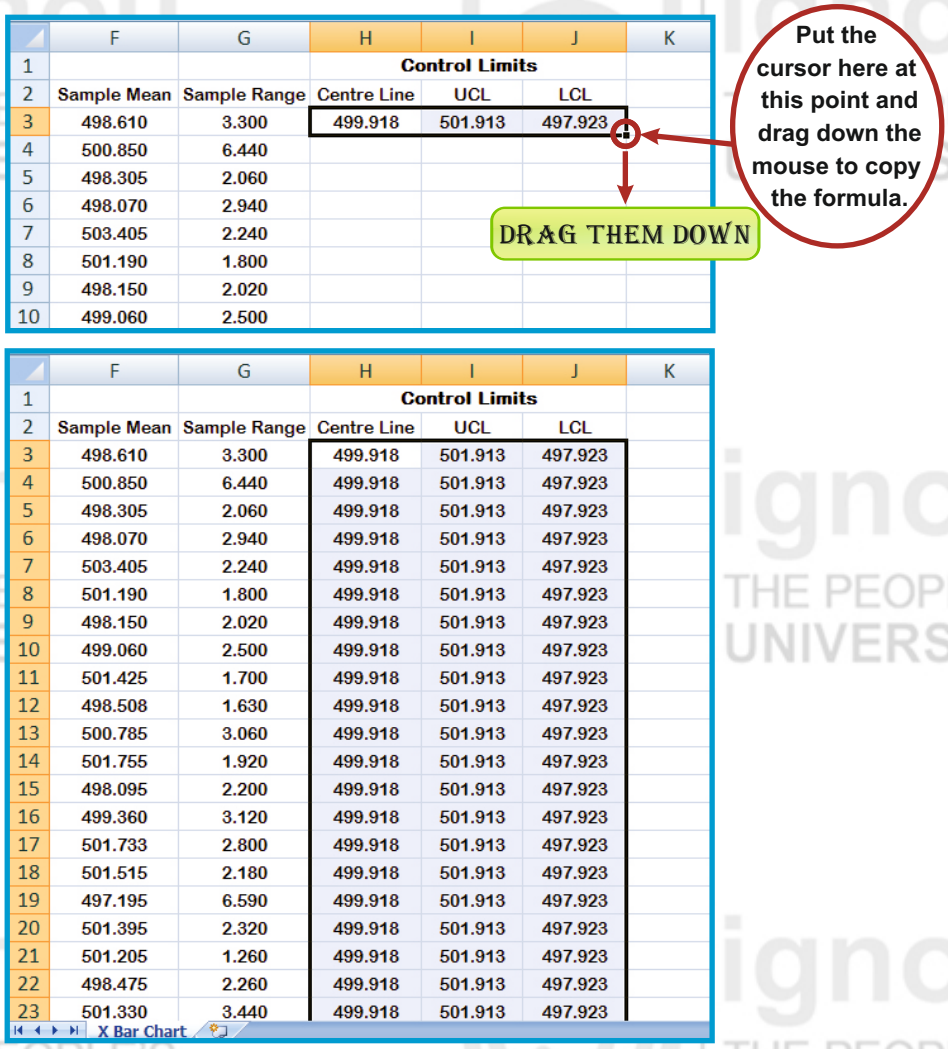
(b)



(c)

Fig. 2.5

Step 6: For plotting control limits on the chart, we first select Cells H3:J3 and drag Cells H3:J3 down up to Row 27. We get the output shown in Fig. 2.6.

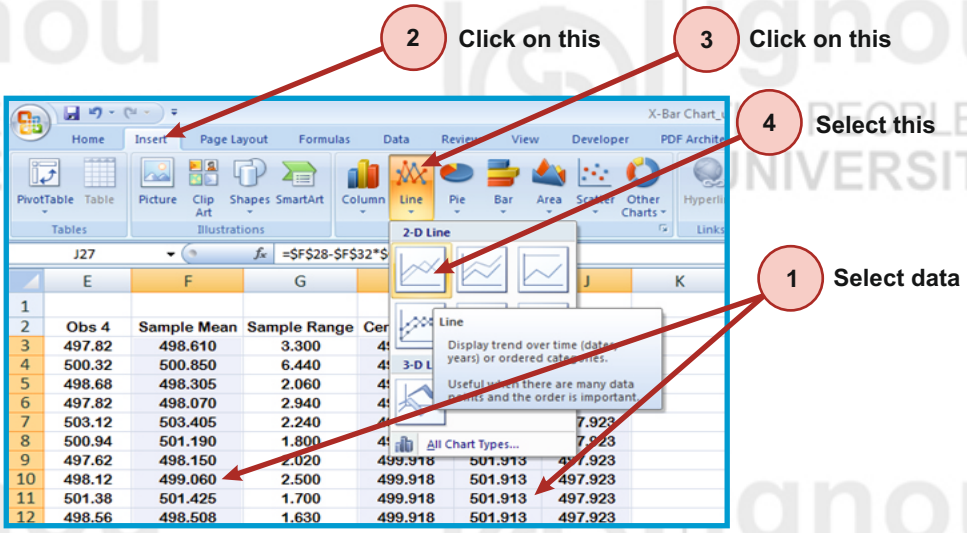


	F	G	H	I	J
1			Control Limits		
2	Sample Mean	Sample Range	Centre Line	UCL	LCL
3	498.610	3.300	499.918	501.913	497.923
4	500.850	6.440	499.918	501.913	497.923
5	498.305	2.060	499.918	501.913	497.923
6	498.070	2.940	499.918	501.913	497.923
7	503.405	2.240	499.918	501.913	497.923
8	501.190	1.800	499.918	501.913	497.923
9	498.150	2.020	499.918	501.913	497.923
10	499.060	2.500	499.918	501.913	497.923
11	501.425	1.700	499.918	501.913	497.923
12	498.508	1.630	499.918	501.913	497.923
13	500.785	3.060	499.918	501.913	497.923
14	501.755	1.920	499.918	501.913	497.923
15	498.095	2.200	499.918	501.913	497.923
16	499.360	3.120	499.918	501.913	497.923
17	501.733	2.800	499.918	501.913	497.923
18	501.515	2.180	499.918	501.913	497.923
19	497.195	6.590	499.918	501.913	497.923
20	501.395	2.320	499.918	501.913	497.923
21	501.205	1.260	499.918	501.913	497.923
22	498.475	2.260	499.918	501.913	497.923
23	501.330	3.440	499.918	501.913	497.923

Fig. 2.6

Step 7: To obtain the $\bar{X}$-chart, we follow the procedure explained in Step 10 of Sec. 1.4, Lab Session 1 (see Fig. 2.7). It means that we

1. select Cells F2:F27 and H2:J27 by holding ***Ctrl*** key,
2. click on the ***Insert*** tab,
3. select the ***Line*** option, and
4. choose the chart subtype.



	E	F	G	J	K
1					
2	Obs 4	Sample Mean	Sample Range		
3	497.82	498.610	3.300		
4	500.32	500.850	6.440		
5	498.68	498.305	2.060		
6	497.82	498.070	2.940		
7	503.12	503.405	2.240		
8	500.94	501.190	1.800		
9	497.62	498.150	2.020	501.913	497.923
10	498.12	499.060	2.500	501.913	497.923
11	501.38	501.425	1.700	501.913	497.923
12	498.56	498.508	1.630	501.913	497.923

Fig. 2.7

Step 8: The values in Columns H, I and J provide the horizontal lines on the chart and represent the centre line, UCL and LCL, respectively. The values in Column F provide the averages for 25 samples on the chart. After we format the chart as explained in Step 12 of Sec. 1.4, we get the control chart shown in Fig. 2.8.

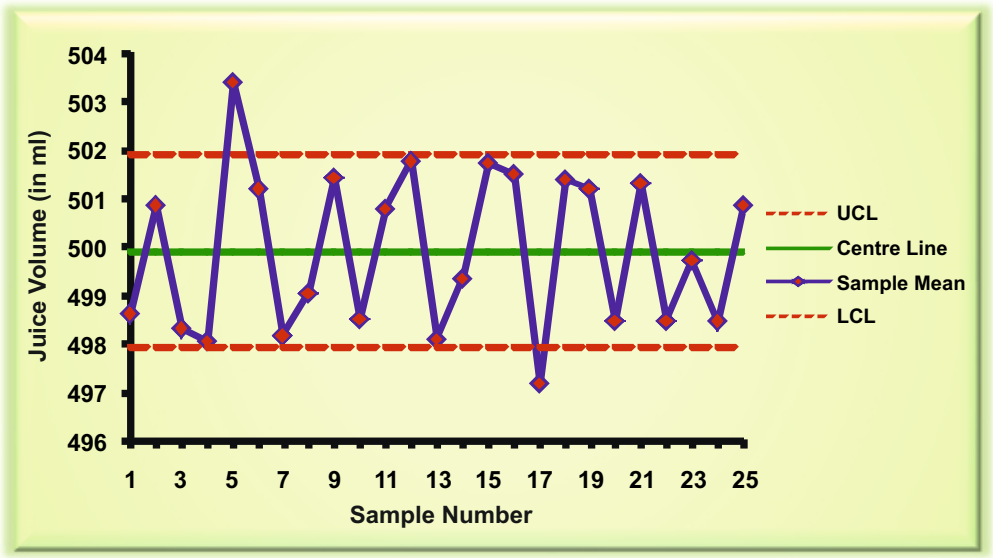


Fig. 2.8

Interpretation

Note from Fig. 2.8 that two points corresponding to Samples 5 and 17 lie outside the UCL and LCL, respectively. Therefore, this control chart indicates that the bottling process of juice manufacturing company **is not under statistical control**. Some **assignable causes** are present in the process. To bring the process under statistical control, it is necessary to investigate the assignable causes and take corrective action to eliminate them.

Note: Let us compare the control limits obtained in Lab Session 1 and Lab Session 2. We have used a known value of process variability, i.e., 2.5 in Lab Session 1 and estimated the value of process variability using average sample range, i.e., 1.3288 in the Lab Session 2. We know that the control limits (UCL and LCL) depend on the process variability (σ). As σ increases, the gap between UCL and LCL also increases. Note that the estimated process variability (= 1.3288) in Lab Session 2 is smaller than the process variability (= 2.5) used in Lab Session 1. Therefore, the UCL and LCL in this case come closer to the centre line in comparison to the UCL and LCL in Lab Session 1. As a result, the 5th and 17th points lie beyond the control limits in Fig. 2.8. Recall that these points were close to the UCL and LCL, respectively, in Lab Session 1 (see Fig. 1.14).

The value of $d_2 = 2.059$ for $n = 4$ from the Appendix given at the end of this lab course.

$\therefore \hat{\sigma} = \bar{R}/d_2 = 1.3288$

2.5 REVISED $\bar{X}$-CHART

After eliminating the assignable causes from the process, we delete the out-of-control samples and calculate the revised centre line and control limits for the $\bar{X}$-chart using the remaining samples. These limits are known as the **revised control limits**.

The process of revising control limits will continue until the process comes under control.

The main steps for computing revised control limits are described below:

Step 1: For revised limits for $\bar{X}$-chart using sample range, we first calculate the new $\bar{\bar{X}}$ and new $\bar{R}$ using the following formulae:

$$\bar{\bar{X}}_{new} = \frac{\sum_{i=1}^{k} \bar{X}_i - \sum_{j=1}^{d} \bar{X}_j}{k-d} \quad \ldots(6)$$

and $$\bar{R}_{new} = \frac{\sum_{i=1}^{k} R_i - \sum_{j=1}^{d} R_j}{k-d} \quad \ldots(7)$$

where $\sum_{j=1}^{d} \bar{X}_j$ – sum of the averages of discarded samples,

d – number of discarded samples, and

$\sum_{j=1}^{d} R_j$ – sum of the ranges of discarded samples.

Step 2 : After determining the new $\bar{\bar{X}}$ and new $\bar{R}$, we reconstruct the centre line and control limits of the chart by replacing $\bar{\bar{X}}$ by $\bar{\bar{X}}_{new}$ and $\bar{R}$ by $\bar{R}_{new}$ as given below:

- ✓ Centre line = $\bar{\bar{X}}_{new}$ …(8)
- ✓ Upper control limit (UCL) = $\bar{\bar{X}}_{new} + A_2\bar{R}_{new}$ …(9)
- ✓ Lower control limit (LCL) = $\bar{\bar{X}}_{new} - A_2\bar{R}_{new}$ …(10)

Step 3: Interpretation of the $\bar{X}$-chart.

Generally, we control the process mean and process variability simultaneously. So we use both $\bar{X}$ and R-charts together.

Steps in Excel

The main steps for calculating the revised centre line and control limits for constructing the $\bar{X}$-chart in Excel 2007 using the remaining samples are as follows:

Step 1: We highlight the samples which lie outside the control limits, i.e., the 5th and 17th samples. We have shown them in light orange colour (Fig. 2.9).

	A	B	C	D	E	F	G	H	I	J
1		Juice Volume (in ml)						Control Limits		
2	Sample No.	Obs 1	Obs 2	Obs 3	Obs 4	Sample Mean	Sample Range	Centre Line	UCL	LCL
3	1	497.32	500.62	498.68	497.82	498.610	3.300	499.918	501.913	497.923
4	2	504.76	500.00	498.32	500.32	500.850	6.440	499.918	501.913	497.923
5	3	499.24	497.18	498.12	498.68	498.305	2.060	499.918	501.913	497.923
6	4	499.26	496.32	498.88	497.82	498.070	2.940	499.918	501.913	497.923
7	5	502.32	503.62	504.56	503.12	503.405	2.240	499.918	501.913	497.923
8	6	502.12	500.32	501.38	500.94	501.190	1.800	499.918	501.913	497.923
9	7	499.34	498.32	497.32	497.62	498.150	2.020	499.918	501.913	497.923
10	8	499.38	498.12	500.62	498.12	499.060	2.500	499.918	501.913	497.923
11	9	501.26	502.38	500.68	501.38	501.425	1.700	499.918	501.913	497.923
12	10	498.60	497.62	499.25	498.56	498.508	1.630	499.918	501.913	497.923
13	11	502.44	500.00	501.32	499.38	500.785	3.060	499.918	501.913	497.923
14	12	501.26	502.32	500.76	502.68	501.755	1.920	499.918	501.913	497.923
15	13	497.32	498.50	497.18	499.38	498.095	2.200	499.918	501.913	497.923
16	14	499.56	498.00	498.76	501.12	499.360	3.120	499.918	501.913	497.923
17	15	502.24	500.32	503.12	501.25	501.733	2.800	499.918	501.913	497.923
18	16	501.76	500.50	502.68	501.12	501.515	2.180	499.918	501.913	497.923
19	17	500.65	497.82	494.06	496.25	497.195	6.590	499.918	501.913	497.923

Fig. 2.9

Step 2: We put the value of d = 2 in Cell F33 in addition to the values of k, n and A_2 as shown in Fig. 2.10.

	C	D	E	F
30			k	25
31			n	4
32		A_2 Value from Table (for n = 4)		0.729
33			d	2

Fig. 2.10

Step 3: To calculate the value of $\bar{\bar{X}}_{new}$ given in equation (6), we type "=(Sum(F3:F27)-F7-F19)/(F30-F33)" in Cell F29 and then press ***Enter*** as shown in Fig. 2.11.

ROUND =(SUM(F3:F27)-F7-F19)/(F30-F33)

	D	E	F
29		Revised Average	=(SUM(F3:F27)-F7-F19)/(F30-F33)
30		k	25
31		n	4
32		A_2 Value from Table (for n=4)	0.729
33		d	2
34			

ENTER

F29 =(SUM(F3:F27)-F7-F19)/(F30-F33)

	D	E	F	G
29		Revised Average	499.885	
30		k	25	

Fig. 2.11

Step 4: Similarly, for calculating $\bar{R}_{new}$, we use equation (7) and type "=(Sum(G3:G27)-G7-G19)/(F30-F33)" in Cell G29 as shown in Fig. 2.12. We get the result when we press ***Enter***.

AVERAGE =(SUM(G3:G27)-G7-G19)/(F30-F33)

	D	E	F	G	H
29		Revised Average	499.885	=(SUM(G3:G27)-G7-G19)/(F30-F33)	
30		k	25		
31		n	4		
32		A_2 Value from Table (for n = 4)	0.729		
33		d	2		
34					

ENTER

G29 =(SUM(G3:G27)-G7-G19)/(F30-F33)

	E	F	G	H
29	Revised Average	499.885	2.590	
30	k	25		

Fig. 2.12

Step 5: We compute the revised centre line and control limits in the same way as explained in Step 5 in Sec. 2.4. Here we use Columns K, L and M for putting the values of the revised centre line, upper and lower control limits, respectively.

i) The formula for revised centre line is $(CL) = \bar{\bar{X}}_{new}$. Since the Value of $\bar{\bar{X}}_{new}$ is given in F29 (see Fig. 2.12), we type "=$F$29" in Cell K3 to obtain the centre line as shown in Fig. 2.13a.

ii) To calculate the upper control limit, we use equation (9). The values of $\bar{\bar{X}}_{new}$, A_2 and $\bar{R}_{new}$ are given in F29, F32 and G29, respectively (see Fig. 2.12). So we type "=$F$29+$F$32*$G$29" in Cell L3 as shown in Fig. 2.13b.

iii) Similarly, we calculate the lower control limit by typing "=$F$29-$F$32*$G$29" in Cell M3 as shown in Fig. 2.13c.

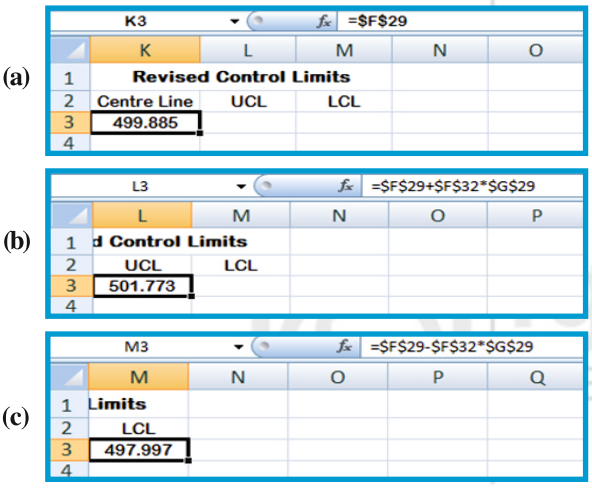


Fig. 2.13

Step 6: For plotting the revised control limits on the chart using Excel, we select Cells K3:M3 and drag them down up to Row 27 as shown in Fig. 2.14.

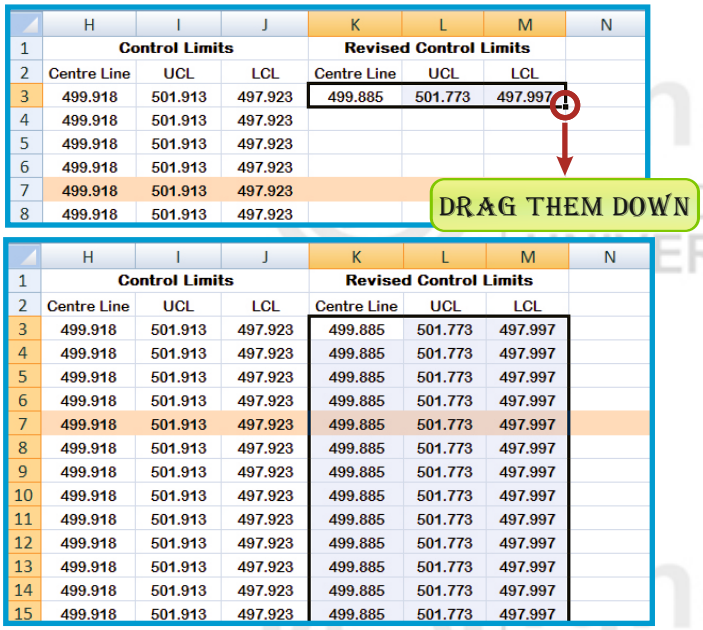


Fig. 2.14

Step 7: For plotting the revised $\bar{X}$-chart, we first select Cells F2:F6, F8:F18, F20:F27, K2:M6, K8:M18 and K20:M27 by holding ***Ctrl*** key as shown in Fig. 2.15. Then we follow Step 7 of Sec. 2.4.

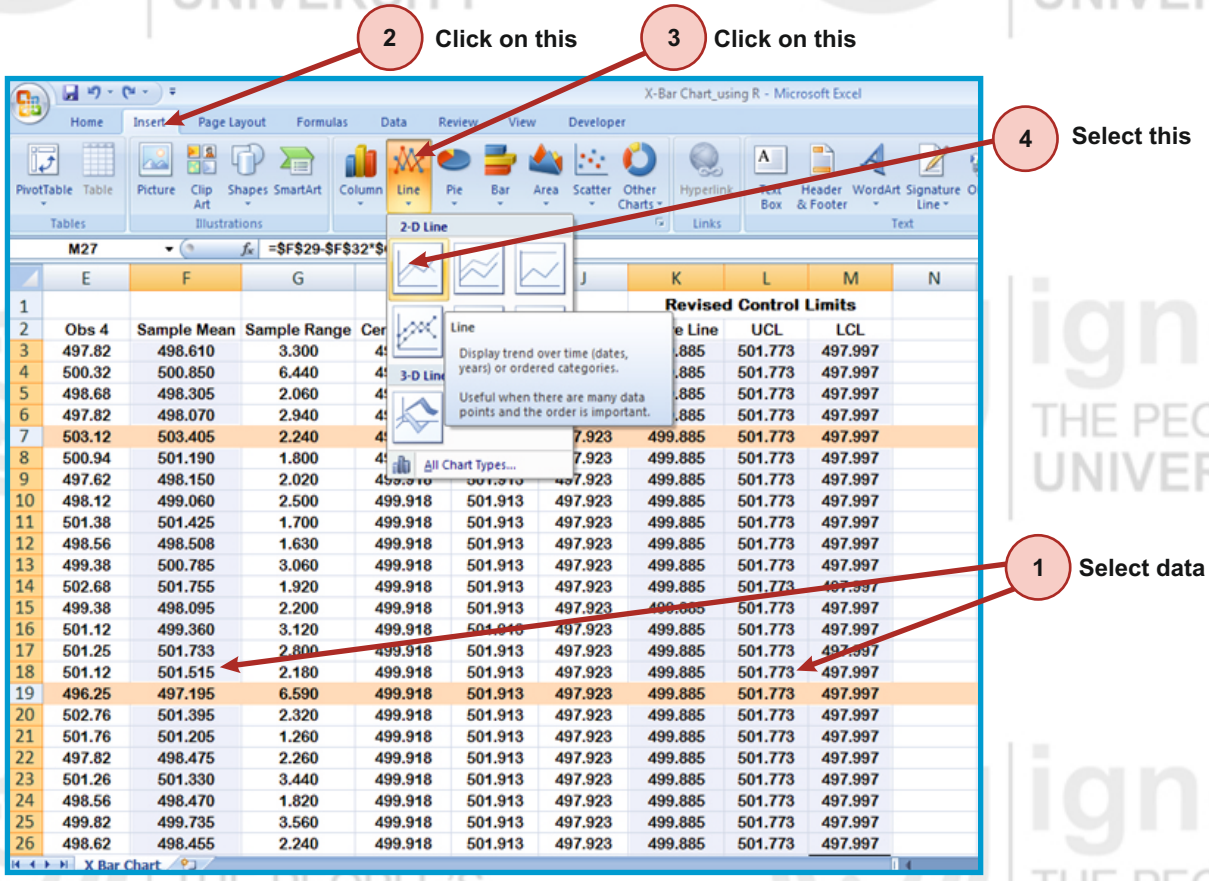


Fig. 2.15

Step 8: The values in Columns K, L and M provide the horizontal lines on the chart representing the revised centre line, UCL and LCL, respectively. The values in Column F provide the averages for 25 samples on the chart. The output is shown in Fig. 2.16.

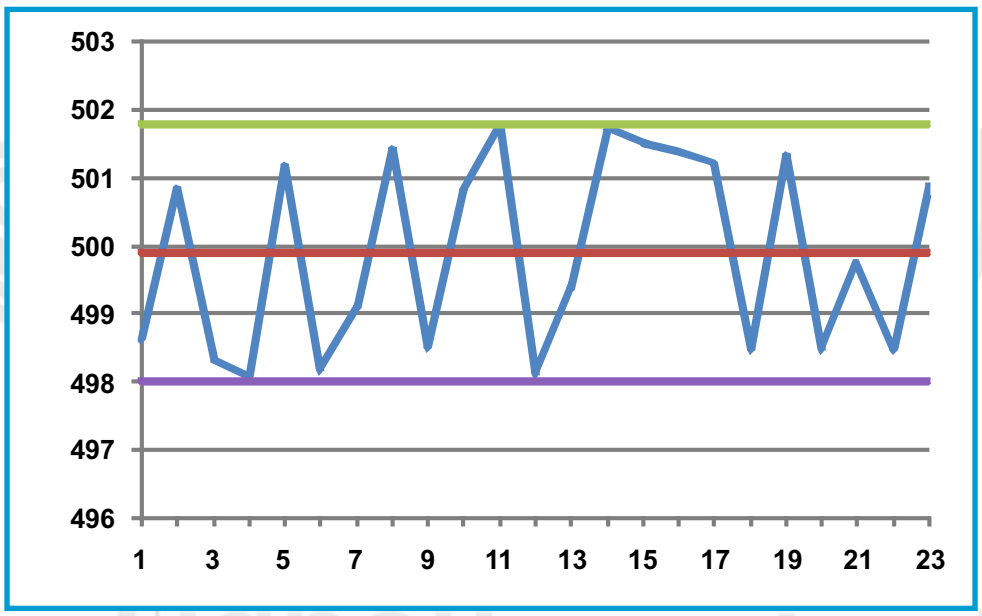


Fig. 2.16

Step 9: The horizontal axis shown in Fig. 2.16 also includes the 5th and 17th samples. To eliminate these points from the horizontal axis, we first click on the chart shown in Fig. 2.16. Then we

1. click on the ***Design*** tab under ***Chart Tools*** as shown in Fig. 2.17a,

2. choose ***Select Data*** option as shown in Fig. 2.17a. It opens a new dialog box as shown in Fig. 2.17b,

3. click on ***Edit*** under ***Horizontal (Category) Axis Labels*** as shown in Fig. 2.17b. It opens a new dialog box shown in Fig. 2.17c, and

4. select Cells A3:A6, A8:A18 and A20:A27, by holding the ***Ctrl*** key as shown in Fig. 2.17d and then press ***Enter***.

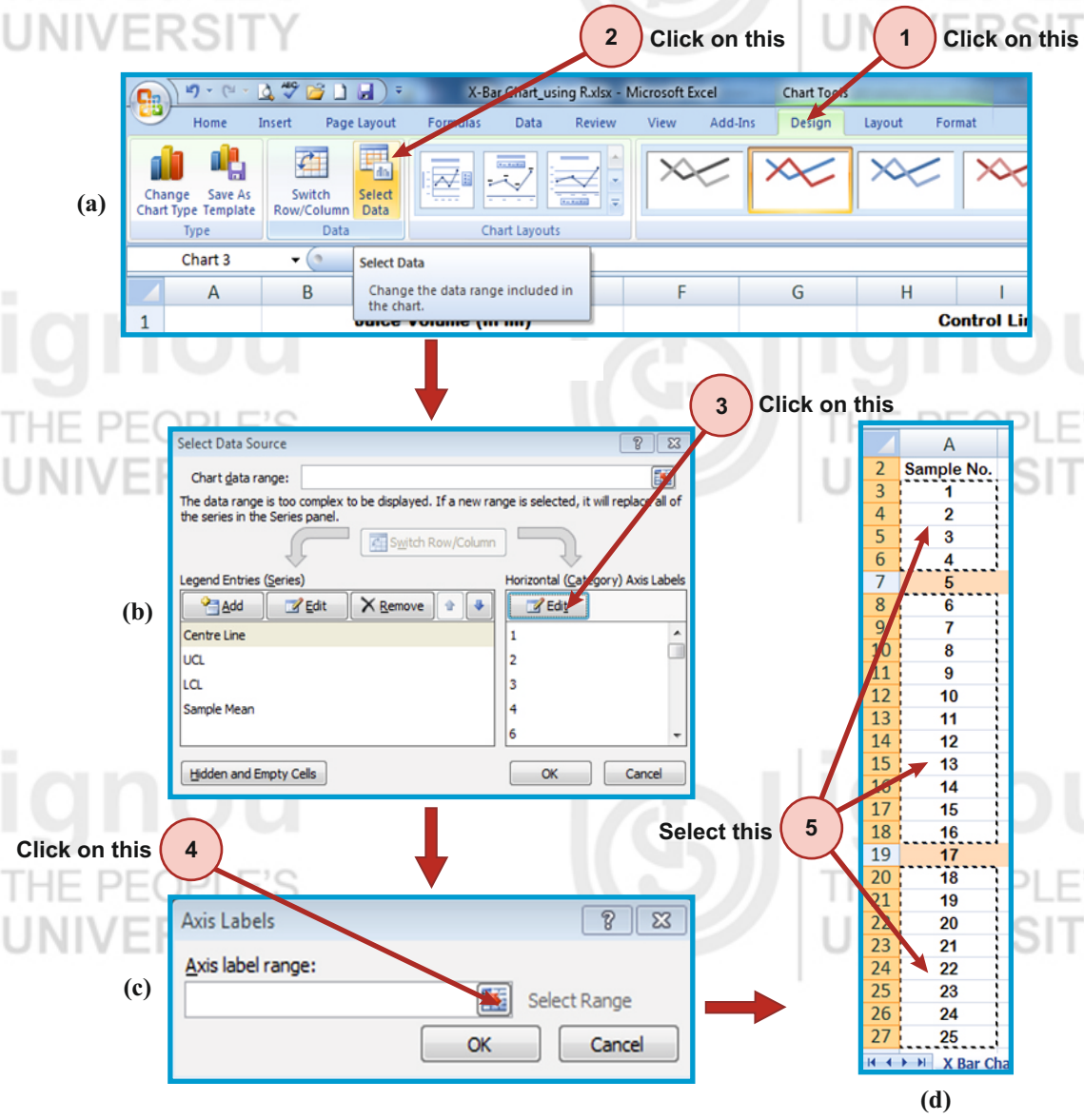


Fig. 2.17

Step 10: After we format as explained in Sec. 1.4, we get the control chart shown in Fig. 2.18. The resulting control chart is called the **revised** $\bar{X}$-chart.

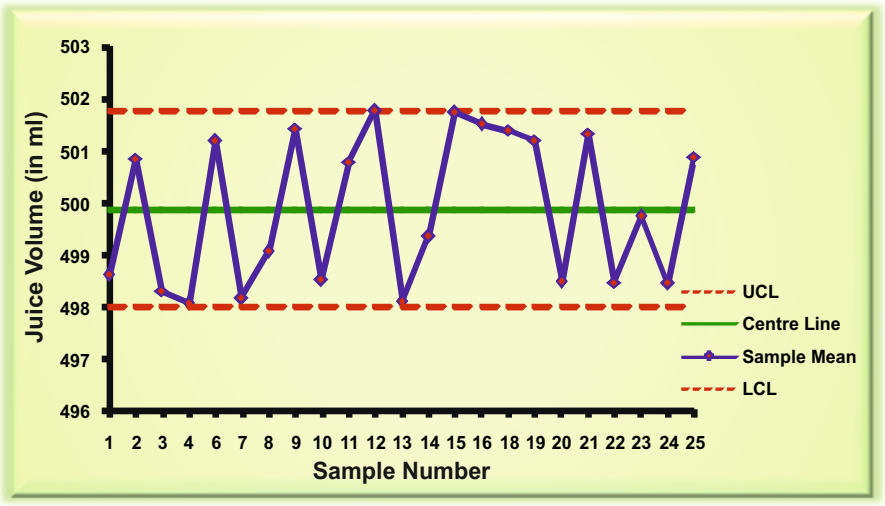


Fig. 2.18

Interpretation

The revised $\bar{X}$-chart shown in Fig. 2.18 indicates that all points lie within the control lines. We can conclude that the process is under statistical control with respect to mean.

Activity 1

You can also determine the revised control limits using another approach. For this purpose, follow the steps given below:

- Select Cells A1:E6, A8:E18 and A20:E27.
- Choose Cell A35 or any other cell and paste the values. You can also use a separate Excel sheet where you can paste these values.
- Repeat all steps given in Sec. 2.4.

It will give you the same results as you have obtained in Sec. 2.5.

You can now solve the following exercises to check whether you have learnt how to develop the control limits when process variability is unknown.

Activity 2

Construct the control charts for mean when process variability is unknown and estimated by sample range with the help of MS Excel 2007 and interpret the results for

A1) Example 3 given in Unit 2 of MSTE-001.

A2) Exercise E6 given in Unit 2 of MSTE-001.

Match the results with the manual calculation done in Unit 2 of MSTE-001.

Continuous Assessment 2

Consider the data given in Continuous Assessment 1 and develop $\overline{X}$ control limits to check whether the process of production of bulb is under control or out-of-control when process variability is unknown. If it is out-of-control, compute the revised control limits.

Home Work: Do It Yourself

1) Follow the steps explained in Sec. 2.4 and 2.5 to construct the control chart for the data of Table 1 in Lab Session 1. Use a different format for the control chart. Take its screenshot and keep it in your record book.

2) Develop the spreadsheet for the exercise "Continuous Assessment 2" as explained in this lab session. Take screenshots of the final spreadsheet and the chart.

3) **Do not forget** to keep the screenshots in your record book as these will contribute in your continuous assessment in the Laboratory.