INDIRA GANDHI INSTITUTE OF TECHNOLOGY,
DEPARTMENT OF MECHANICAL & AUTOMATION ENGG.
Kashmere Gate, Delhi-110006.

QCQA LAB.

INSTRUCTION MANNUAL
For
Experiment No.1

To collect data from Shewart's bowl and draw Normal Distribution Curve

M.A.E DEPARTMENT (I.G.I.T)

QCQA LAB.

EXPERIMENT NO. 01

AIM: To collect data from Shewart's bowl and draw normal distribution curve. Also study its main features.

APPARATUS: Shewart's Bowl with chips.

PROCEDURE:

(i) COLLECTION OF DATA:

Data can be of various types:-
(a) Primary Data
(b) Secondary Data

Primary Data: Data collected originally or when one itself collects data.

Secondary Data: Data which is already available in magazines, journals etc. or the data which is collected from the already existed data.

The data which is collected in this experiment is primary data. For this type of data collection, take the Shewart's bowl which consists of thousands of chips.

Steps for Data Collection :

- Take Shewart's bowl having thousands of chips.
- Shuffle the chips well and draw one chip at a time.
- Note down the chip number.
- Repeat the process 200 times.
- Shuffle the chips well, each and every time.
- Make the frequency distribution table and mark the chip number according to class interval in the frequency distribution table.

(ii) TABULATION:
After collection and editing of data, an important step is towards the presentation. One of the simplest and most revealing devices for summarizing data and presenting them in meaningful fashion is the statistical table. A table is a systematic arrangement of statistical data in colums and rows. The purpose of a table is to simplify the presentation and to facilitate the comparisions. The simplification results

from the clear cut and systematic arrangement, which enables the reader to quicly locate desired information.

Comparison is facilitated by bringing related items of information close together.

The main parts of a table are:

(1) Table Number
(2) Title of Table
(3) Caption
(4) Stub
(5) Body of Table
(6) Headnote
(7) Footnote

(iii) <u>ANALYSIS</u> :

<u>Calculations</u>

(i) Mean = $\sum fx / \sum f$

(ii) Median = $L + \frac{N/2 - cf}{f} \times i$

where,

L = lower limit of median class

cf = cumulative frequency of class preceding the median class

f = frequency of median class

i = class interval of median class

N = total no. of observation

(iii) Mode = $L + \frac{f1-f0}{2f1-f0-f2} \times i$

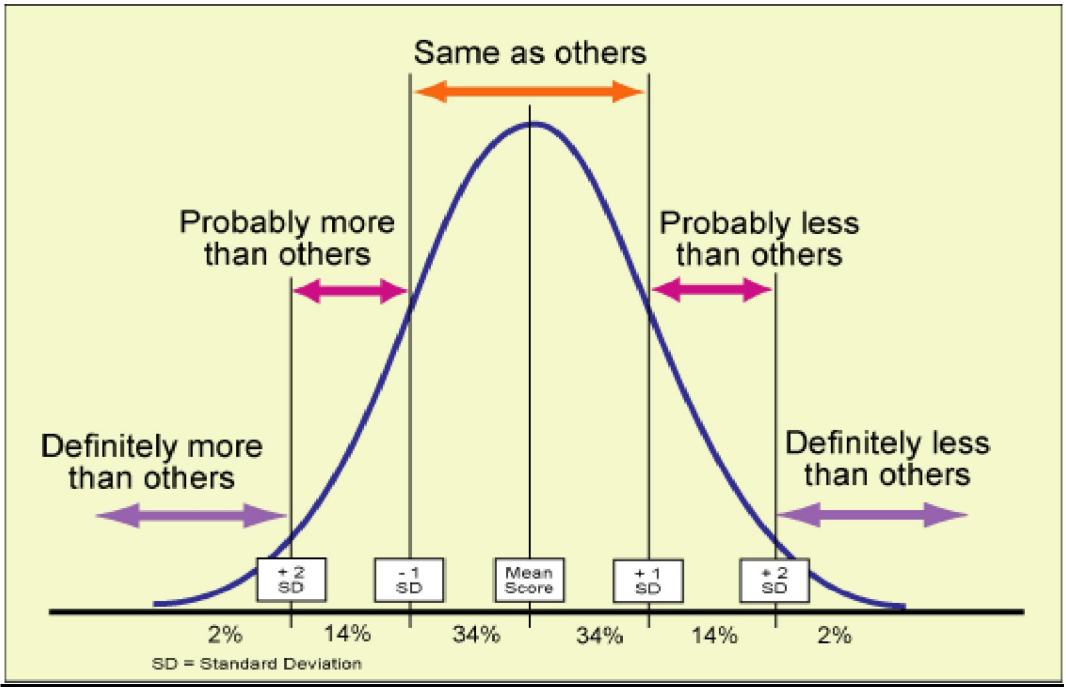
Where,

L = lower limit of modal class

f1 = frequency of modal class

f0 = frequency of class preceding modal class

f2= frequency of class succeeding the modal class



RESULT :

Calculated values of Mean, Mode and Median to be written.

ERROR :

For error values following calculations to be done

Mean – Median = ?

Mean – Mode = ?

INTERPRETATION OF RESULT :

The curve between variables and frequency is to be plotted. The curve should be bell shaped and symmetrical about the mean and normal curve should be obtained. The mean, median and mode should be calculated and if a difference is found between there values, the difference may be due to following reasons

(i) Due to non-uniform mixing of the chips
(ii) The data is actually discrete in nature
(iii) If the graph is plotted for a sample rather than the actual population

CONCLUSION :

The error occurs because the number of chips drawn from the bowl are less. For a symmetric distribution, the mean should be equal to mode and mode should be equal to median.

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QCQA LAB.

INSTRUCTION MANNUAL
For
Experiment No.2

To Draw the Normal Distribution Curve for
(i) 400 chips with replacement (ii) 400 chips without replacement

M.A.E DEPARTMENT (I.G.I.T)

QCQA LAB.

<u>EXPERIMENT NO. 02</u>

<u>AIM</u>: To collect data from Shewart's bowl and draw normal distribution curve for
(i) 400 chips with replacement ii.) 400 chips without replacement.

<u>APPARATUS</u>: Shewart's Bowl with chips.

<u>PROCEDURE</u>:

(i) <u>DATA COLLECTION</u>:

For case-1, the chips were drawn one time and then replaced and then the second one was drawn. The frequency here noted for each of the ranges as the 400 chips were drawn. For case-2, the chips were drawn one after the other without replacing the chips in the bowl. This way, 400 chips are drawn.

(ii) <u>TABULATION OF DATA:</u>

After collection and editing of data, an important step is towards the presentation. One of the simplest and most revealing devices for summarizing data and presenting them in meaningful fashion is the statistical table. A table is a systematic arrangement of statistical data in colums and rows. The purpose of a table is to simplify the presentation and to facilitate the comparisions.

(iii) <u>ANALYSIS</u> :

The frequency table is made and according to the data, Histogram and frequency curves are drawn. If a symmetric curve is obtained, this means that the curve is a normal curve and data is normally distributed. In this type of curve

(a) Mean will divide the curve into two equal parts
(b) Mean = Median = Mode

(iv) <u>CALCULATIONS</u> :

For Case-1 (with replacement) and Case- 2

(i) Mean = ∑fx / ∑f

(ii) Median = <u>L+N/2 - cf x i</u>

f

where,

L = lower limit of median class

cf = cumulative frequency of class preceding the median class

f = frequency of median class

i = class interval of median class

N = total no. of observation

(iii) Mode = $L + \frac{f1-f0}{2f1-f0-f2} \times i$

Where,

L = lower limit of modal class

f1 = frequency of modal class

f0 = frequency of class preceding modal class

f2= frequency of class succeeding the modal class

(iv) Standard Deviation

$\sigma = \sqrt{\sum fd^2/n - (\sum fd/n)^2}$

(v) Kurtosis : It refers to the degree of flatness or peakedness in the region about the mode of a frequency curve. The degree of kurtosis is measured relative to the peakedness of a normal curve. If a curve is more peaked then the normal curve it is called 'leptoburtic'; If it is more flat-topped than the normal curve, it is called platyburtic or flat topped. The normal curve itself is known as mesoburtic. It is denoted by B2.

$$B2 = \mu 4/(\mu)^2$$

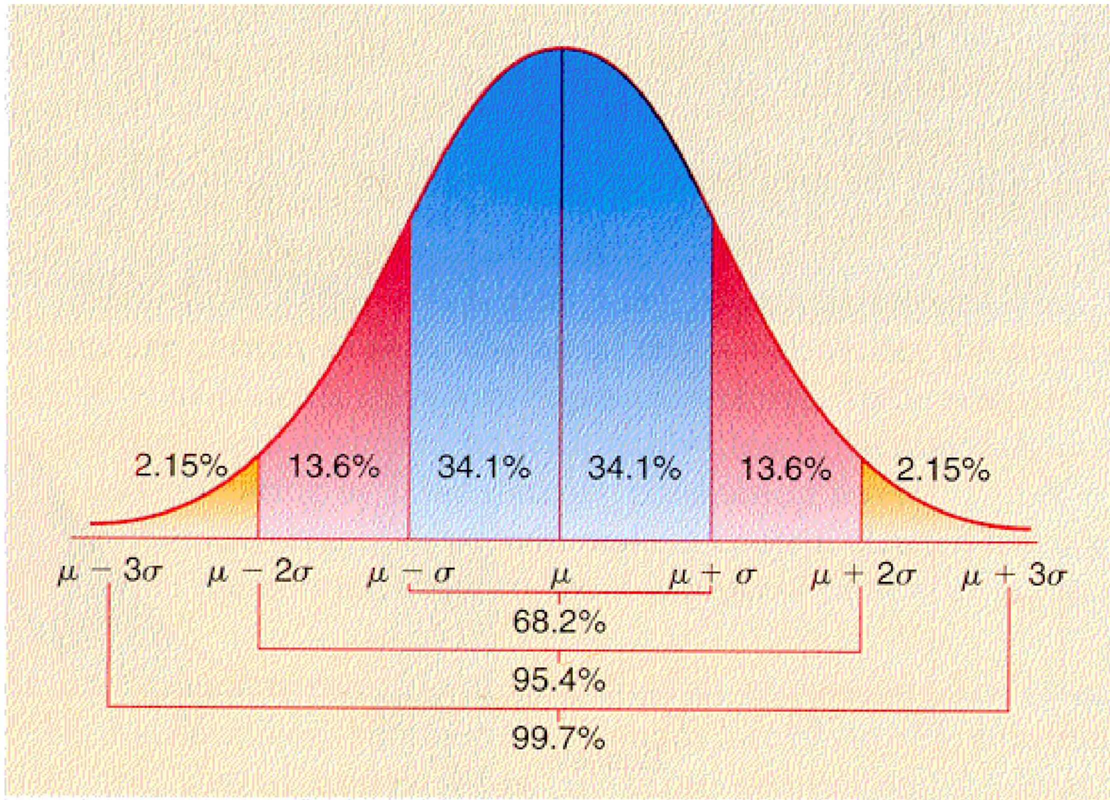
$$\mu 4 = \sum fd4/N$$

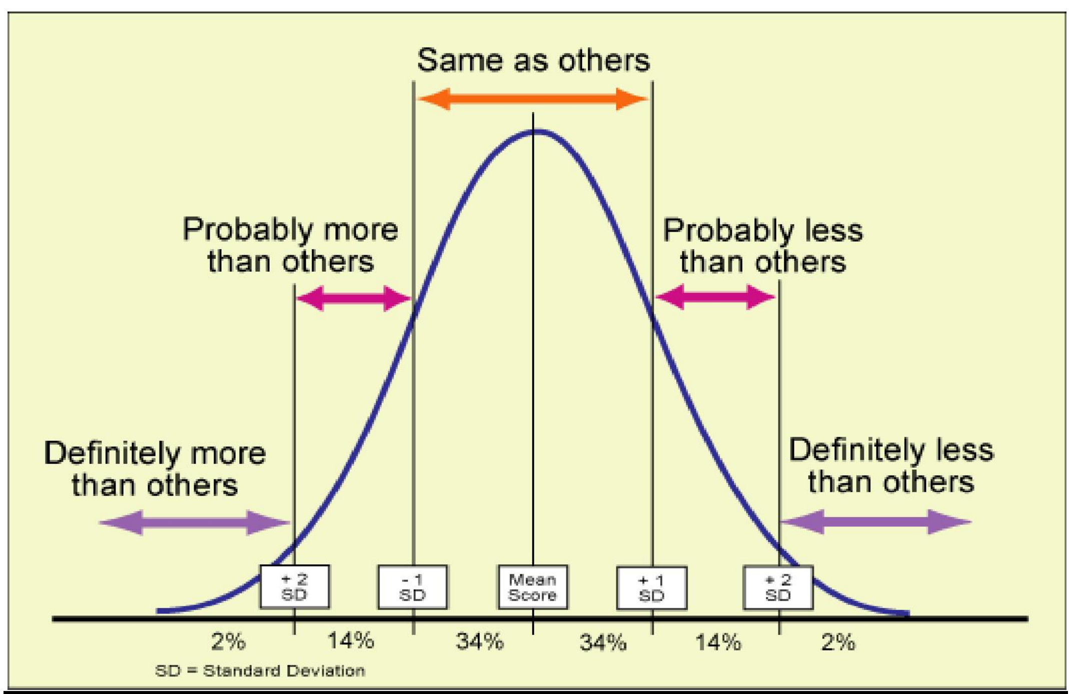
$$\mu 2 = \sum fd^2/N$$

therefore, $B2 = \mu 4/(\mu 2)^2$

(vi) Skewness : It is the derivation of curve from the normal curve

Skewness = $\frac{\text{Mean} - \text{Mode}}{\Sigma}$


2.15%
13.6%
34.1%
34.1%
13.6%
2.15%
$\mu - 3\sigma$
$\mu - 2\sigma$
$\mu - \sigma$
μ
$\mu + \sigma$
$\mu + 2\sigma$
$\mu + 3\sigma$
68.2%
95.4%
99.7%


Same as others
Probably more than others
Probably less than others
Definitely more than others
Definitely less than others
+ 2 SD
- 1 SD
Mean Score
+ 1 SD
+ 2 SD
2%
14%
34%
34%
14%
2%
SD = Standard Deviation

RESULT :

For both the cases, Values of Mean, Mode, Median, Standard Deviation, Skewness, and Kurtosis are calculated.

ERROR :

For both cases, error calculation to be done as following:

Mean – Mode = ?

Mean – Median = ?

Sources of Error :

(i) Number of chips drawn is less in case-3 as compared to case-1 and 2, so variation in result is there.

(ii) The kurtosis of case-1 and 2 are less than 3, so the curve for two cases are platoburtic and more kurtosis value of case-3 are more than 3, so curve is leptoburtic.

Conclusion :

The error in case-2 (without replacement) is more than in case-1.

Indira Gandhi Institute of Technology

Guru Gobind Singh Indraprastha University

Kashmere Gate, Delhi

Lab Manual

For

QCQA LAB.

(ETME-452)

INDIRA GANDHI INSTITUTE OF TECHNOLOGY,
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QCQA LAB.

INSTRUCTION MANNUAL
For
Experiment No.3

Draw X- Bar and R -Chart for
(i) Small subgroup size (4) (ii) Large subgroup size (15).
(Chips are drawn with replacement)

M.A.E DEPARTMENT (I.G.I.T)

QCQA LAB.

EXPERIMENT NO. 03

AIM: Draw X-Bar and R-Chart for
(i) Small subgroup size (4each), (ii)Large subgroup size (15 each).
(Chips to be drawn with replacement)

APPARATUS: Shewart's Bowl with chips.

THEORY :

The statistical tool applied in Process Control is the control chart.

Control Chart :

A Control Chart is a device principally used for the study and control of a repetitive process. In other words control chart is a graphical representation of collected information. The information may pertain to measured quantity characteristics or judged quality of samples. A control chart consists of three control lines.

(i) A central line (CL) to indicate the desired standard or level of the process.
(ii) Upper Control Limit (UCL).
(iii) Lower Control Limit (LCL).

X-Bar Chart :

The X-Bar Chart is used to show the quality averages of the samples drawn from a given process. X-Bar Chart is constructed:

(i) To obtain the mean of each sample i.e $\bar{x}_1$, $\bar{x}_2$ …………….. and then calculate $\bar{\bar{x}} = \sum \bar{x}/n$,
Where n = no. of samples

(ii) To calculate the control limits
U.C.L = $\bar{\bar{X}} + A_2\bar{R}$
L.C.L = $\bar{\bar{X}} - A_2\bar{R}$

R-Chart :

The R-Chart is used to show the variability or dispersion of the quality produced by a given process. The importance of R-Chart depends on the type of production process. The R-Chart is generally used with $\bar{X}$-Chart.

The required value for constructing R-Chart are:

(i) The range of sample R

(ii) The mean of sample $\bar{R}$

(iii) Calculate the control limits

U.C.L = $D4\bar{R}$

L.C.L = $D3\bar{R}$

Control charts for variables are often given or found to be more economical means of controlling quality than control charts based on attributes.

Procedure :

Steps for Data Collection

(i) Take Shewart's bowl having 998 chips

(ii) Shuffle the chips well and draw 4 chips at a time.

(iii) Draw 4 chips at a time, replace them and again 4 chips are drawn. In total, 4 chips are drawn 10 times in such manner.

(iv) Tabulation is done and calculations done as per the formulae given above.

Interpretation :

To provide maximum homogeneity within subgroups, the size of subgroup should be as small as possible. However four or give is most commonly accepted subgroup size, on statistical grounds. The distribution of $\bar{X}$ is nearly normal for subgroup of four or more. Even though the samples are taken from a normal universe, This fact is helpful in interpretation of control chart limits.

Larger subgroups such as 10 or 20 are some times advantageous when it is desired to make the control chart sensitive to small variations in the process average. The larger sample will cause the limits of a control chart to be closer to control limits line on the chart (control limits will become narrower), and it becomes easy to detect small variations.

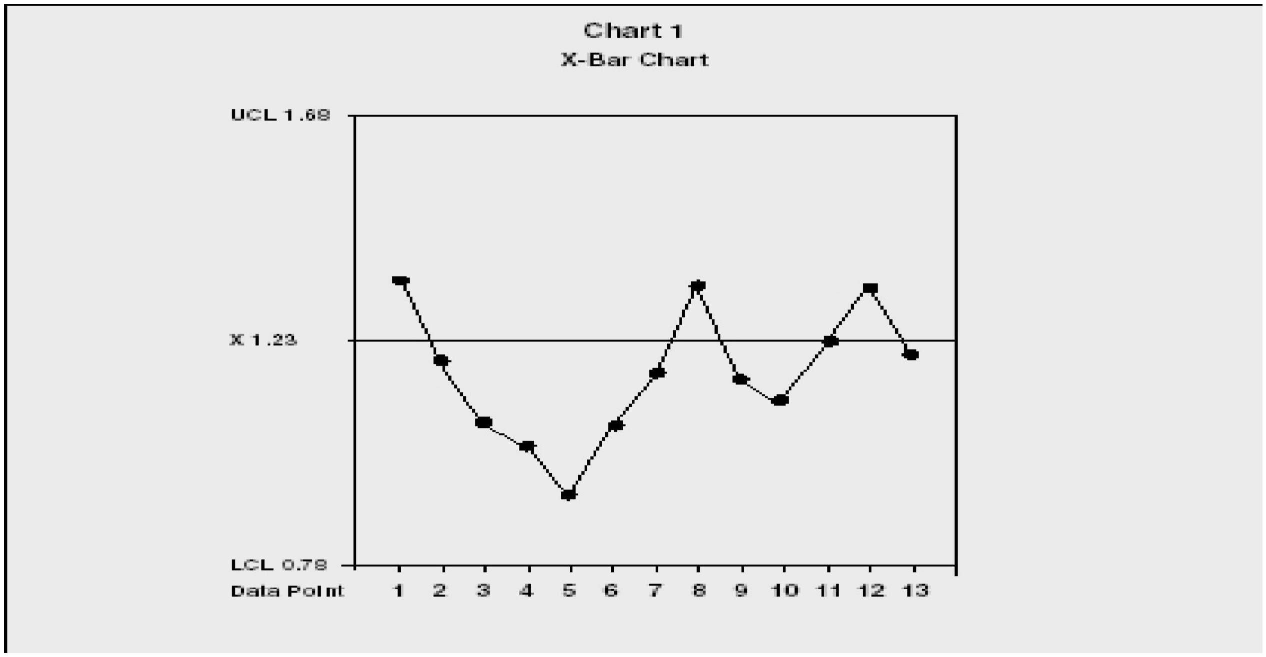
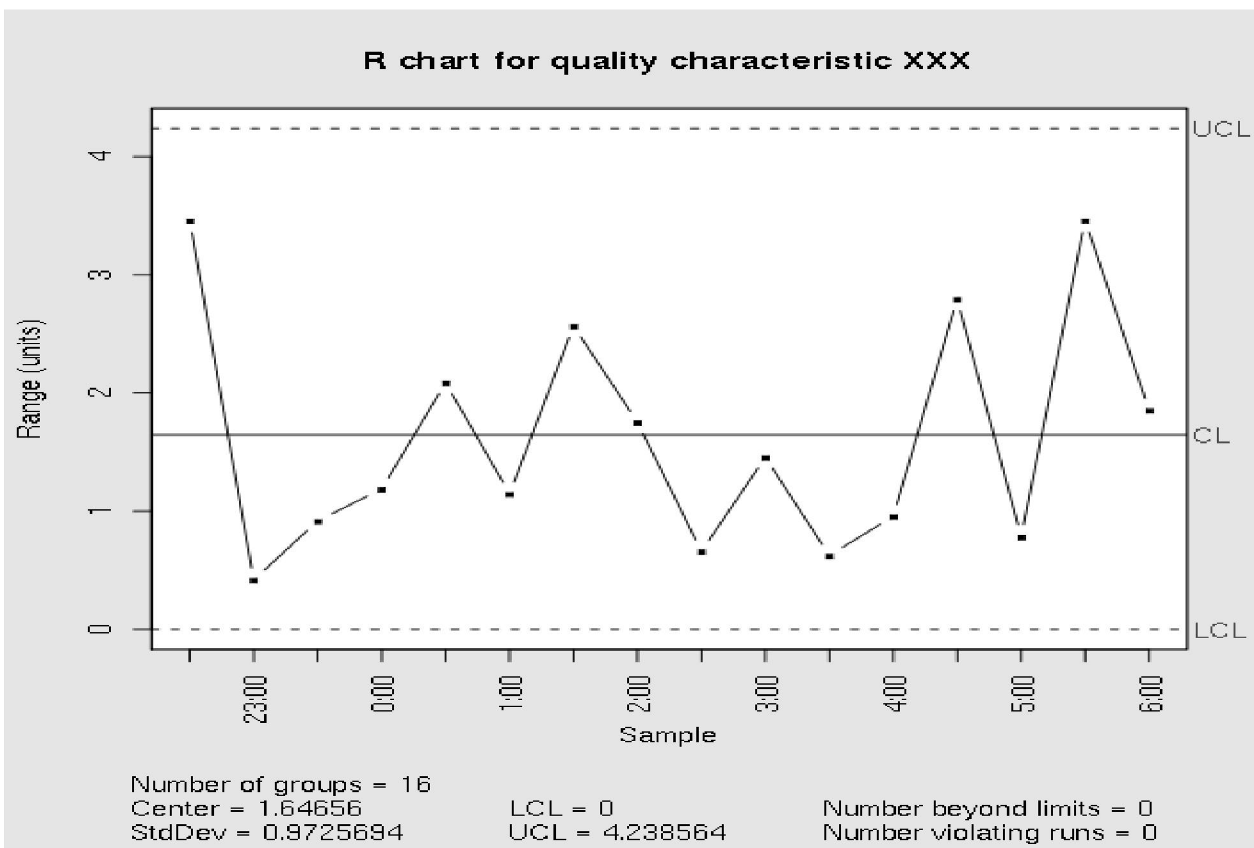


Chart 1
X-Bar Chart
UCL 1.68
X 1.23
LCL 0.78
Data Point
1 2 3 4 5 6 7 8 9 10 11 12 13


R chart for quality characteristic XXX
Range (units)
0 1 2 3 4
UCL
CL
LCL
23:00 0:00 1:00 2:00 3:00 4:00 5:00 6:00
Sample
Number of groups = 16
Center = 1.64656
StdDev = 0.9725694
LCL = 0
UCL = 4.238564
Number beyond limits = 0
Number violating runs = 0

<u>Sensitivity of Control Charts</u> :

The $\bar{X}$-Chart for subgroup size 4 shows some points near the center line and few points far away. Size 15 shows most of the points are near the center line and only one or two points are some far from the center line which indicates natural pattern to exist.

Natural Pattern is indicative of a process that is in control, i.e they demonstrate the presence of a stable system of common cause.

As most of the points are near the centre line in $\bar{X}$-Chart for subgroup size 15, Than the $\bar{X}$-Chart for subgroup size 4, it shows that the subgroup size 15 on $\bar{X}$-Chart indicates a stable system of common causes.

The R-Chart for subgroup size 4 shows less variations as compared to R-Chart for subgroup size 15. This shows that as the subgroup size increases, there is tendency of variation in the system.

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INSTRUCTION MANNUAL
For
Experiment No.4

Draw X-Bar and R-Chart for given data (75 subgroups of size 4 each, without replacement) & Detect lack of control in the chart

M.A.E DEPARTMENT (I.G.I.T)

QCQA LAB.

EXPERIMENT NO. 04

AIM: i. Draw X-Bar and R-Chart for given data (75 subgroups of size 4 each, without replacement)
ii. Detect lack of control in the chart.

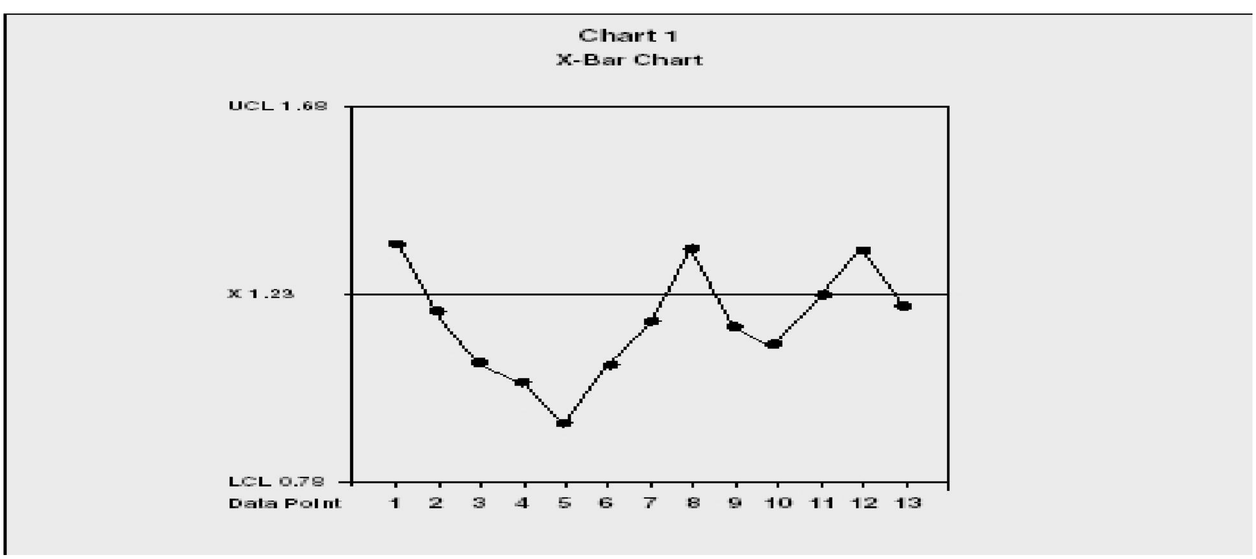
APPARATUS: Shewart's Bowl with chips.

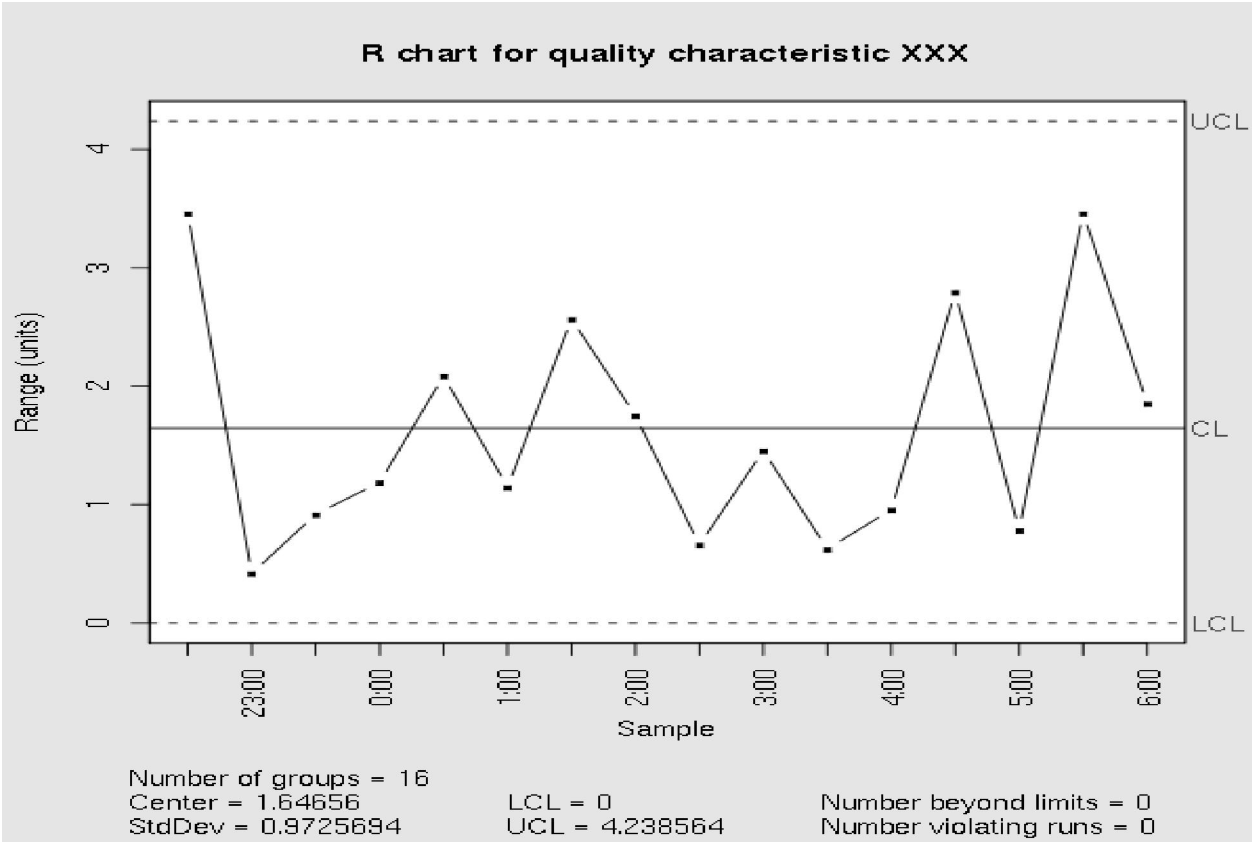
PROCEDURE :

The given data are the rating of resistance of the order of 90.00. Given values are two digits after the decimal. Conduct the study by following given steps.

(i) Comments on the process, by plotting $\bar{X}$ and R values on the charts.
(ii) Is there any shift observed with subgroup collection on $\bar{X}$,R and σ- charts.
(iii) The three charts are plotted
$\bar{X}$ is calculated for:
- X-Chart
- R-Chart
- σ- Chart

(iv) In this way the data is studied.





Analysis :

(i) To provide maximum homogeneity within subgroups, the size of subgroup should be as small as possible. However four or give is most commonly accepted subgroup size, on statistical grounds. The distribution of $\bar{X}$ is nearly normal for subgroup of four or more. Even though the samples are taken from a normal universe, This fact is helpful in interpretation of control chart limits.

(ii) Larger subgroups such as 10 or 20 are some times advantageous when it is desired to make the control chart sensitive to small variations in the process average. The larger sample will cause the limits of a control chart to be closer to control limits line on the chart (control limits will become narrower), and it becomes easy to detect small variations.

(iii) This is because the standard deviation of P,$\bar{X}$, or R varies inversely with $\sqrt{n}$.

Hence the larger the sample size, the smaller the standard deviation, and the closer 3σ limits will be the central line on the chart.

However, if the cost of measurement is quite high then it may be necessary to use smaller sample size of two or three.

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INSTRUCTION MANNUAL
For
Experiment No.5

To Find the trial and Final Control Limits for a Control Chart & Analyze the Control of Process by the given procedure

M.A.E DEPARTMENT (I.G.I.T)

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EXPERIMENT NO. 05

AIM: To Find the Trial and Final Control Limits for a Control Chart and Analyze the control of process by the given procedure.

APPARATUS: Given data

DAY	BOLTS OF CLOTH PRODUCED / INSPECTEN(ni)	NO. OF IMPERFECTIONS(ci)
1	20	27
2	20	23
3	20	30
4	21	38
5	22	34
6	18	37
7	16	19
8	23	33
9	28	54
10	20	34
11	22	30
12	23	42
13	13	22
14	19	15
15	22	13
16	22	8
17	19	12
18	23	19
19	25	22
20	26	21

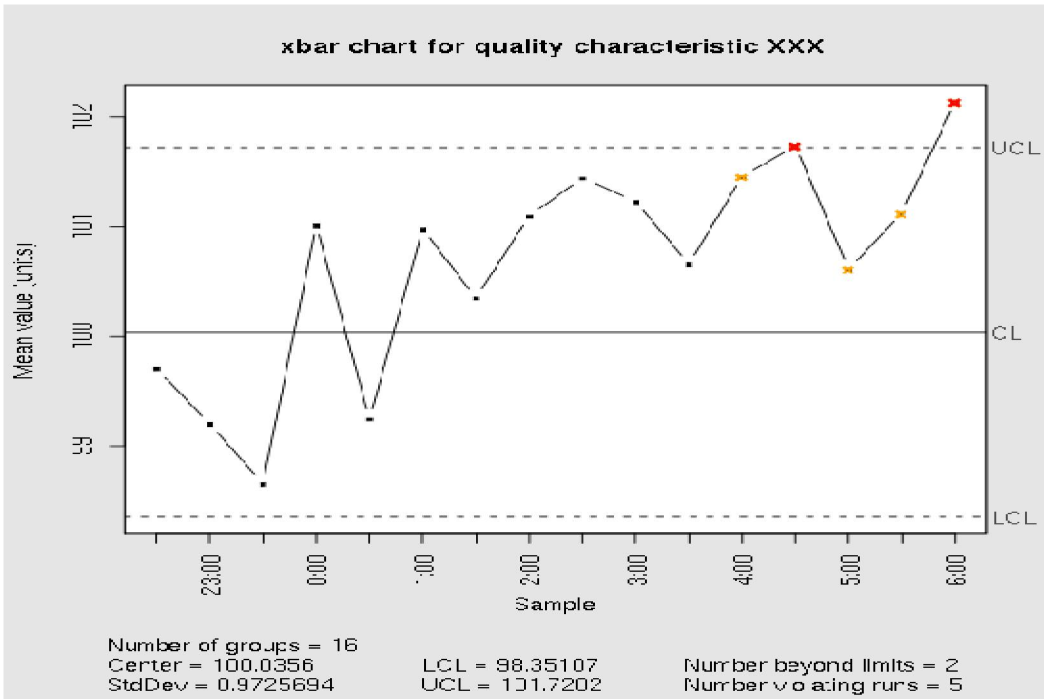
THEORY :

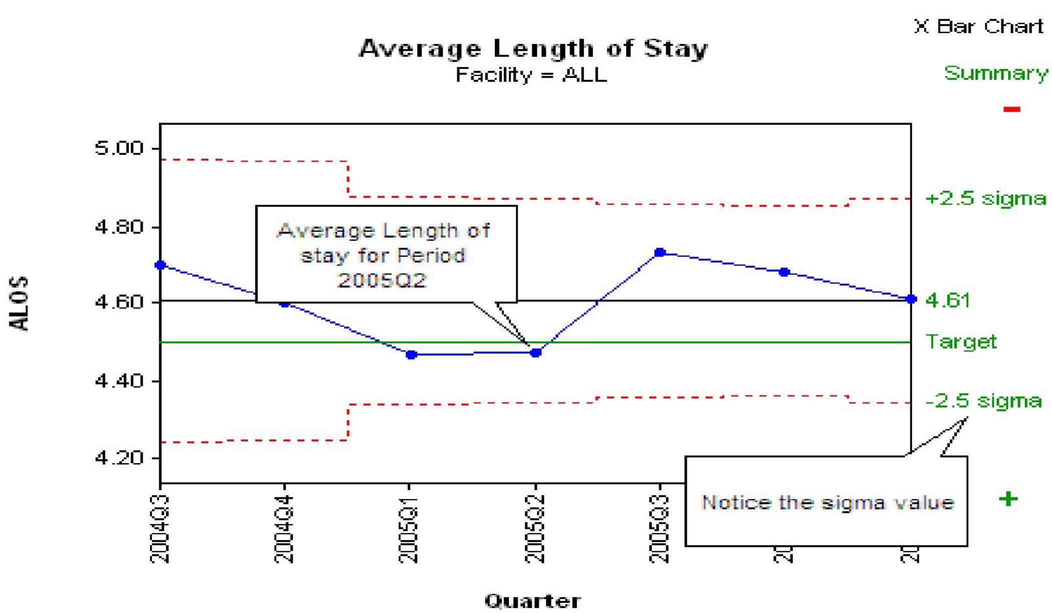
An attribute is a quality characteristics for which a numerical value is not specified. It is measured on a nominal scale; that is, it does or does not meet certain guidelines. There are three categories, p-chart, c-chart and μ-chart.

The first category includes control chart that focus on proportions, the proportion of non conforming items (p-chart) and the number of non conforming items (np-chart). These are based on binomial distribution.

The second category deals with 3 charts that focus on the non conformity itself. The chart for the non conformities per unit (u-chart) is applicable to situations in which the size of samples.

The third category, u-chart deals with combining non-conformities on a weighted basis.





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INSTRUCTION MANNUAL
For
Experiment No.6

To Conduct Process Capability Analysis using given data and tabulate Results in given format & To analyze the case and draw conclusions

M.A.E DEPARTMENT (I.G.I.T)

QCQA LAB.

EXPERIMENT NO. 06

AIM: To Conduct Process Capability Analysis using given data and tabulate Results in given format & To analyze the case and draw conclusions

APPARATUS: Given data

THEORY :

Process Capability: Process Capability may be applied and defined as the minimum spread of a specific measurement variation which will include 99.7% of the measurement from the given process. "No two products can be produced hundred percent identical ", this law holds good for mass production. Every process is set to give a desired value of concerned parameters. Process Capability is maximum spread of variation of a process parameter about the central value on both sides. Central Value may be different from aimed at value as it is determined from the distribution of dimensions produced by the process. Total spread of the variation is called the Process Capability of the process.

Process Capability Analysis: It is the act of comparing the Process Capability of a process with its permissible tolerance or specification limits. As a result of this comparison, process capability may be found equal to, less than, or greater than the permissible tolerance.

GIVEN DATA :

A process of making ignition keys for automobiles consists of trimming and pressing of raw key blanks, cutting grooves, and plating. Measurements of a critical groove dimension are tabulated here. Due to high volume of production, 20 samples of 5 keys each are collected at an interval of 20 minutes. Table shows the data of measurement of groove thickness.

SUB GROUP NO.	MEASUREMENT OF GROOVE THICKNESS IN INCHES, n=5 TAKEN AFTER 20 MINS.				
1	0.0061	0.0084	0.0076	0.0076	0.0044
2	0.0088	0.0083	0.0076	0.0074	0.0059
3	0.0080	0.0080	0.0094	0.0075	0.0070
4	0.0067	0.0076	0.0064	0.0071	0.0088
5	0.0087	0.0084	0.0088	0.0094	0.0086
6	0.0071	0.0052	0.0072	0.0088	0.0052
7	0.0078	0.0089	0.0087	0.0065	0.0068
8	0.0087	0.0094	0.0086	0.0073	0.0071
9	0.0074	0.0081	0.0086	0.0083	0.0087
10	0.0081	0.0065	0.0075	0.0089	0.0097
11	0.0078	0.0098	0.0081	0.0062	0.0084
12	0.0089	0.0090	0.0079	0.0087	0.0090
13	0.0087	0.0075	0.0089	0.0076	0.0081
14	0.0084	0.0083	0.0072	0.0076	0.0069
15	0.0074	0.0091	0.0083	0.0100	0.0071
16	0.0069	0.0093	0.0064	0.0078	0.0064
17	0.0077	0.0089	0.0091	0.0060	0.0064
18	0.0089	0.0081	0.0073	0.0091	0.0079
19	0.0081	0.0090	0.0086	0.0087	0.0080
20	0.0074	0.0084	0.0092	0.0074	0.0103

PROCEDURE :

i) Tabulate the data in a format shown in table and calculate mean and range of each group.

ii) Calculate grand mean ($\bar{\bar{X}}$) and mean of all values of ranges ($\bar{R}$), these will act as central values.

iii) Find the values of D3,D4,D5 and A2 for n=5 from the statistical tables.

iv) Find the Control Limit on R-Chart as UCL = $D4\bar{R}$ and LCL = $D3\bar{R}$

v) Find Control Limits on $\bar{X}$-Chart as $\bar{\bar{X}} \pm A2\bar{R}$

vi) Plot the $\bar{X}$ and R-Charts for trial control limit by taking values of $\bar{X}$ and R on Y- axis and sample number on X-axis. The central line on both the charts is solid horizontal line. Upper and lower limits are shown as dashed horizontal lines.

vii) Draw $\bar{\bar{X}}$ and R chart by plotting the points on it and calculate the control limits for further use.

To conduct Process Capability analysis, follow the steps given below:

i) Find Standard Deviation of population as $\sigma = \bar{R}/d2$

ii) Find the value of k as, $k = \left[\left\{\frac{USL+LSL}{2}\right\} - \bar{\bar{X}}\right] / [(USL - LSL)/2]$

iii) Find $CP = (USL - LSL) / 6\sigma$ and $CPk = (1-k)\ Cp$

iv) Find percentage defective going out side LCL, UCL total by following the steps given below :

To find the area under normal distribution curve from x1to x2……

a) Find randomized variables z1 and z2 as given below

$Z1 = (X1 - \bar{\bar{X}}) / \sigma$

$Z2 = (X2 - \bar{\bar{X}}) / \sigma$

b) Find area under normal distribution curve from statistical table and draw normal distribution curve.

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INSTRUCTION MANNUAL
For
Experiment No.7

(a) The step by step procedure for constructing the OC Curve for a Single Sampling Plan and
(b) To draft the OC Curve of the single sampling plan for n= 300 and c= 5

M.A.E DEPARTMENT (I.G.I.T)

QCQA LAB.

EXPERIMENT NO. 07

AIM OF EXPERIMENT:

(*a*) Explain the step by step procedure for constructing the OC curve for a single sampling plan.

(*b*) Draft the OC curve of the single sampling plan

$$n = 300, \ c = 5.$$

APPARATUS: Given data

THEORY & CONSTRUCTION OF OC CURVE :

The step by step method for constructing the OC curve for a single sampling plan is as follows :

1. Set up table headings and the P_a column as follows :

n	np'	p'	P_a	$P_a \cdot p'$
			0.98	
			0.95	
			0.70	
			0.50	
			0.20	
			0.05	
			0.02	

where, n = sample size
np' = number of defectives
p' = fraction defective
P_a = probability of acceptance
$P_a \cdot p'$ = AOQ = Average Outgoing Quality.

The chosen values of P_a will give ordinate values which, when co-ordinated with p' values to be derived, will facilitate construction of an OC curve.

2. Search Table G, (Appendix) under the given np' value until the desired P_a (or closest value to desired P_a) is located.

(If the exact value is not found, the value in the P_a column should be changed to correspond with the one selected).

3. Place the np' value associated with the selected P_a in the np' column.

4. Divide the np' value by n. This will give the p' co-ordinate of P_a for the OC curve.

(*b*) To draft the OC curve for the single sampling plan, $n = 300$, $c = 5$.

1. Table construction

n	np'	p'	P_a	$P_a \cdot p'$
300			0.98	
300			0.95	
300			0.70	
300			0.50	
300			0.20	
300			0.05	
300			0.02	

2. Finding np' and p'

Search through Table G, (Appendix) under $np' = 5$ discloses P_a value of 0.983. This is the closest value to 0.98. The np' value associated with a P_a value of 0.983 is 2.0. This value of np', when divided by $n = 300$ gives p' value of 0.0067. The same procedure is followed for each of the other P_a values until the table is computed.

n	np'	p'	P_a	$P_a \cdot p' = AOQ$
300	2.0	0.0067	0.983	0.0065
300	2.6	0.0087	0.951	0.00827
300	4.4	0.0147	0.72	0.0106
300	5.6	0.0187	0.512	0.00957
300	7.8	0.025	0.210	0.00526
300	10.5	0.035	0.05	0.00175
300	12.0	0.04	0.02	0.0008

The $P_a.p'$ column is provided to give the necessary values for the graphing of an AOQ curve with p' being the abscissa and $P_a.p'$ the ordinate.

Fig. (*a*) and (*b*) shows both of these curves as plotted from the data of the table above.

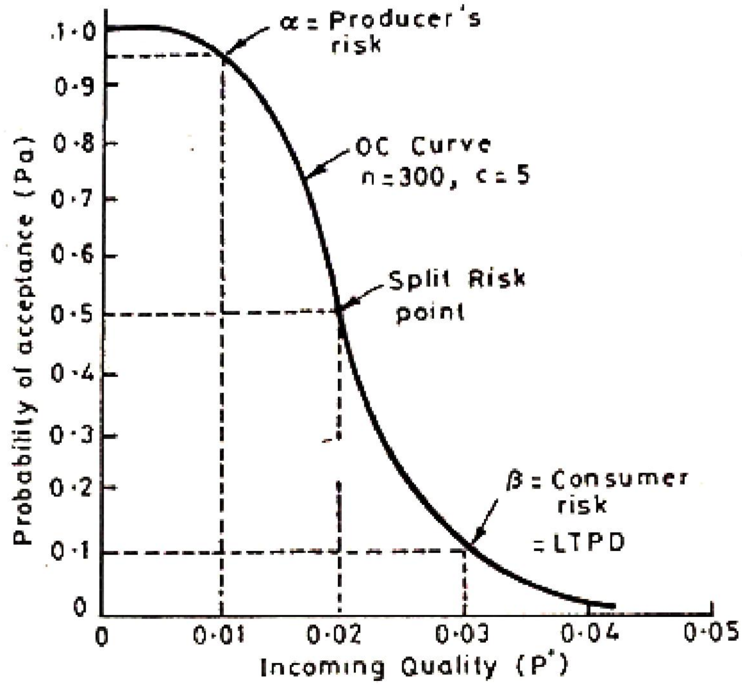
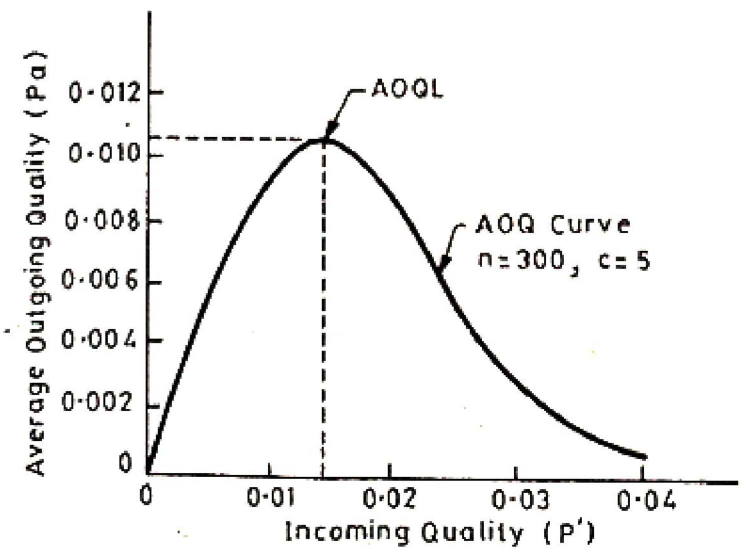


Fig. 10.10.



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INSTRUCTION MANNUAL
For
Experiment No.8

To Determine the required SQC Parameters (Probability of Acceptance of Lot and AOQ) from given data

EXPERIMENT NO. 08

AIM: To determine the required SQC Parameters (Probability of Acceptance of Lot and AOQ) from given data

Data Given is :

A single sampling plan is given as $N = 10{,}000$, $n = 100$ and $c = 2$.

(*a*) Compute the approximate probability of acceptance of lots with 1% defective (use Poisson).

(*b*) Determine the AOQ value for the above lots.

(*c*) What will be the average inspection in per cent ? (Assume acceptance, rectification plan).

APPARATUS: Given Data

PROCEDURE : Considering the above data Following are the steps of calculating required SQC Parameters

$$np' = 100 \times 0.01 = 1.$$

From Table *G*, probability of 2 or less defective

$$= 0.920$$

$\therefore$ Probability of acceptance of lot

$$= 92\%.$$

(*b*)
$$AOQ = P_a . p'$$
$$= 0.92 \times 0.01 = 0.0092.$$

(*c*) Total inspection of say 100 lots

= 100 articles each in 92 lots + 10,000 articles in 8 lots

$$= 9200 + 80{,}000 = 89{,}200$$

Total average percentage inspection

$$= \frac{89,200}{100 \times 10,000} \times 100 = 8.9\%.$$