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Inventory

→ Inventory is the stock of any item or resources that are used in any organisation. It may be defined as stock in hand at a given time and it may be held for the purpose of later use or sale.

→ It is a useable but idle resource having an economic value & it may include Raw materials, work in process inventory, semi-finished inventory or finished goods.

Examples

- Raw materials used in production.
- Finished goods (item ready for sale / distribution)
- Unfinished goods (goods which are in-process)
- Stock of finished goods (to handle escalation in customer demands)
- Spares of critical equipment to ensure continuity of production.

Inventory control

→ Inventory control is defined as the process of maintaining company's stock at optimum level to meet customer demands with minimum inventory costs.

→ Inventory control help in continuity of supplies during cuts and shortages.

→ Inventory control maintain balance between (b/w) out of stock and over stock.

Classification of inventory →

- Raw materials inventory
- Stores and spares
- Works in process inventory
- Finished goods inventory

1. Raw material inventory →

→ The unprocessed material which is used to create finished goods. For example: wood is used as raw material to make table, chair, etc. similarly leather is used as raw material to make bags, shoes, belts, car covers etc.

2. Stores and Spares →

→ This includes those products which are accessories to the main products produced for the purpose of sale. examples of stores and spares are bolts, nuts, clamps, screws, etc. These spare parts are generally bought from outside.

3. Work in Process inventory →

→ The materials and components which starts their transformation to finished goods.

→ state of material between raw material and final product.

4. Finished goods inventory →

→ Finished goods are the products which have completed their production process and ready for sale.

→ Raw material is completely transformed into new shape and form.

* Objectives of inventory control →

→ Minimize inventory costs.

→ Inventory forecasting & optimization

→ Minimize inventory wastage (obsolete & expire items)

→ Investment decisions (invest on best selling items)

→ To protect against inflation.

→ Gain discounts from bulk purchases.

Functions of inventories

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- To ensure smooth production.
- To minimize capital investment.
- To helps in minimising loss by obsolescence, damage, wastage, theft etc.
- To protect against the uncertainties of demand and supply.
- To decouple operations
- To protect against stock-outs
- To take advantages of order cycles.
- To help hedge against price increases.
- To permit operations.
- To take advantages of quanity discounts.

Benefits of inventory control →

- It improves customer relations because of the timely delivery of goods and services.
- Maintain the right level of inventory that ensure smooth and uninterrupted production.
- Efficient utilization of working capital.
- Forecasting for short-term and long-term stock.
- Help to know Real-time inventory levels.

Cost associated with inventory.

Economic order quantity. (EOQ)

- Whenever you entered in shopping mall & you see there is huge stock of multiple items.
- Did you think that the only cost associated with inventory or stock is purchase cost ? No, you are wrong.
- There are some other costs like carrying or handling cost or stock-out cost.

* Inventory costs is divided into three categories.

1. ordering cost
2. carrying cost
3. shortage or stock-out cost

* Inventory cost:

Inventory cost is defined as the cost incurred over procurement, storage & management of inventory.

→ Huge cost is associated with inventory procurement or purchasing, inventory handling or storage & inventory management.

ordering costs →

→ ordering cost is also named as setup cost.

→ ordering cost is the cost incurred while procuring. inventory. ordering cost include.

→ cost of inventory purchase
⇒ cost of administering procurement
⇒ cost of inbound logistic
⇒ Receiving cost

- cost of electronic data interchange
- cost of finding suppliers & placing supply orders.
- ordering cost depends on two factors.
- cost of ordering excess & cost of ordering less
- ordering excess will increase carrying cost while ordering less will increase replenishment cost.
- Total stocking cost (TSC) = cost of ordering excess + cost of ordering less.
- There is a need to balance between ordering excess and ordering less.

Carrying cost →

- carrying cost is also named as holding cost.
- carrying cost is the cost incurred over inventory storage and management.
- storage could be either in the organization's own warehouse or the third party warehouse.

carrying cost include →

- Administrative cost over inventory record keeping.
- opportunity cost of the money invested in the inventory.
- storage space cost (building rent, ventilation, lighting etc.)
- Handling cost (equipment required for movement of inventory, labor etc.)
- Depreciation cost (inventory may damage while handling, chemical changes etc.)
- Inventory Risk cost (loss of inventory, theft, fraud etc.)
- obsolescence cost (inventory may obsolete)
- insurance cost (to secure inventory from loss & theft or flood etc.)
- Taxes
- Inventory financing cost.

Shortage cost ⇒

⇒ Shortage cost is also named as stock-out cost.

⇒ Shortage cost or stock-out cost & cost of replenishment is incurred when businesses becomes out of stock due to unusual circumstances.

⇒ Shortage cost include :

⇒ Disrupted production cost (fixed cost increased due to non working of human resource.

⇒ Emergency shipment cost (Paying extra for shipment in less time or on time.

⇒ Customer Loyalty & Reputation cost.

Terminology in inventory control.

1. ⇒ Demand ⇒ It is the number of products required per unit of time. The demand may be either deterministic or probabilistic.

2. ⇒ Order cycle ⇒ The time period between two successive order is called the order cycle.

3. ⇒ Lead time ⇒ The length of time between placing an order & receipt of the item is called Lead time.

4. Safety stock ⇒ It is also called buffer stock or minimum stock. It is the stock or inventory needed to account for delays in materials supply and to account for a sudden increase in demand due to rush order

5. Inventory Turnover → If the company maintains inventories equal to 3 months consumption. It means that inventory turnover is 4 times a year. i.e. the entire inventory is used up and replaced 4 times a year.

6. Re-order level → It is the point at which the replenishment action is initiated. When the stock level reaches Re-order level the order is placed for the Product.

7. Re-order quantity → This is the quantity of material (items) to be ordered at the reorder level. Normally this quantity equals the economic order quantity.

Economic order quantity (EOQ)

→ EOQ is the optimum quantity of goods to be purchased at one time in order to minimize the annual total costs of ordering and carrying or holding items in-ventory.

$$EOQ = \sqrt{\frac{2 \times D \times S}{H}}$$

D = Annual demand (units)

S = Cost per order ($)

C = Cost per unit ($)

I = Holding cost in (%)

H = Holding cost ($) = I × C

Q) Sowemand needs 1000 coffee makers per year. The cost of each coffee maker is $78. ordering cost is $100 per order. carrying cost is 40% of per unit cost. what is the optimal order quantity ?

$D = 1000$ coffee makers

$S = 100\ \$$

C = cost per unit $= 78\ \$$

$I = 40\%$

$H = I \times C = 78 \times \frac{40}{100} = 31.2$

$$EOQ = \sqrt{\frac{2 \times D \times S}{H}} = \sqrt{\frac{2 \times 1000 \times 100}{31.2}}$$

$$= 80.06$$

ABC Analysis

→ Value based system of a material control. In this technique, material are analysed according to their value so that costly and more valuable materials are given greater attention and care.

→ Always better control method.

'A' Items →

→ Most important items in stock, having high financial value, few in numbers, high sales volume.

→ 'A' Items need careful and close inventory control.

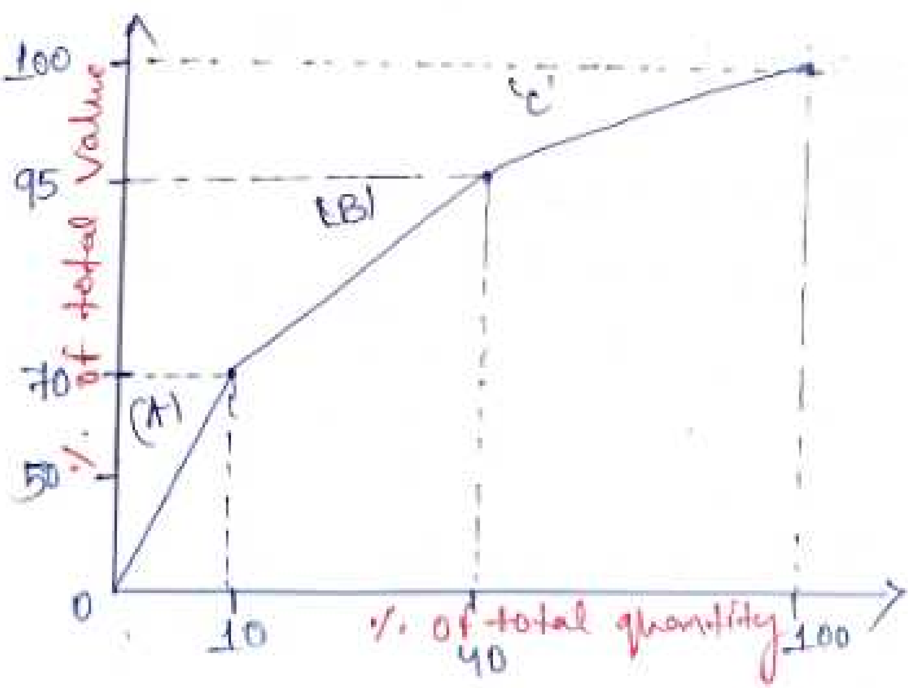
'B' items

⇒ Mid-level category, slightly tighten control required with good accuracy of records.
⇒ Item in class-B are greater in number than class-A but less in value.

'C' items

⇒ Least important items in stock, having low financial value, high in numbers. Simplest control required with minimum records.

category	% of total value	% of total quantity	Type of control
A	70 %	10	Strict
B	25 %	30	moderate
C	5 %	60	loose
Total	100	100	



Inspection and Quality control

* Inspection ⇒ Inspection is a method to identifies defects.

⇒ Inspection is defined as a process used to controlling and checking the quality of products as per quality standard.

⇒ In other words inspection means checking the acceptibility or manufacture product.

⇒ Product quality may be specified by its strength, hardness, shape, surface finish, dimensions etc.

Need & Importance of Inspection

⇒ To detect and remove the faulty raw materials before it undergoes Production.

⇒ Inspection separates defective components from non defective ones and thus ensures the proper quality of products.

⇒ To measure process capability.

⇒ To measure the precision of the measuring instrument.

⇒ Inspection prevents further work being done on semi finished products already detected as spoiled.

⇒ Inspection makes sure that the product works & it works without hurting any body i.e. the operation is safe.

⇒ Inspection builds up the reputation of the concern as it helps reducing the number of complains from the customers.

Types of inspection

1. Floor inspection
2. centralized inspection
3. combined inspections
4. functional inspection
5. first piece inspection
6. Pilot piece inspection
7. final inspection

1. Floor inspection

⇒ In this system, the inspection is performed at the place of production.

⇒ It suggests the checking of materials in process at the machine or in the production time by patrolling inspections.

⇒ These inspections move from machine to machine and from one to the other work centres.

⇒ Inspectors have to be highly skilled. This method of inspection minimize the material handling, does not disrupt the line layout of machinery and quickly locate the defect and readily offers field and correction.

2. Centralized inspection

⇒ Inspection is carried in a central place with all testing equipment, sensitive equipment is housed in air-conditioned area. samples are brought to be inspection floor for checking. centralised inspection may locate in one more places in the manufacturing industry.

3. Combined inspection.

- combination of two methods whatever may be the method of inspection, whether floor or central.
- The main objective is to locate and prevent defect which may not repeat itself in subsequent operation to see whether any corrective measure is required and finally to maintain quality economically.

4. Functional Inspection

- This system only checks for the main function the product is expected to perform.
- Thus an electrical motor can be checked for the specified speed and load characteristics.
- It does not reveal the variation of individual parts but can assure combined satisfactory performance of all parts put together. Both manufacturers and purchasers can do this, if large number of articles are needed at regular intervals. This is also called assembly inspection.

5. First Piece inspection.

- First piece ~~inspection~~ of the shift or lot is inspected. This is particularly used where automatic machines are employed.
- Any discrepancy from the operator as machine tool can be checked to see that the product is within control limits.
- Excepting for need for precautions for tool wo are check and disturbance in machine setup, this yields good result if the operators is careful.

6. Pilot Piece inspection.

⇒ This is done immediately after new design or product is developed. Manufacturer of product is done either on regular shop floor if production is not disturbed.

⇒ If production is affected to a large extent, the product is manufactured in a pilot plant.

⇒ This is suitable for mass production and products involving large number of components such as automobiles aeroplanes etc and modification are design or manufacturing process is done until satisfactory performance is assured or established.

7. Final Inspection

⇒ This is also similar to functional or assembly inspection. This inspection is done only after completion of work. This is widely employed in process industries where there is not possible such as.

· electroplating or anodizing products.

⇒ This is done in conjunction with incoming material inspection.

Quality control → (QC)

⇒ QC is a process of detecting and correcting defects or errors in products or services after they have been produced.

⇒ This is achieved by implementing testing and correct any issues that arise. QC involves reactive measures to identify and correct problems after they occur.

* Advantages and disadvantages of quality control!

Advantages

1. It can help to prevent faulty goods and services being sold.
2. It is not disruptive to production - workers continue producing, inspectors do the checking
3. As with any quality system, the business may benefit from an improved reputation for quality and this may increase sales

Disadvantages

1. It does not prevent waste of resources when products are faulty
2. The process of inspecting the goods or service costs money, e.g. the wages paid to the inspectors, the cost of testing goods in the laboratory.
3. It does not encourage all workers to be responsible for quality.

Study of factors influencing the quality of manufacture ⇒

There are many factors which influence the quality of manufacture.

1. Raw material ⇒ The quality of finished products basically depends up the incoming raw material. for a quality product, the raw material should be of fine quality.

2. <u>Skilled manpower</u>

→ Skilled manpower is needed to produce a quality work.

3. <u>Machinery and equipment</u>

→ Modern machinery like C.N.C machine, automatic machines, semi-automatic machines etc are required for the best quality of manufactured product.

4. <u>Process</u>

→ The process adopted should be right and according to the requirement.

5. <u>Design</u>

→ Sometimes, the quality is affected by the design of product. so the design should be simple in nature.

5. <u>Purpose</u>

→ Quality varies according to the requirement. for a precision work the quality desired is high and for general purpose work, the quality may be a little bit lesser. So it depends upon the purpose for which the product is manufactured.

Statistical quality control → (SQC)

→ A quality control system performs inspection, testing and analysis to conclude whether the quality of each product is as per laid quality standards or not. It is called statistical quality control when statistical techniques are employed to control quality or to solve quality control problems.

→ SQC makes inspection more reliable and at the same time less costly.

→ The fundamental basis of SQC is the theory of probability. According to the theories of probability. The dimensions of the component made on the same machine and in one batch vary from component to component. This may be due to inherent machine characteristics or the environmental conditions.

→ Relying itself on the probability theory, SQC evaluates batch quality and controls the quality of processes and products.

* Control chart

→ It is a graphical presentation of the collected information. The information present is to measure quality characteristic of the items of the system.

→ Control charts can be used to monitor processes where output is measured as either variables or attributes.

Advantages of control chart →

- A control chart indicates whether the process is in control or out of control.
- It determines process variability and detects unusual variations taking place in a process.
- It ensures product quality level.
- It warns in time, and if the process is rectified at that time, scrap or percentage rejection can be reduced.
- It provides information about the selection of process and setting of tolerance limits.

Types of control charts.

Control charts

- Variables
  - $\bar{X}$ charts
  - R charts
  - σ chart
- Attributes
  - p-chart
  - C-chart
  - np-chart
  - U-chart

⇒ Control charts are based on attributes or variables. In other words, quality can be controlled either through actual measurement (dimension, weight, strength etc.) or through attributes (as yes or no criteria).

→ A comparison of variables and attribute charts is given below

Variables charts involve the measurement of the job dimensions and an item is accepted or rejected if its dimension are within or beyond the fixed tolerance limits, where as an attribute chart only differentiates between a defective item and a non-deffective item without going into the measurement of its dimensions.

→ Variables charts are more detailed and contain more information as compared to attribute charts.

→ Attribute charts, being based upon go and nogo data require comparatively bigger sample size.

→ Variables charts are relatively expensive because of the greater cost of collecting measured data

$\overline{X}$ chart

→ It shows changes in Process average and is affected by changes in Process variability.

→ It is a chart for the measure of central tendency.

→ It shows cyclic shifts in the Process.

→ It detects steady Progress changes, like tool wear.

→ It is the most commonly used variables chart.

→ $\overline{X}$ and R charts when used together form a Powerful instrument for diagnosing quality Problems.

R Chart

- It controls general variability of the process and is affected by changes in process variability.
- It is a chart for measure of spread.
- It is generally used along with an $\overline{X}$ chart.

Plotting of $\overline{X}$ and R charts

- A good number of samples of items coming out of the machine are collected at random at different intervals of times and their quality characteristics are measured.

For each sample, the mean value and range is found out.

Example

If a sample contains 5 items, whose diameters are d_1, d_2, d_3, d_4, d_5.

the sample average $\overline{X} = \dfrac{d_1+d_2+d_3+d_4+d_5}{5}$

and

Range (R) = maximum diameter − minimum diameter

Sample no. (sample size - 5)	$\overline{X}$	$\overline{R}$
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
	$\Sigma\overline{X} = 42.0$	$\Sigma R = 12$

$$\bar{\bar{X}} = \frac{\Sigma \bar{X}}{\text{No. of samples}} = \frac{12}{5} = 2.5$$

$$\bar{R} = \frac{\Sigma R}{\text{no. of samples}} = \frac{12}{5} = 2.4$$

* **For $\bar{X}$ chart**

upper control limit

$$UCL = \bar{\bar{X}} + A_2\bar{R}$$

Lower control limit

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$

* **For R chart**

upper control limit (UCL) = $D_4\bar{R}$

Lower control limit (LCL) = $D_3\bar{R}$

→ The value of various factors (like A_2, D_4, D_3) based on normal distribution can be found from the following table.

Sample size (No. of items in a sample)	A_2 limit Average	D_3 Range lower limit	D_4 Range upper limit
2	1.88	0	3.27
3	1.02	0	2.57
4	0.72	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
8	0.37	0.14	1.86
10	0.31	0.22	1.78
12	0.27	0.28	1.72

∵ sample size is 5,

so $A_2 = 0.58$

$D_3 = 0$

$D_4 = 2.11$

so for $\bar{X}$ chart

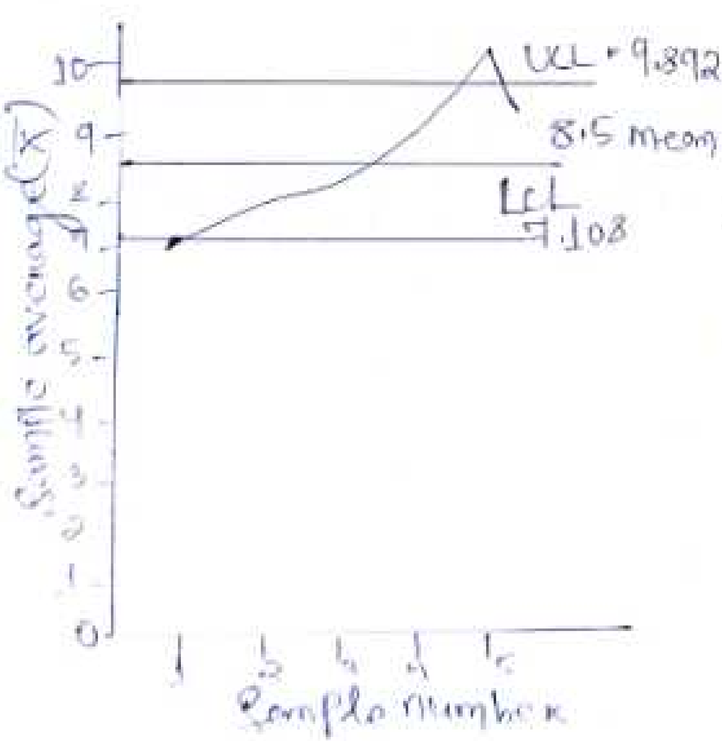
$$UCL = \bar{\bar{X}} + A_2\bar{R}$$
$$= 8.5 + (0.58 \times 2.4)$$
$$= 9.892$$

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$
$$= 8.5 - (0.58 \times 2.4)$$
$$= 7.108$$

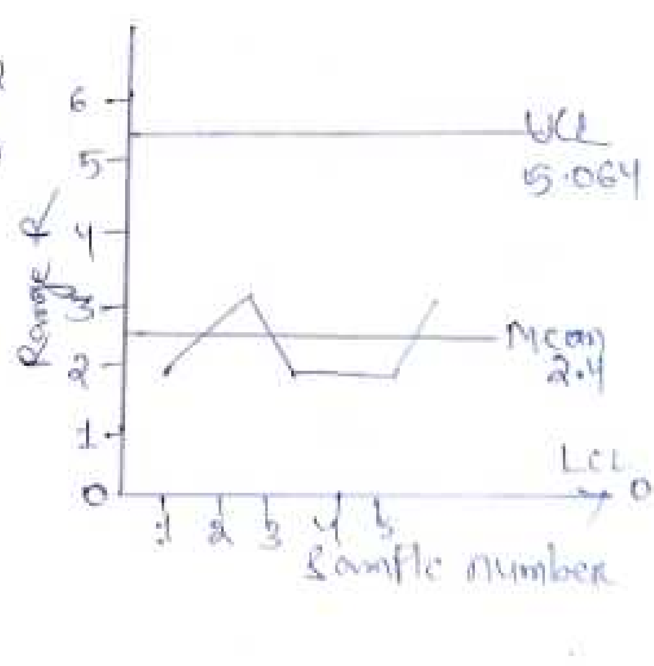
For R chart

$$UCL = D_4\bar{R}$$
$$= 2.11 \times 2.4 = 5.064$$

$$LCL = D_3\bar{R}$$
$$= 0 \times 2.4 = 0$$



$\bar{X}$ chart



R chart

P' Charts

- A P-chart is a commonly used control chart for attributes, whereby the quality characteristics is counted rather than measured. This chart is used to control the general quality of the component parts.
- It can be a fraction defective chart or % defective chart.
- Each item is classified as good or bad.

Upper control limit

$$UCL = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

lower control limit

$$LCL = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

Where $\bar{P} = \dfrac{\text{Total no. of defective pieces found } (\Sigma b)}{\text{Total no. of pieces inspected } (\Sigma a)}$

'n' = No. of pieces inspected every day.

Example

Date	No. of pieces inspected (a)	No. of defective pieces found (b)	fraction defective $P = b/a$	% defective $b/a \times 100$
1.Dec	200	15	0.075	7.5
2.Dec	200	20	0.100	10
3.Dec	200	10	0.050	5
4.Dec	200	30	0.150	15
5.Dec	200	25	0.125	12.5
	$\Sigma a = 1000$	$\Sigma b = 100$		

$$\bar{P} = \frac{\Sigma b}{\Sigma a} = \frac{100}{1000} = 0.1$$

n = no. of pieces inspected every day = 200

$$UCL = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

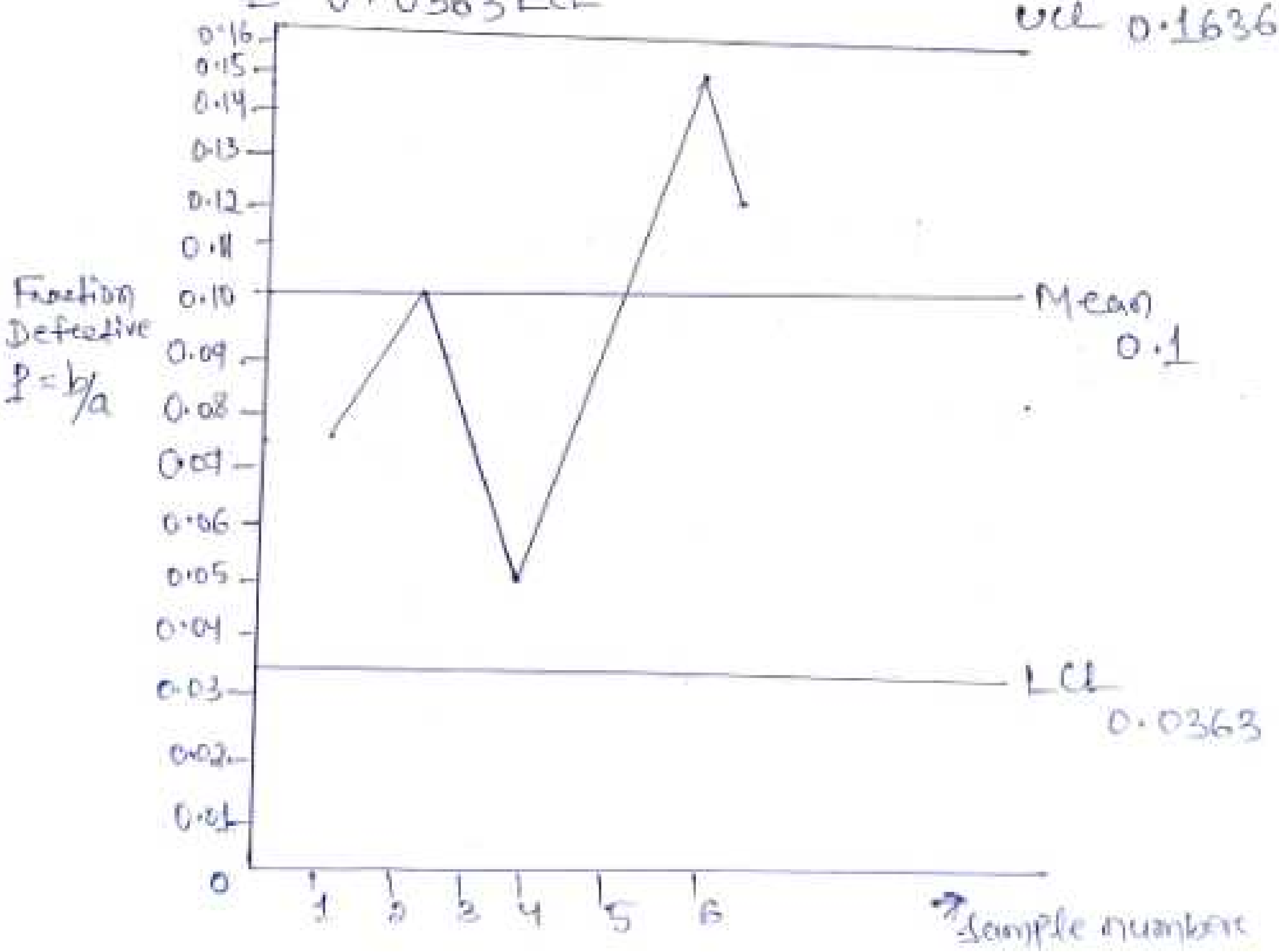
$$= 0.1 + 3\sqrt{\frac{0.1(1-0.1)}{200}}$$

$$= 0.1636$$

$$LCL = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

$$= 0.1 - 3\sqrt{\frac{0.1(1-0.1)}{200}} = 0:363$$

= 0.0363 LCL



C - Chart

→ It is the control chart in which number of defects in a piece or a sample are plotted.

→ It controls number of defects observed per unit or per sample.

→ Sample size is constant.

→ P- chart considers the number of defective pieces in a given sample, C-chart takes into account the number of defects in each defective piece or in a given sample. A defective piece may contain more than one defect.

→ The C- chart is preferred for large and complex parts.

Upper control limit

$$UCL = \bar{C} + 3\sqrt{\bar{C}}$$

Lower control limit

$$LCL = \bar{C} - 3\sqrt{\bar{C}}$$

$$\bar{C} = \frac{\text{total no. of defects found on inspection}}{\text{no. of sample}}$$

Example

casting	No. of defects found on inspection (C)
1	2
2	4
3	1
4	5
5	3
no. of sample = 5	15

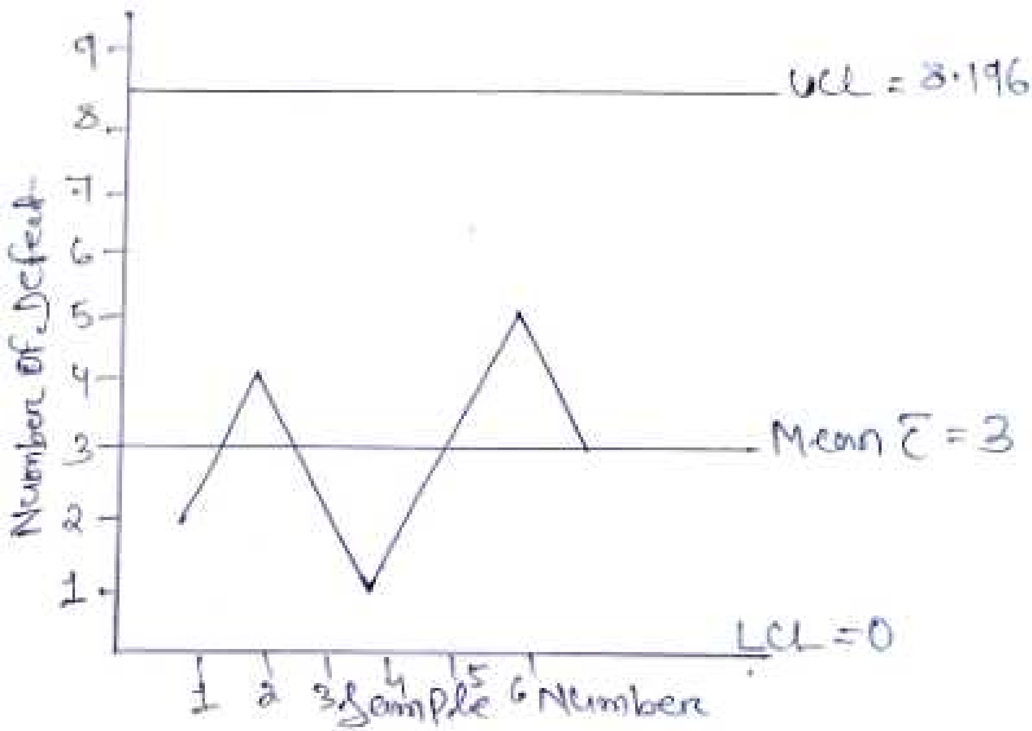
$\bar{C} = 15/5 = 3$

$UCL = \bar{C} + 3\sqrt{\bar{C}}$

$= 3 + 3\sqrt{3} = 8.196$

$LCL = \bar{C} - 3\sqrt{\bar{C}}$

$= 3 - 3\sqrt{3} = -2.196 = 0$



Exmple. Given $(A) = 40$, $(B) = 30$, $(AB) = 20$.
$N = 100$

Check the association between the A & B, α and β. A and β. α and β.

attributes	A	α	Total
B	$(AB) = 20$	$(\alpha B) = 10$	$(B) = 30$
β	$(A\beta) = 20$	$(\alpha\beta) = 50$	$(\beta) = 70$
	$(A) = 40$	$(\alpha) = 60$	$N = 100$

$\Rightarrow (AB) + (A\beta) = (A)$
$20 + (A\beta) = 40$
$(A\beta) = 40 - 20 = 20$

$\Rightarrow (A) + (\alpha) = N$
$40 + (\alpha) = 100 \Rightarrow (\alpha) = 100 - 40 = 60$

$\Rightarrow (B) + (\beta) = N \Rightarrow 30 + (\beta) = 100$
$\Rightarrow 100 - 30 = 70$

$\Rightarrow (AB) + (\alpha\beta) = (B)$
$\Rightarrow 20 + (\alpha\beta) = 30$
$\Rightarrow (\alpha\beta) = 30 - 20 = 10$

$\Rightarrow (A\beta) + (\alpha\beta) = (\beta)$
$\Rightarrow 20 + (\alpha\beta) = 70$
$\Rightarrow (\alpha\beta) = 70 - 20 = 50$

→ $(AB) = 20$

$$(AB) = \frac{(A) \times (B)}{N} = \frac{40 \times 30}{100} = 12$$

$$(AB) > \frac{(A) \times (B)}{N}$$ A, B Positive association

→ $(\alpha\beta) = 50$

$$(\alpha\beta) = \frac{(\alpha) \times (\beta)}{N} = \frac{60 \times 70}{100} = 42$$

$$(\alpha\beta) > \frac{(\alpha) \times (\beta)}{N}$$ α, β positive association

→ $(A\beta) = 20$

$$(A\beta) = \frac{(A) \times (\beta)}{N} = \frac{40 \times 70}{10} = 28$$

$$(A\beta) < \frac{(A) \times (\beta)}{N}$$ Negative association

Example $(A) = 50$, $(B) = 60$, $(AB) = 10$, $N = 100$

Find the association between A & B

$(AB) = 10$

$$(AB) = \frac{(A) \times (B)}{N} = \frac{50 \times 60}{100} = 30$$

$$(AB) < \frac{(A) \times (B)}{N}$$ Negative association

Example. In a Population of N = 200 students (A) = 20 out of (B) = 60 students and (AB) = 24. It is required to find out whether the attributes of A and B are independent.

(AB) = 24

Now. $(AB) = \frac{(A) \times (B)}{N} = \frac{20 \times 60}{200} =$

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Lecture of Mechanical.