STANDARDS & QUALITY

Lecture: 1 — Standards, quality and Maintenance — Date: 7 July 2017

①

- Six sigma
- sampling
- Quality
- Quality control tool
- Maintenance
- ISO standards
- TQM
- Inventory

• Maintenance:

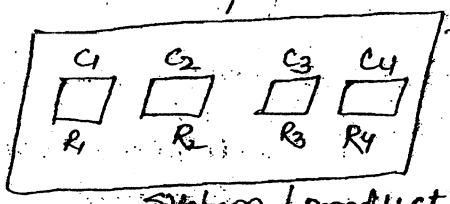
→ Reliability:

Reliability of a product, system can be defined as the probability that product will perform a required function under specific condition for certain period of time.

$R(t=0) = 100\%$ initially (without use)

→ NO product is guaranteed with 100% certainity to function properly. Whoever company know that high reliability is an imp. part of customer oriented quality and try to build it into product design.

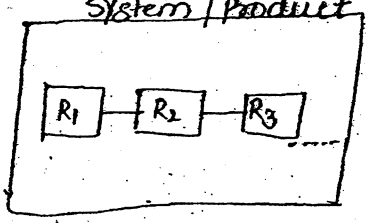
• Reliability of system is the function of reliability of its individual component.



System / product

$R(\text{system}) \propto R(\text{component})$

→ For Series Connection:



$R_S = R_1 \times R_2 \times R_3 \ldots\ldots R_n$

R_s = Reliability of system (2)

$R_1 - R_n$ = Reliability of component (1), (2) --- (n)

Example: assume that A product has 2 component both of which must work for product to function. Component (1) has the reliability of 80% and (2) has reliability of 90% the Compute the reliabity of product.

Soll.

$$R_s = R_1 \times R_2$$
$$= .80 \times 0.90$$
$$= 0.72$$

72% Reliable system.

NOTE:

1. Reliability of system is always lower than or equal to that of individual component when component connected in series.

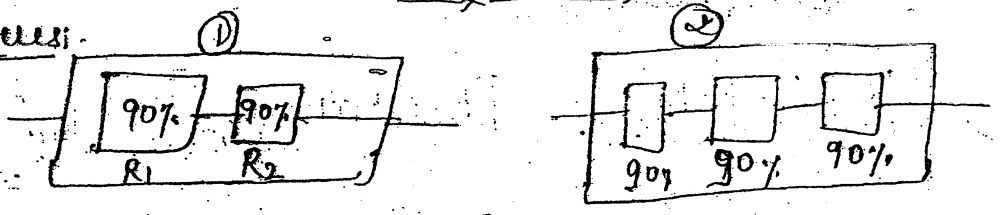
$$R_s \leq \{R_1\ R_2\ R_3 \text{ ---- } R_n\}$$

→ holds only in 2 conditions:

equality (1) Individual component make a system.

(2) Every component of system having 100% Reliability.

Ques.



$R_s = 81\%$ — $R_s = 72.9\%$

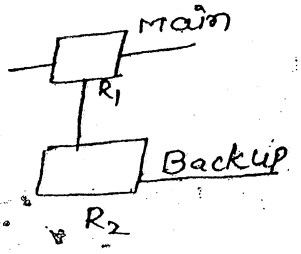
③ Note:

① As the Number of System / components in a system increase probability of system decreases. Reliability.

How to increase the reliability of a system or Product:

- one way to increase the reliability of system is to build redundancy in the form of backup part into the product design.

For parallel connection:



$$R_S = 1-(1-R_1)\times(1-R_2)$$

$$R_S = R_1+R_2-R_1R_2$$

$$R_S = R_1+R_2(1-R_2)$$

$$R_S = \{\text{Reliability of comp.①}\} + \{\text{Reliability of comp.②}\} \times \{\text{Prob. of failure of comp.①}\}$$

$$\Downarrow$$

$$\{\text{Prob. of Need of comp.②}\}$$

Example: Two power generators provide electricity to a facility that is main and backup generator. main generator Reliability = 0.95 and backup generator have reliability of 0.9 then R_S = ?

Sol: $R_S = 1-0.05\times0.1 = 1-(1-R_1)\times(1-R_2)$

$= 1-0.005 = 0.995$

99.5%

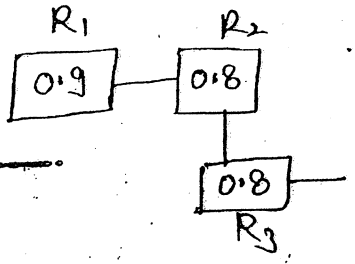
NOTE:-

(i) Reliability of the system is always greater than reliability of its individual comp. When they are connected in parallel.

$$R_s \geq \{R_1, R_2 \text{----} R_n\}$$

(ii) As the no. of backup components increases the reliability of system will increase

Example 3



$R_2, R_3 \rightarrow$ Parallel

$R_1 \sim \{R_2 R_3\} \rightarrow$ In series.

$$R_s = R_1 * (1 - (1 - R_2)(1 - R_3))$$

$$= 0.9 \times (1 - 0.2 \times 0.2)$$

$$= 0.9 \times (1 - 0.04)$$

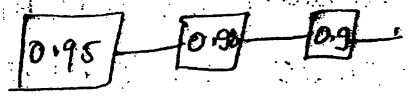
$$= 0.9 \times 0.96 = 0.864$$

86.4%

$$R_{system} = 86.4\%$$

→ Backup component have maximum value of reliability is equal to main component reliability.

Q: A central system have 3 component in series with individual reliability Given in Fig. 0.95, 0.98, 0.9. If a parallel system similar to above system is designed then compute Rs of whole system



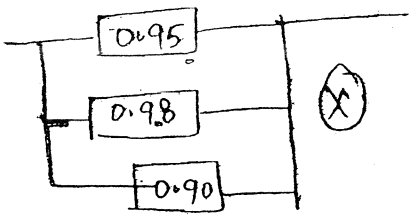
Sol:-

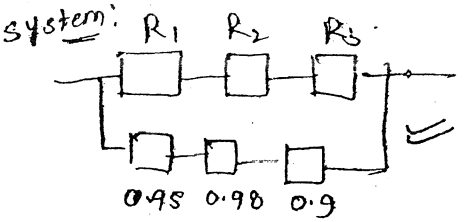
$$1 - (1-0.95)(1-0.98)(1-0.9) \quad .00010$$

$$= 1 - 0.05 \times 0.02 \times 0.10 = 0.0001$$

$$= .9999$$

(5)





$R_{S_2} = R_{S_1} = 0.95 \times 0.98 \times 0.90$

$= 0.8379$

$R_S = 1 - (1 - R_{S_1})(1 - R_{S_2})$

$= 1 - .1621 \times 0.1621 = 0.9737$

$R_S = .9737\%$

- Reliability Prediction using Exponential distribution:

It is the one of the most commonly used distribu in reliability Prediction and it is used to predict the probability of survival to a particular time.

$$R(t) = e^{-\lambda t}$$

Where t = time

λ = failure rate $= \frac{N}{t}$

R = reliability

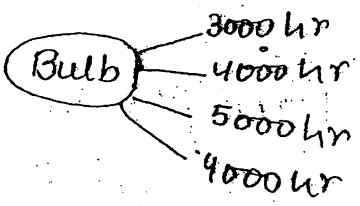
N = no of component failed during time period "t_i".

(1) MTTF: (Mean time to Failure)

It is on average time, a product may expected to function before failure.

{used for Non repairable products}

Example:



$$MTTF = \frac{3000 + 4000 + 5000 + 4000}{4}$$ (6)

$$= 4000 \text{ hrs}$$

(ii) MTBF (Mean time between failure):—

It refers to time between failures. It is used for repairable products.

$$MTBF = \frac{\text{Total device hours}}{\text{No. of failure}}$$

(iii) MTTR (Mean time to repair):

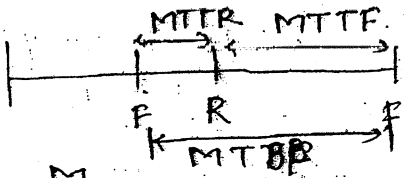
$$MTTR = \frac{t_1 + t_2 + t_3 \cdots t_N}{N}$$

Where t_1 = repair time of failure (1)

t_2 = " " " " (2)

t_N = " " " " (N)

• Relation between MTTF, MTBF & MTTR:

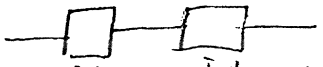


$$MTBF = MTTR + MTTF$$

$$\lambda = \frac{1}{MTTF}$$ Non repairable

$$\lambda = \frac{1}{MTBF}$$ repairable Product

Example:

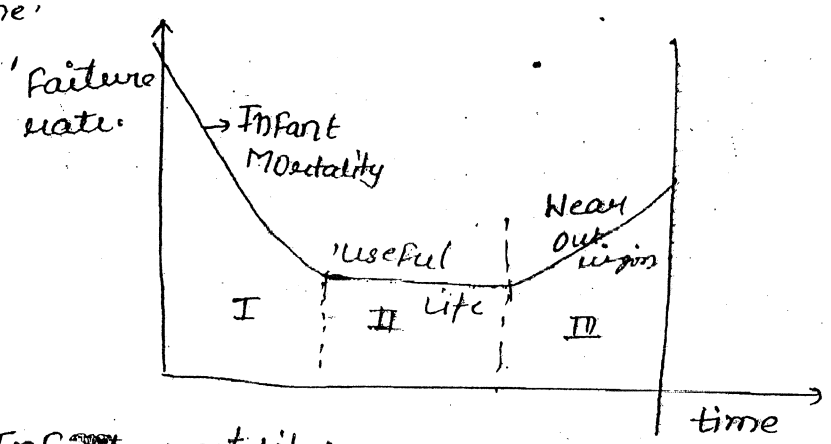


$R_s = R_1 \times R_2$

$= e^{-\lambda_1 t_1} \times e^{-\lambda_2 t_2}$.

Bathtub Curve:

Bathtub curve is a Graphical representation of life time of a population of a product. the Bathtub curve does not depict the failure rate of a single component but it describe the relative failure rate of the entire population over of product time.



→ Infant mortality:

It also known as Early failure (Debugging failure). Failure rate decrease with time. In Beginning of infant Mortality state failure rate is high and than decreases with time after early failure are removed.

Example: poor connection, Poor welding, all manufacturing errors.

→ Useful life:

It is the middle stage of the bath tub curve. Failure rate is const. in this region. It is the most significate state for reliability predictions.

→ Wear out life:

It is the final stage of Bathtub curve. the failure rate increases as the product begain to wear out because of lack of maintenance or age of prod.

Types of Maintenance: (8)

① Reative Maintainance (Breakdown maintenance)

Reative maintenance basically runs it till its break no action or Effort are taken to maintain the equipment as the designer originally indented to ensure that designed life is treached.

② Preventive Maintenance:

Routine servicing on a plan schedule to prevent Failure.

③ Predictive Maintenance:

Timely replacement of component based on the condition monitoring before they cause any break down.

—x—x—x—

Chapter 2 Sampling

Sampling is a technique in which a sample is drawn at random and on the basis of this sample it is decided to accept and reject the lot.

Inspection:
- ① 100% inspection
- ② sampling inspection

→ 100% inspection:
- Generally very expensive.
- Handling by inspection induce defect.
- Can not used while product destroyed during inspection.

② Sampling inspection:

N = lot size
n = sample size
C = Acceptance No.

(N) ⟹ (n) → 100% Inspection

found

(i) d = No. of defeat ≤ Acceptance No → Accept the lot.

(ii) d = No. of defeat ≥ Acceptance No. → Reject the lot.

Sampling involve some risk:

① Good lot is rejected — Producer risk
② Bad lot is accepted — Consumer risk

—x—x—x—

• Acceptance sampling:

- It is an important field of SQC (Statistical quality control.
- on the basis of random sample, a lot is accepted or rejected.
- It is popularized by Dodge and Roming.
- It was originally applied by US military for testing of built during World war-II.
- It also known as "the middle of the road."

Types:

① Acceptance sampling for attributes
② " " " Variables

A.S. for attributes	A.S. for Variable.
↓ Countable data	↓ Measurable data
- It is based on "Go gauge" and "No Go gauge".	- It is also known as continuous measurement.
- A sample is taken and it contain ≥ many non conforming	- It is usually measured By Mean and standard

Product then batch is rejected otherwise it is accepted	deviation. (10)

Sampling plan:—

The most important element of acceptance sampling is choosing an appropriate sampling plan that specify lot size, sample size, No. of sample and acceptance rejection criteria.

Types of sampling plan:

① Single sampling plan
② Double sampling ,, — Triple sampling (X)
③ Multiple ,, ,, /sequencial sampling plan.

① Single sampling plan:

When the decision of acceptance or rejection of a lot is made on the bases of 1 sample. then acceptance sampling plan is called single sampling plan.

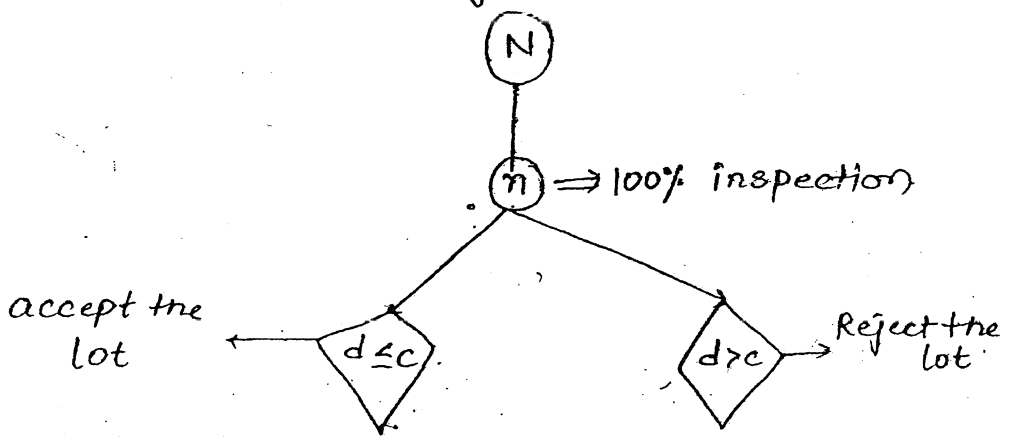
N = lot size
n = sample size
c = acceptance No.
d = No. of defeat

Rule:

① $d \geq c \Rightarrow$ Reject the lot
② $d \leq c \Rightarrow$ Accept the lot

Flow chart for single sampling plan:

(11)



(ii) Double sampling plan:

In double sampling plan, the decision of acceptance or rejection of the lot may be on the basis of "2" sample.

N = lot size

n_1 = size of First sample

n_2 = " " second " "

$n_1 + n_2$ = " " Both combined sample

c_1 = acceptance NO. for First sample.

c_2 = " " Both combined sample

d_1 = NO. of defect in First sample

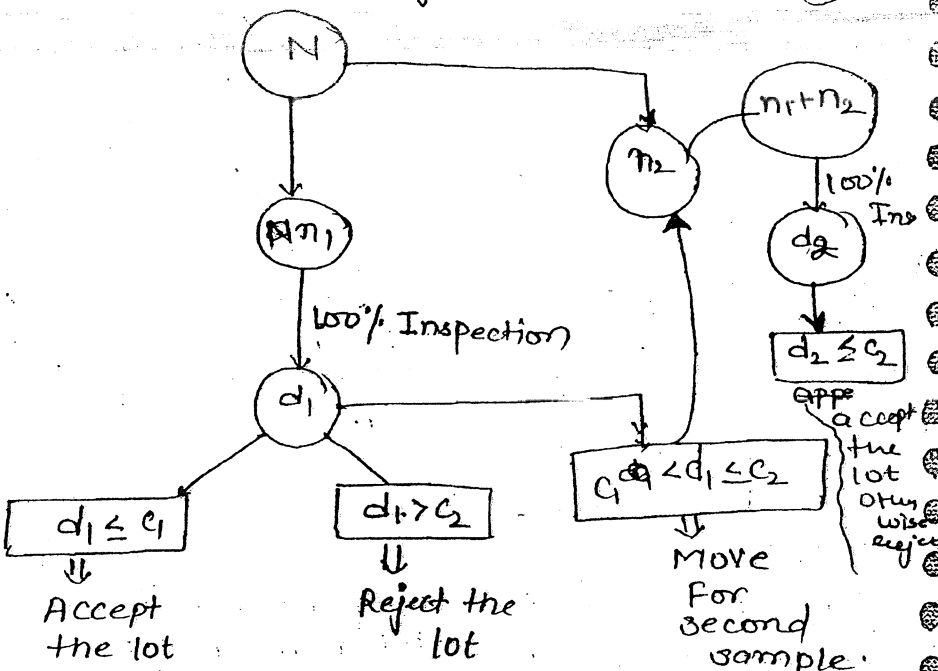
d_2 = NO. of defect in Both combined sample.

Rule:

1. $d_1 \leq c_1$ ⇒ Accept the lot
2. $d_1 > c_2$ ⇒ Reject the lot
3. $d_1 > c_1$ and $d_1 \leq c_2$ ⇒ Move for second sample.

Flow chart for double sampling plan.

(12)



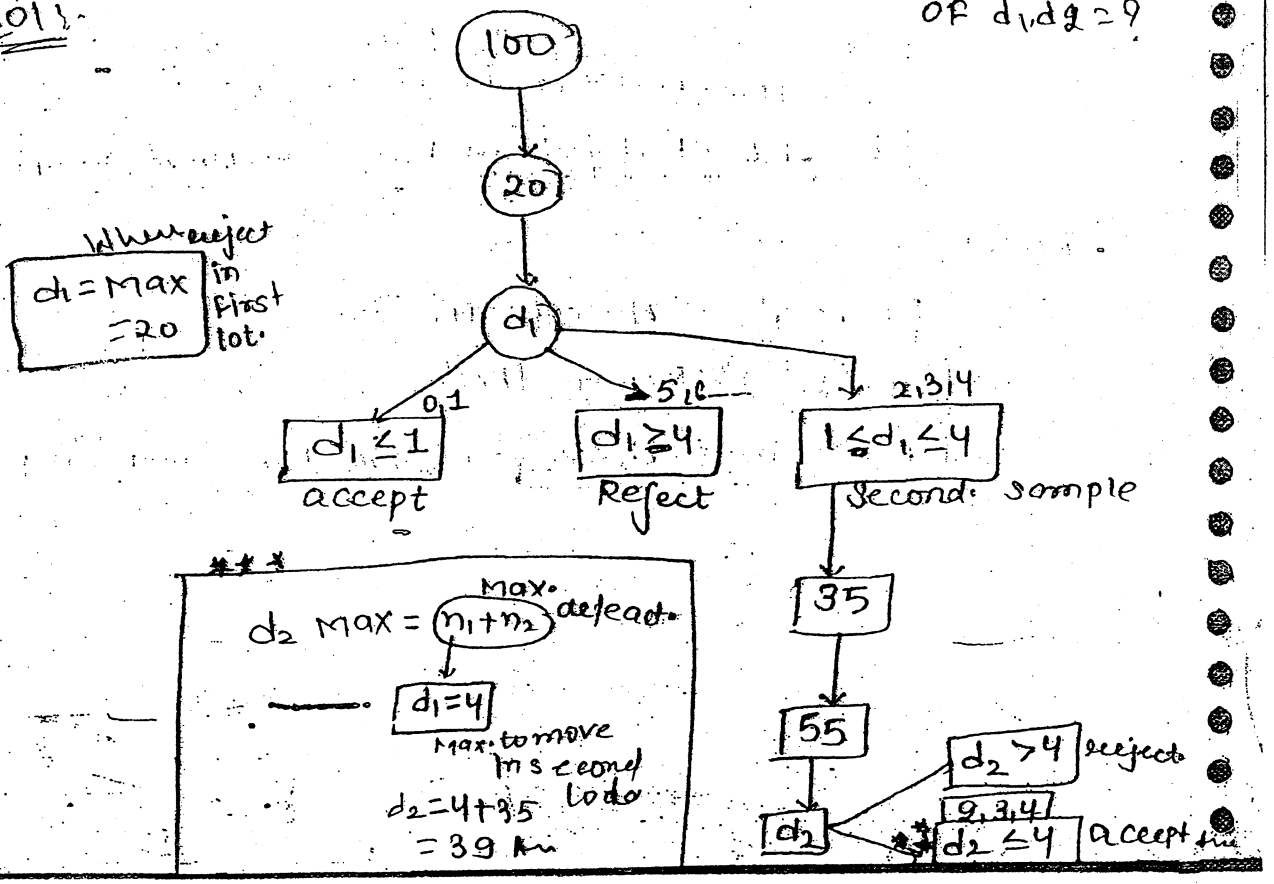
—x—x—x—

Ques: N = 100, n_1 = 20, n_2 = 35, c_1 = 1, c_2 = 4

Flow chart = ?

Possible values of d_1, d_2 = ?

Sol:



(B) Sampling term:

(I) AQL: (Acceptance quality level):
The (%) of defect at which consumer are willing to accept the lot as "Good".

Example:- NO Electricity 15 mint. in a day.
-Newspaper Not delivered 5 times in a year.

—x—x—x—

(II) RQL: (Rejectonee quality level): (LTPD):- lot toterance % defective):—
The upper limit on the (%) of defect that consumer is willing to accept.

—x— x—

(III) Producer risk:
It represent the probability that lot containing the acceptonee quality level will be rejected.
→Good lot rejected — Type one error.
→"α" (denoted by α)
→It is 5% common)

—x—x—

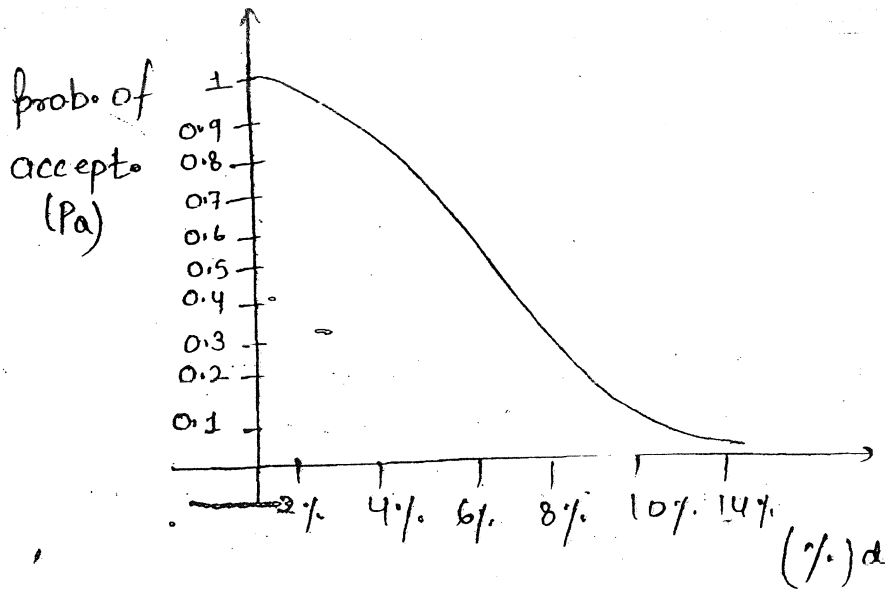
(IV) Consumer risk:
It represent the probability that lot containing the defective exceeding the [LTPD/RQL] will be accepted.
-A bad lot is accepted
— Consumer risk
— Type-II error
— denoted by β.
— It is 10% common.

—x—x—x—

OC curve:
OC curve is the Graph of % defective (P) in a lot or in a batch Verses the probability that sampling plan accepted the lot.

OC curve :- (Operating Characteristic curve)

(14)



Probability of Acceptance (Pa):

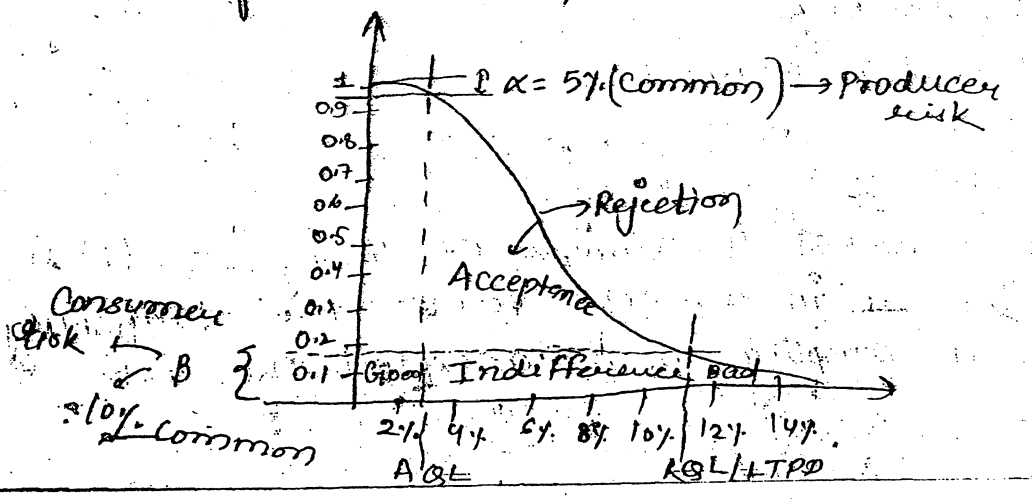
$$Pa = \sum_{d=0}^{d=c} {}^{n}C_{d} (P)^{d} (1-P)^{n-d}$$

Probability of rejection:

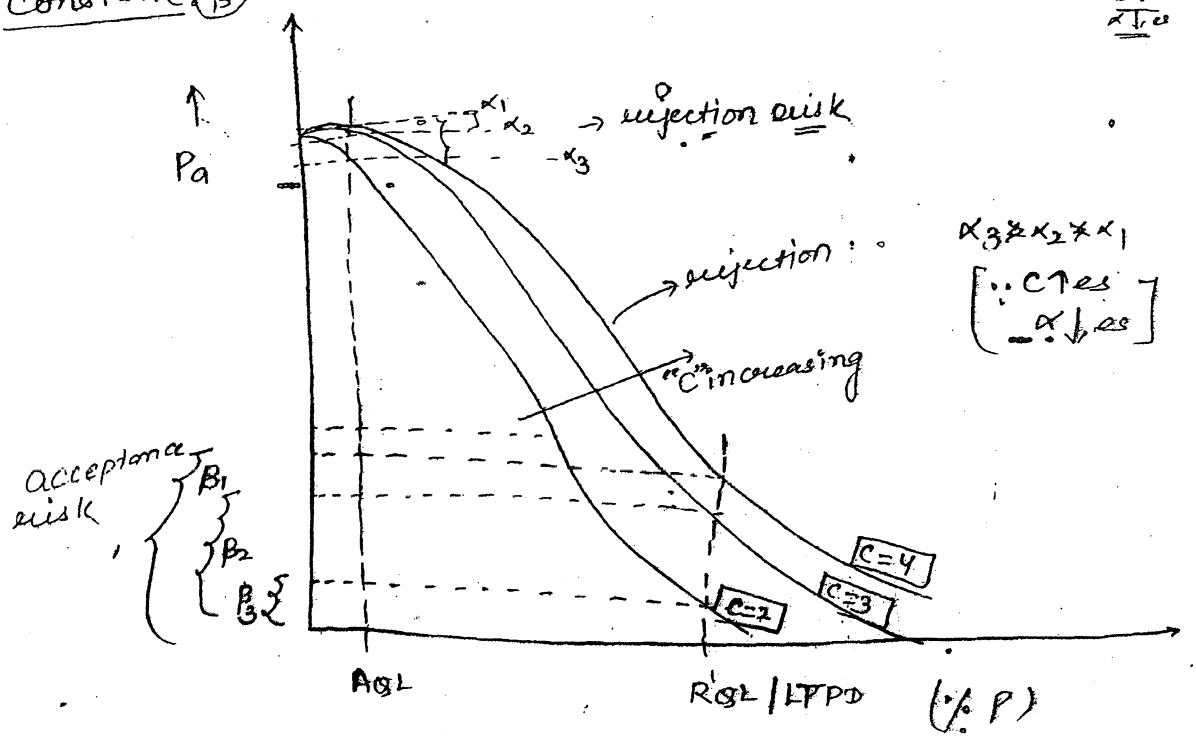
$$P_R = 1 - Pa$$

Where P = % defective.

- Probability of acceptance will be high for low value of % defective.
- Probability of acceptance of a lot will be low for high value of % defective.



Effect of acceptance No. on OC curve keeping sample size constant (15)

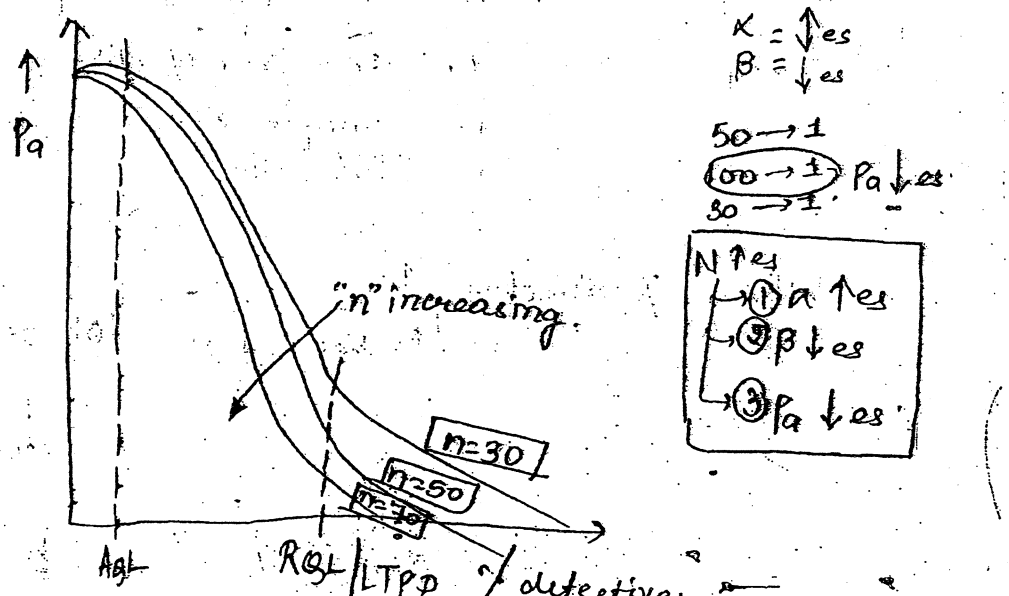


→ When c increases (n = constant)

1. Probability of acceptance increases.
2. Consumer risk increases.
3. Producer risk decreases.

Effect of sample size on OC curve keeping acceptance No. constant:

N↑es c=cons.



α = ↕es
β = ↓es

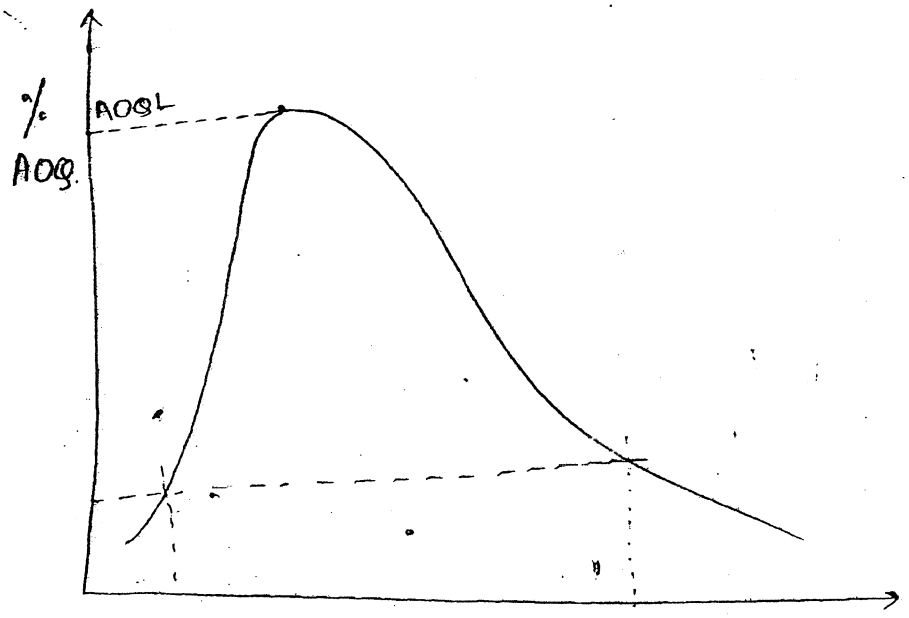
50 → 1
100 → 1 } Pa ↓es
30 → 1

N↑es
→ (1) α ↑es
→ (2) β ↓es
→ (3) Pa ↓es

(16)

AOQ: Average outgoing quality:

It represent average % defective in outgoing product after inspection.



→ When % defective less

Pa ↑es then in AOQ → defective also less.

$$AOQ = P_a \times P_d \times \frac{(N-n)}{N}$$

Where

Pa = Probability of acceptance

Pd = Proo % defective

N = sample size

n = lot size

When N = very large

Then $AOQ = P_a \times P_d$

→ When % defective ↑es

Pa ↓es then lot select ↓es

then % defective also less.

Ques: ~~A box~~ If the probability of acceptance of a lot = 0.95 then AOQ is when N is very large?

Sol:-

$$AOQ = 0.95 \times 0.01 = P_a \times P_d$$
$$= 0.0095$$

Ques: A box contain 1000 part is subjected to an accept. sampling plan that examine 50 part. the actual fraction defective in box = 0.02 and sampling plan has 0.53 probability of accepting a box of this quality. What is the avg. outgoing quality = ?

Sol:-

$$AOQ = P_a \times P_d \times \left(\frac{N-n}{N}\right)$$

$$AOQ = 0.53 \times 0.02 \times \left(\frac{1000-50}{1000}\right)$$

$$= \frac{0.53 \times 0.02 \times 950}{1000}$$

$$= 0.01007$$

Ques: Which one of the following statement best regarding OC curve:-

(a) As % defective ↓es the Probability of accepting the lot also ↓es

(b) As the LTPD ↓es the consumer risk also ↓es

(c) As % defective ↑es the Probability of acc. also increases.

(d) As the AQL ↓es then Producer risk also ↓es.

(d) Ans.

Lecture:2 Date: 8 July 2016

Ques- Maximum % defect that a consumer is called (18)
May find

(a) AOQL
(b) LTPD
(c) AOQ
(d) AQL

(d) A

—x——x—

Quality

In general, the quality can be defined as degree of ~~satisfaction~~ satisfaction.

- Dimension of Quality:
  - Performance
  - conformance
  - Reliability
  - serviceability
  - Durability
  - Aesthetic
  - Special Features

- Types of quality:
  1. Quality of design
  2. quality of conformance
  3. Performance

Quality of design:
It means the intension of designer to include or exclude features in product or services

Manufacturing sector	Service sector
Ford and BMW	Economy Hotel and J-s

Quality of conformance:

It means how well product or services are meet the specification determined by designer.

Ex:- When go to purchase a bolt and seller tells its size = 3±0.003 & then we come back to Home and check its dimension we get 3.002. that means it confirm its quality.

- colour, length, dimension all comes under this

Quality of Performance:-

it is associated with reliability of product or service performing its intended function under prescribed set of conditions.

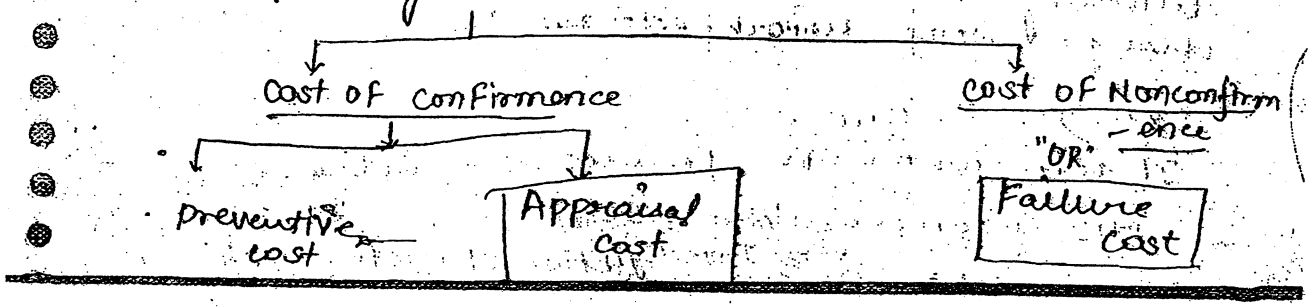
Example: Voltage Stablizer (180-270 Volt)

A voltage stablizer is design to work over a voltage range from 180 to 270 Volt. If it don't perform satisfactory in this range. It means quality of performace is poor. If it work Efficiently in this range, it means quality of Performace is good.

If it perform in the range of 170 to 280 Volt it means this is a robust product and having excellent quality of performance

***Cost of quality:

cost of quality measure the impact of any quality in any Business. Business lose money due to poor quality.



Failure cost (2V)

Internal failure cost. | External failure cost

Cost of confirmance:

It is cost of providing product or services as per required standard.

→ Preventive cost:

It is cost related to attempt. meet to prevent failure.

↳ Process simplification, process improvement, training of employe cost comes under this.

→ When Preventive cost ↑es failure cost ↓es.

—x—x—x—

② Appraisal cost:

It is a cost for activity to ensure that no. defect are found.

Example: cost of inspection, auditing cost, checking cost.

—x—x—x—

Failure cost:

It is a cost associated with a process not operating according to the requirement. cost occur due to faulty service or ~~source~~ part. defective.

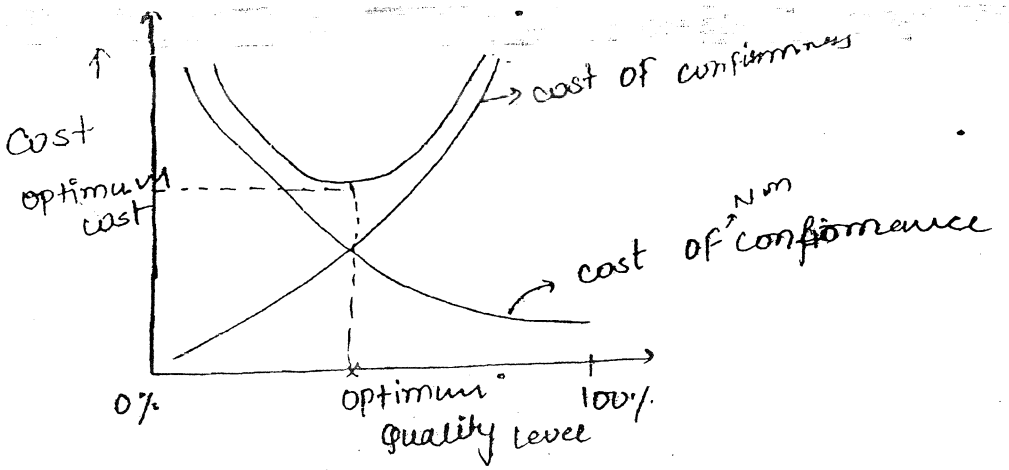
Internal failure cost:

It arises when the product are failed to reach the design standard and are detected before delivering to customer. some corrective action, some changes, some redwork. ~~External fa~~

External failure cost:

It arises when the product are delivered to ~~cus~~ customer. → Warranty cost
→ Investigation of cust. complains.

(21)



Quality management Gurus:

A quality management Guru is a good, wise person. and a teacher. a quality should have all of these (+) have a concept and approach the quality within business that has measure and/ lasting impact.

(1) Dr. W. Edward Deming: father of quality control (U.S.)
He is known as father of japone's post war industrial revival. He is EXP to improve the war material. Deming Price is the nigrest quality.

(2) Peice of japanese.

"Quality is every one responsibity."

contribution:

(1) Deming cycle:

(1) PDSA – Plan do study act
(2) PDCA – Plan do check Act
do

(2) 14 points of transfering managent:

(3) 7 deadly ~~disees~~ disease:

(4) ~~Dr~~ Josh Joseph

(2) 14 points of transfering Management

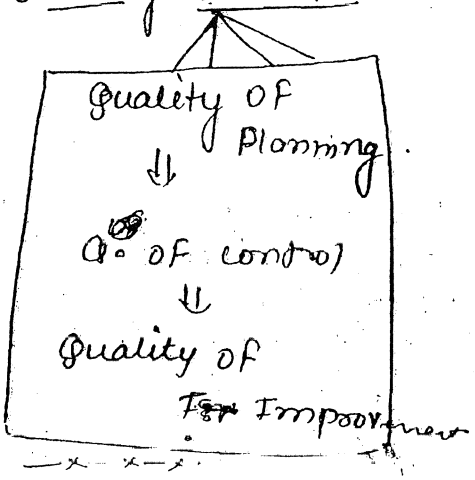
(3) 7 deadly disease.

(2) Joseph M. Juran (America / US)

"quality don't happen by accident"

contribution..

Quality Trilogy



(3) Philip crosby:

"The fun uncle of Quality revolution."

- He had popularised the idea of "cost of Poor quality"

contribution:-

- zero defect
- Fre quality is free
- cost of quality — Book Written by "Pilip crosby."

(4) Armond Vallin Feighenbaum:

American quality control Expert and Business man.

- concept of quality control

leter known as TQM (Total Quality management)

(5) Kaoru Ishikawa: Japanese
(23)
- father of quality control circle.

Contribution:
- seven quality control tool.

—x—x—x—

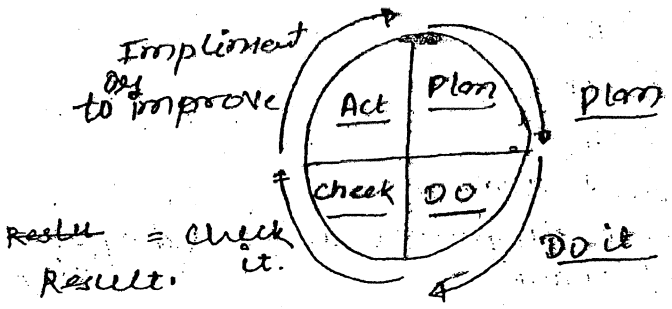
(6) Genichi Taguchi: Japanese

Contribution:
(1) Taguchi loss fonction
(2) Robust design → DOE (Design of Expre Experiment)

—x—x—x—

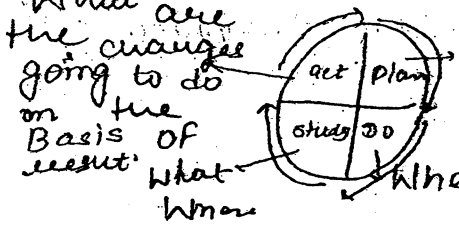
Deming Cycle:
The model provide a frame work for improvement of process or system.

PDCA:- Plan do check Act:
↓
It was originally conceived by "walter Shewart" → later adopted by deming.



—x—x—x—

PDSA: Plan do Study act:
↳ it was originally Given by deming.



Model of Impe Improvement:

Ques: "You can not let your failure, you have to let your failure teach you." (2)

(a) Joseph Juran.
(b) Philip. Crosby.
(c) Jack welch → (1) M.
(d) Barak obama

"CEO of General Elective" (Six Sigma)

—x—x—x—

- Quality control tool:

Quality control tool are used to improve the Quality of product and improvement of services.

"Prof. Kaoru Ishikawa".

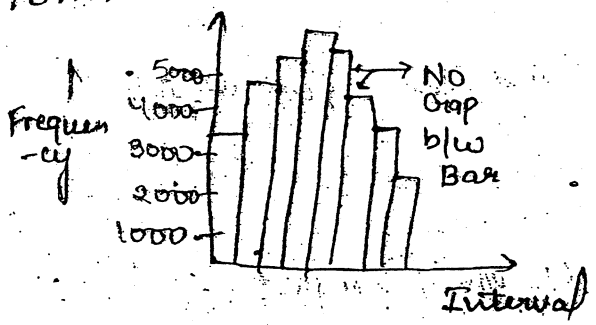
↓ Japan.

↓ seven quality control tool

H	→ Histogram
F	→ Flow chart
P	→ Pareto chart
C	→ Check sheet
S	→ Scattered diagram
F	→ Fishbone diagram (Cause and effect diagram) // Ishikawa diagram.
C	→ Control chart

Histogram:

A Bar graph that shows that distribution of data. It is used to determine the spread and variation of data point in the Graphical form. ~~it is used~~



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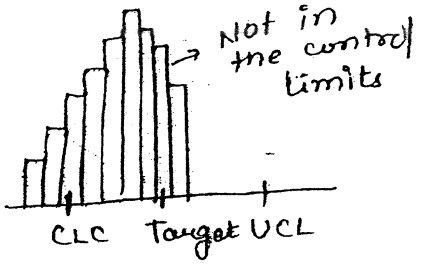
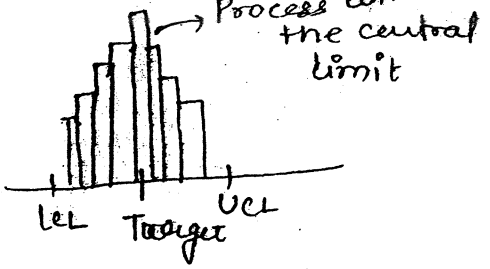




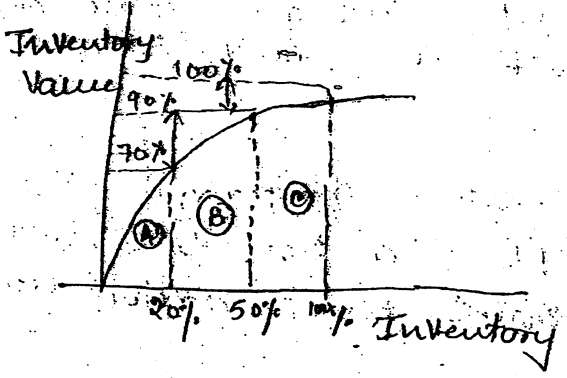
• Flow ~~cha~~ chart:
A graph that uses graphical symbol to depict the nature and flow of steps in process.

Process	Symbol
○	Operation
△	Storage
□	Inspection
⇒	Transportation
D	Delay
→	Flow line
▱	Input and output
⬭	start/stop
◇	Decision Making

• Pareto chart: / ABC / 80-20 law:

Vilfredo Pareto

Italian Economist



Pareto's statement, "20% of the population are having 80% of the wealth." it also known as 80-20 law. (26) later adopted by Joseph juran. and Give a statement, "approximately 80% of the problem are created by 20% of the cause."

—x—x—x—

- Check sheet / Tally sheet /
  It is used to keep the track of defect data collected can be used as input data for other quality control tools

		Mc-I	Mc-②
Operator A	Morning	X	X
	Evening	XX	XXXXX
Operator B	Morning	X	XX
	Evening	XX	XXXXXX XXXX

X ⇒ No. of times supervison called per day.

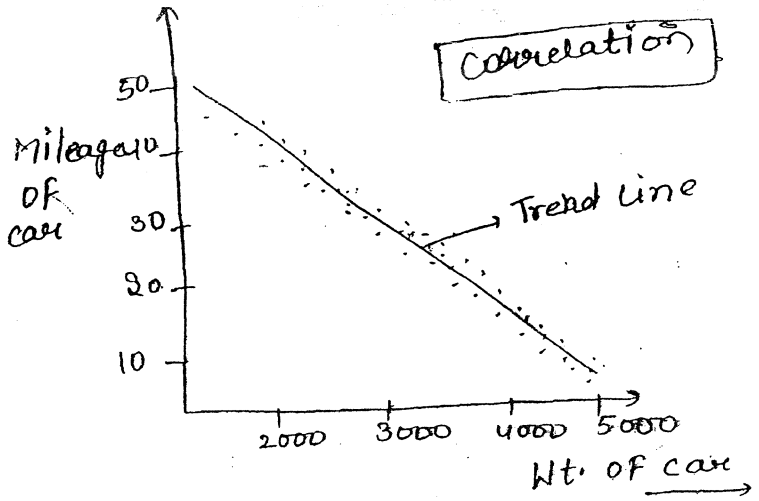
- In the morning both operater and both machine seems to be good However in the evening both operator making defect and machine "2" makine more defect.
- There may be some operator fatigue involve and there are some condition on machine which needs to be investigated.

—x—x—

- Scatter diagram:-
  It is a plot b/w two variables. The plot shows the correlation between these "2" variable.

(27)

Correlation



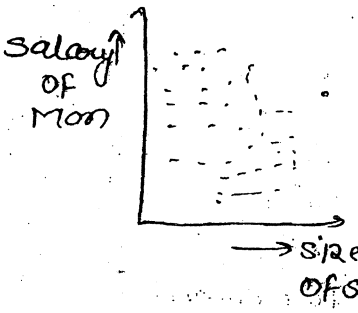
(Wt, Mileage)

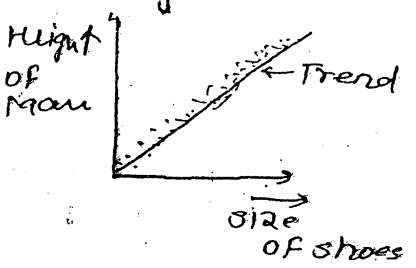
(1) Trend line is going down:
⇓
Negative Co-relation.

Wt. of car ↑ = Mileage of car ↓

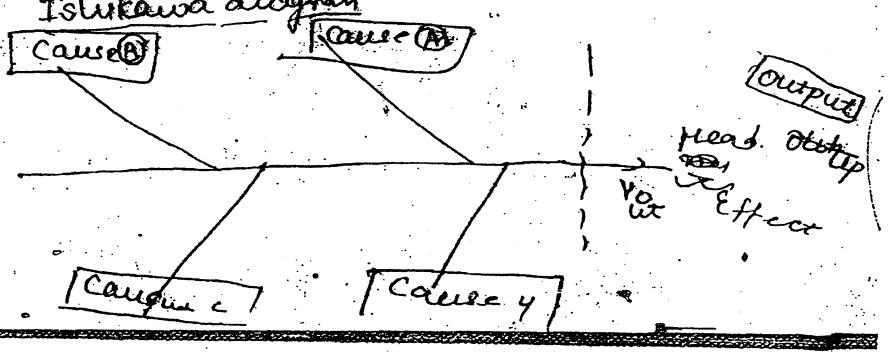
(2) Trend line going up:
⇓
Positive correlation. ↑ ⇒ ↑

(3) No Correlation:





→ Fishbone diagram (cause and effect diagram)



Fishbone diagram is the most significant diagram for quality control. (28)

Head ⟶ output

When system become complicated then small small branches are det.

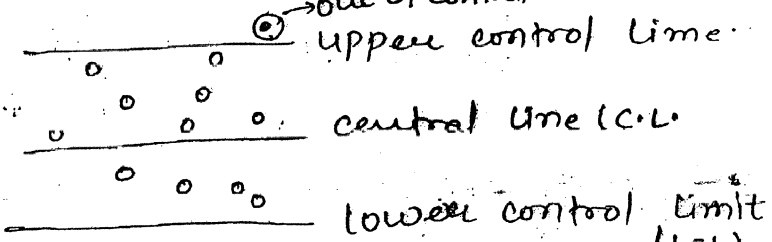
⟶ It is used for root of problem.

Branch ⟶ cause

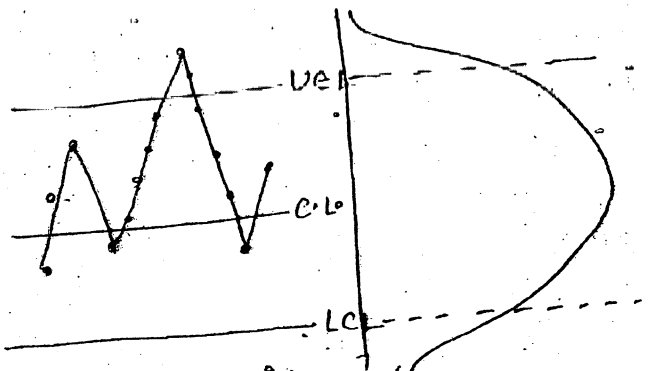
sub branch ⟶ Room.

⟶ control chart:-

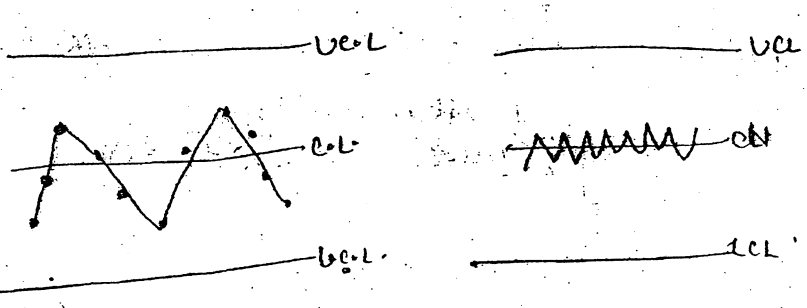
The primary work of control chart is to Product. expected output product.



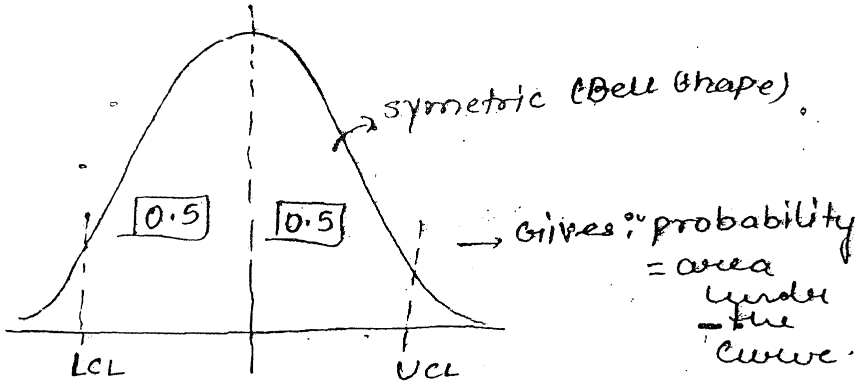
(1)



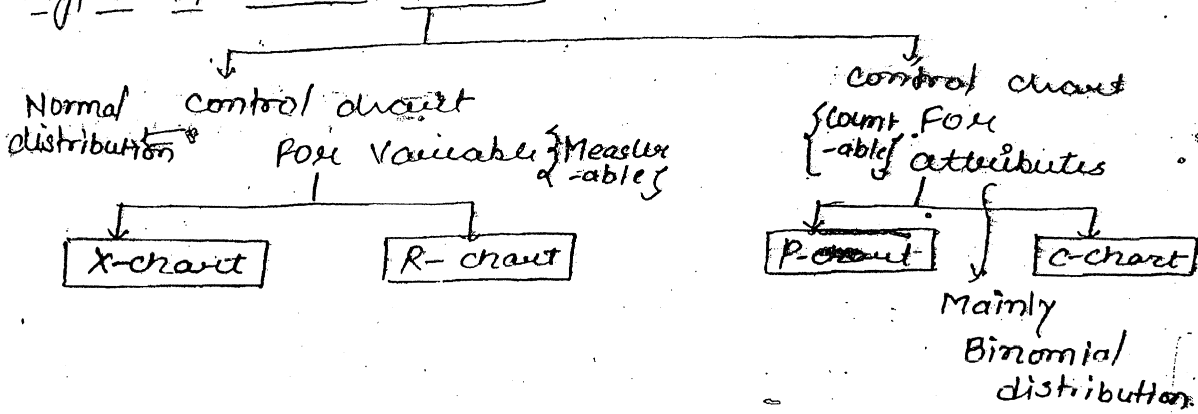
Process is not within the control



- control chart develop ... to study how the process changes over time.
- → control chart variation can also be defined by Normal distribution curve.



• Types of control chart:



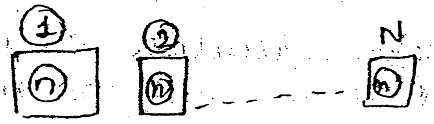
① $\bar{X}$-chart (Mean chart):

It shows the centring of the process.

n = No. of observation in each sample

$\bar{X}$ = mean of variation of each sample

R = Range of variation of each sample



n=5 {2,3,4,3,2}

$\bar{X} = \frac{2+3+4+3+2}{5} = 2.8$

Range = Max − min = 4−2 = 2

$\bar{X}_1$ = Mean of Variation of sample (1) (3°)

$\bar{X}_2$ = " " " " " (2)

$\bar{X}_N$ = " " " " " (N)

$$\bar{\bar{X}} = \frac{\bar{X}_1 + \bar{X}_2 + \bar{X}_3 \cdots \bar{X}_N}{N}$$

$$\bar{\bar{X}} = \sum_{i=1}^{N} \frac{\bar{X}_i}{N}$$

Control limit:

$$C.L. = \bar{\bar{X}}$$
$$UCL = \bar{\bar{X}} + 3\sigma_{\bar{X}}$$
$$LCL = \bar{\bar{X}} - 3\sigma_{\bar{X}}$$

$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$

$\sigma_{\bar{X}}$ = Standard deviation for sample mean

σ = universal / St. deviation process

For 2σ

$$C.L. = \bar{\bar{X}}$$
$$UCL = \bar{\bar{X}} + \frac{2\sigma}{\sqrt{n}}$$
$$LCL = \bar{\bar{X}} - \frac{2\sigma}{\sqrt{n}}$$

Ques: A drilling machine has ~~more~~ bore hole. with mean diameter of 0.5230 cm. and St. deviation of 0.0032. Calculate 2σ and 3 sigma Upper and lower C.L. for mean of sample of 4.

Sol:-

$n = 4$

$\sigma = 0.0032$

$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}} = \frac{0.0032}{2}$$

$$= 0.0016$$

(3) For 3σ

U.C.L = 0.5230 + 3X0.016

= 0.5230 + 0.0048 = 0.5278

L.C.L = 0.5230 − 3X0.0016

= 0.5230 − 0.0048 = 0.5182

For 2σ

U.C.L = 0.5230 + 2X0.0016 = 0.5230 + 0.0032 = 0.5262

L.C.L = 0.5230 − 0.0032 = 0.5198

— X — X — X —

• Range chart: {R-chart}

R_1 = Range of variation of sample (1)

$= X_1^{max} - X_1^{min}$

R_2 = Range of variation of sample (2)

$= X_2^{max} - X_2^{min}$

R_N = Range of variation of sample (3)

$= X_N^{max} - X_N^{min}$

$$\bar{R} = \frac{R_1 + R_2 + R_3 \cdots R_N}{N}$$

$$\bar{R} = \sum_{i=1}^{N} \frac{R_i}{N}$$

Control Limit = $\bar{R}$

UCL = $D_4\bar{R}$

LCL = $D_3\bar{R}$

Where

D_4 = Factor for R chart for UCL

D_3 = Factor for R chart for LCL

NOTE: D_3, D_4 are constants and only depends on sample size n.

(32)

For $n < 7 \Rightarrow$ $\boxed{D_3 = 0}$

—x—x—

③ p- chart:

It is control chart for fraction defective. It is used when sample size is not const. It is control chart for attributes.

Sample NO	sample size (n)	NO. of defect (d)	F. defective (p)
1	n_1	d_1	d_1/n_1
2	n_2	d_2	d_2/n_2
3	n_3	d_3	
⋮	⋮	⋮	⋮
N	n_3	d_N	$P_N = \frac{d_N}{n_N}$

Avg. ~~fraction~~ defective: $(\bar{p})$

$$\bar{p} = \frac{p_1 + p_2 + p_3 - - - - p_N}{N}$$

$$\bar{p} = \frac{\sum_{i=1}^{N} p_i}{N}$$

Avg. sample size $(\bar{n})$

$$\bar{n} = \frac{n_1 + n_2 + n_3 - - - - - n_N}{N}$$

$$\bar{n} = \frac{\sum_{i=1}^{N} n_i}{N}$$

Control limit:

For 3σ

$$C.L. = \bar{p}$$
$$UCL = \bar{p} + 3\sigma_p$$
$$LCL = \bar{p} - 3\sigma_p$$

Where $\sigma_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{\bar{n}}}$

For 2σ $\Rightarrow$

$$UCL = \bar{p} + 2\sigma_p$$
$$LCL = \bar{p} - 2\sigma_p$$

• np-chart:

(33) Special case of "p"-chart where sample size is constant.

$$n_1 = n_2 = n_3 ----- = n$$

Control Limits:-

$$C.L. = \overline{np} = \bar{n}\bar{p} = n\bar{p}$$

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

$$\boxed{L.C.L. = n\bar{p} \pm 3\sqrt{n\bar{p}(1-\bar{p})}}$$

—x——x—

• C-chart:

It follows the poisson's distribution. it is used to compute the defect.

mean = Variance

$$\bar{c} = \sigma^2$$

$$\sigma = \sqrt{\bar{c}}$$

Control Limit

$$\boxed{\begin{aligned} C.L. &= \bar{c} \\ UCL &= \bar{c} + 3\sqrt{\bar{c}} \\ LCL &= \bar{c} - 3\sqrt{\bar{c}} \end{aligned}}$$

Variable ← $\bar{X}, R$ ⟶ Normal distribution

Attributes → c ⟶ Poisson's distribution

Attributes → np, p ⟶ Binomial "

—x——x——x—

Ques: A manufacturer find on his experiment that on an avg. 1 out of 10 item produced by a machine is defective on a particular day he select a lot of 100 and find that 18 of them are defective find the control limit for p chart and find process is within control limit or Not.

Sol: $N = 100$

$$CP. = \bar{p}$$

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

~~$\bar{p} = \frac{18}{100} = 0.18$~~

$\bar{p} = \frac{1}{10} = 0.1$

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

$= 0.1 + 3\sqrt{\frac{0.1(1-0.1)}{100}}$

$= 0.19$

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

$= 0.01$

UCL = 0.19
C.L = 0.1
LCL = 0.01
0.18

$\frac{18}{100} = 0.18$ Within the control limit.

—x—x—x— Date: 9 July 2017

Lecture 3

- Six sigma (6σ):

— It is a methodology or quality symbol.

OR

— It is a quality philosophy and the way of improving performance by knowing where you are and where you can be.

OR

It is pure purely scientific method used for process improvement and this method is known as "DMAIC".

D — Define
M — Measure
A — Analyse
I — Improve
C — Control

OR

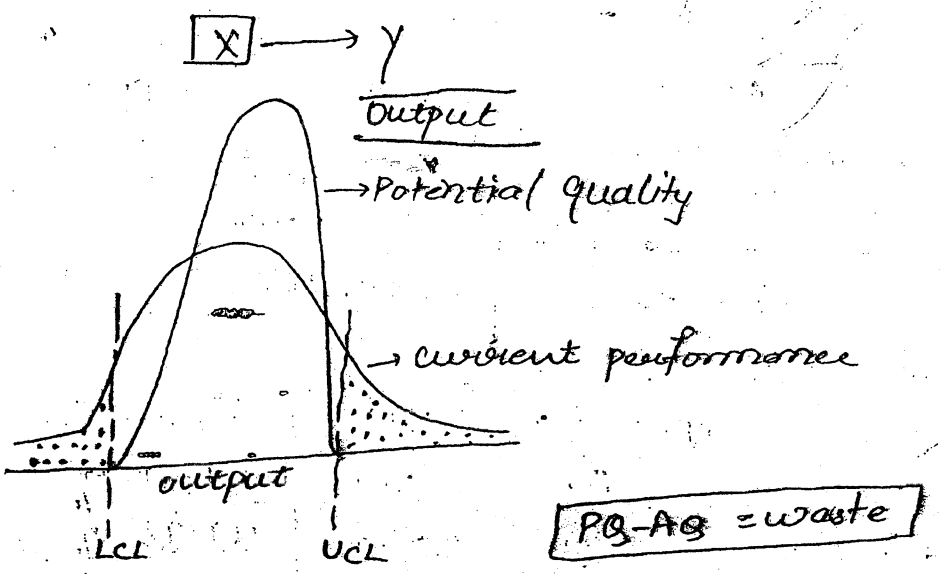
Main focus in quality improvement and reduction of defect, its target to bring down

(3) the Error rate to 3-4 apmo (Defect per million opportunites) or 3-4 EPMO (Error " ")

Quality

Potential Quality (PQ)
OR
Maximum quality
OR
Where you can be.

Actual quality
OR
current Performance
OR
Where you are



PQ-AQ = waste

→ That waste can be reduced by six sigma.

-x——x——x—x-

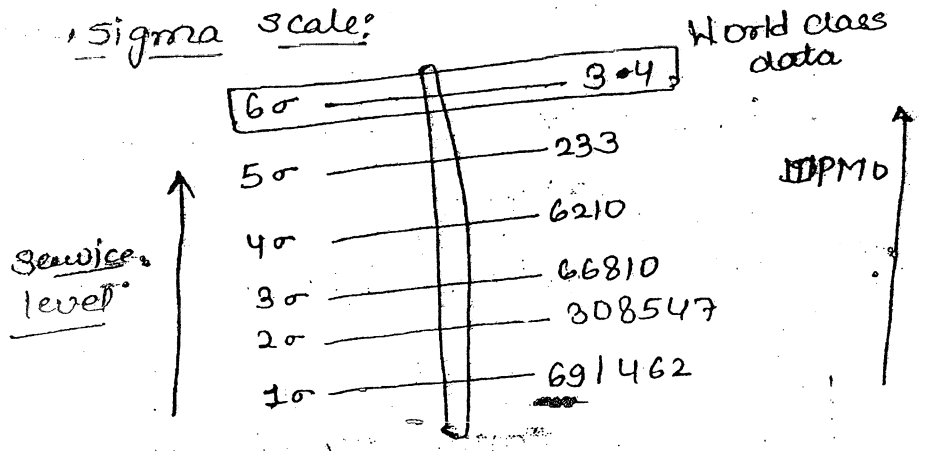
- Father of six sigma is "Bill smith". An engineer in motorala company. In 1970 Motorala started with problem solving through statistical analysis in 1987 Motorala officaly launch "6σ" programme due to this motorala known as quality leader and profit leader.

- In 1988, Motorola won "Malcom Baldrige National quality Award" (MBNQA) → U.S. price (36)
- In 1991, Motorola certified its First "Black belt"
- In 1995, six sigma became Well known after mister jack Welch (CEO of GE) ("Manager of century")

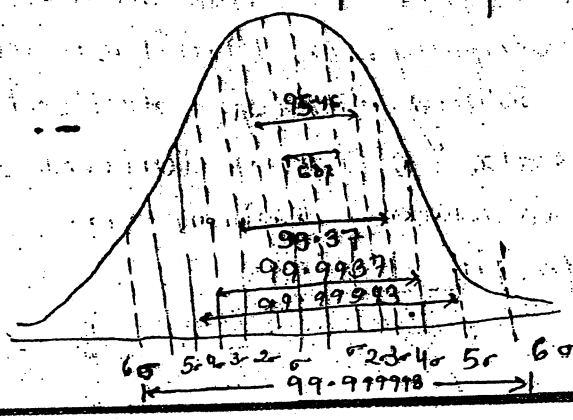
—x—x—x—x—
a Given Process

Why σ: sigma measure how far deviate From perfection Higher sigma capability better Performances

Sigma scale:

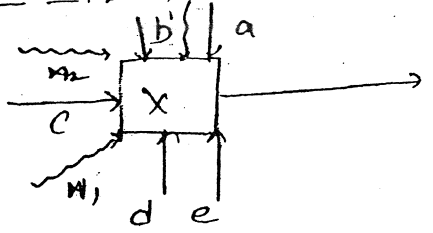


Sigma level	DPMO	% Good
6σ	3.4	99.9997 %
5σ	233	99.98 %
4σ	6210	99.38 %
3σ	66810	93.32 %
2σ	308547	69 %
1σ	691462	31 %

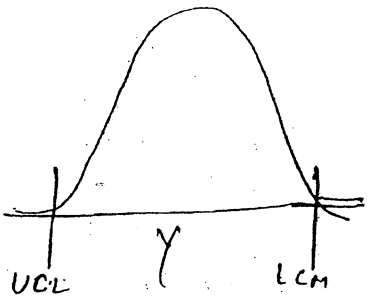


Why not zero defect ? (03)

(37)



n = Noise Factor



3.4 defects
zero defects

- Every organisation want to make more and more profit and some time when we go for reduce 3.4 defects into zero defect cost associated become very large thus this is avoided generally.

DPMO: (Defect Per million Opportunity)

$$DPMO = \frac{\text{No. of defect}}{\text{No. of unit produced}} \times 10^6$$

EPMO = service sec.

Ques:- In PNB, during the last month discovered 9 error while processing 2000 Statement.

(1) What is EPMO?

(2) What is σ level?

Sol! $EPMO = \frac{9}{2000} \times 10^6 = \frac{9000}{2} = 4500$

$$\sigma = \frac{2000-9}{2000} \times 100 = \frac{1991}{2000} \times 100$$ (38)

$$= \frac{1991}{20} = 99.55\%$$

lie between $[5\sigma \rightarrow 4\sigma]$.

—x——x——x—

Six sigma Methodology:

"DMAIC"

It is an process improvement Methology: It is used for Improvement of existing process.

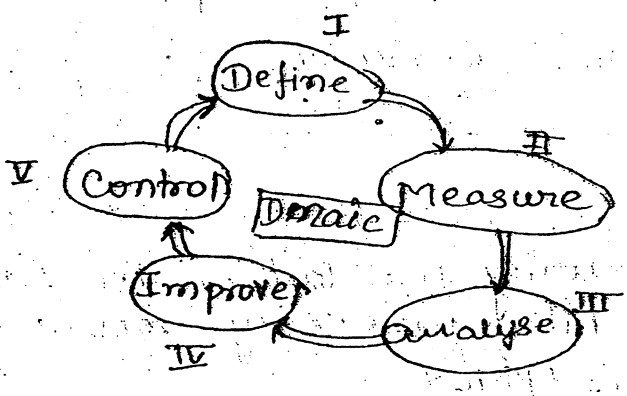
- Define
- Measure
- Analyse
- Improve
- Control

→ It is used for Improving, Optiming, Stabilising business process and design.

→ It is core tool which is used to drive 6σ.

→ It is a logical and structured approach for problem solving and process improvement

→ It is five step iterative process.



→ DMADV → For New product

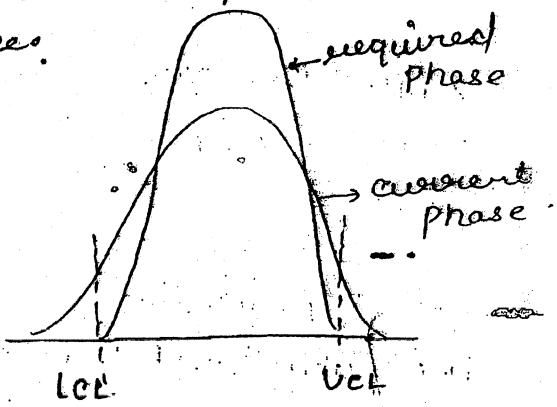
DMAIC → For existing product

1. Define Phase: (39)
- Target
- Goal
- Project.
- Project scope

VOC = "CTQ"
VOC → Voice of customer
"CTQ" → Critical to quality

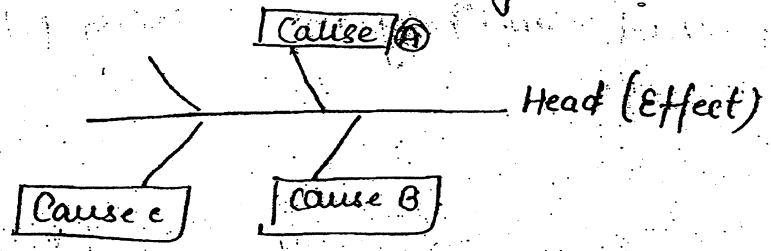
• This "DMAIC" approach is used for existing. Product. thus in define phase, we want to hear Customer's voice and according to that define target and goal.

2. Measure Phase:
In this phase, existing system, or process is measured Identify the gap between current performace and the required performance.



X → Y
⇓
Measure output the existing process.

** 3. Analyse Phase:
In this phase, system is analyse to identify the way to eliminate the Gap between current Performance and required phase.
To analyse a system or process Fishbone diagram (Ishikawa diagram) is used because it provide all information till its root cause of any problem (Effect).



(40)

4. Improve Phase:

Purpose of this phase is to identify the test and implement a solution to the problem Whether in a factor or for Whole process. In this phase team try to find the way to do the things cheaper better and faster.

Tools:- Brainstorming.
- six thinking "hat"
- DOE (Design of Experiment)

↓

Done by research and development Department.

↳ White, Red, Yellow, Green, Blue, Black. six parts of improve phase team to find solution of Problem.

5. Control phase:

The purpose of this phase is to control or sustain the gain.

DMADV: → For New Products/process.

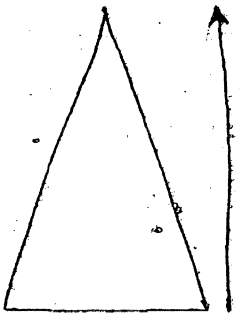
- Define
- Measure
- analyse
- Design → Design the New process
- Verify → The Performence.

- It is used When we need to replace by new process rather simplifing the existing process.

(VII) Six sigma certification programme OR Different level in six sigma

- six sigma training and certificate ~~tabels~~ organised into level
- a hierarcy of individual can achieve in six sigma.
- It is important for each certified 6σ Perfossi - on to know his role or responsibility within an organisation.
- lower ~~tabet~~ level individual will report to higher ~~level~~ level individual with their problem and " level individual are responsible for monitoring the lower level individual.

Champions
Master Black Belt
Black Belt
Green Belt
Yellow Belt
White Belt



(1) White Belt:
- Yellow Belt serve as a trainer on the basic overview of the six sigma.

White Belt level not fully recognised by the entire six sigma comittee many consider yellow belt to be lowest.

(2) Yellow Belt:
Having Basic knowledge of six sigma but does not lead any project on their own responsible for development of process map responsible for running small process improvement project using PDCA. Methodology.

(3) Green Belt:
Having inhanced problem solving skill on the DMAIC. They can lead small scale skill improvement Project with their respective area. They can be the Project TEAM Member.

(4) Black Belt:
Having knowledge of six sigma philosophy and Principal. and they have complex understanding of DMAIC "OR" DMADV. They can be the project team leader.

(5) Master Black Belt:
Having Experience of Managing several project on six sigma. offering mentorship and coaching For those whose willing within the Black Belt.
- They are able to trained and cecitified others in six sigma methodology.

(6) Champions:
Champions is senior or middle executive. their role is choosing and sponsering the project.
champions is a person in the team Who knows the business from outside or inside.

Dabbawala: "NMTBSA"
Nutan Mumbai tiffin box supplier association

- Started in 1880.
- In 1956 registered charitable trust.
- World record in best time management.
- Having Name in gini Book of world record (gini = guinness)

| 1 Error → 16 Million Transaction |

— 2 lakh daily → 9hrs. → 8th Grade employee
— current president of Dabbawala → Raghunath Medge

-started by "Hayaj Bachoie.

(43)

-: TQM :→

{Total Quality Management}.

"TQM" is a culture, not a program. TQM is not a collection of tool or technique. The Goal of "TQM" is Customer satisfication.

Q vs Q

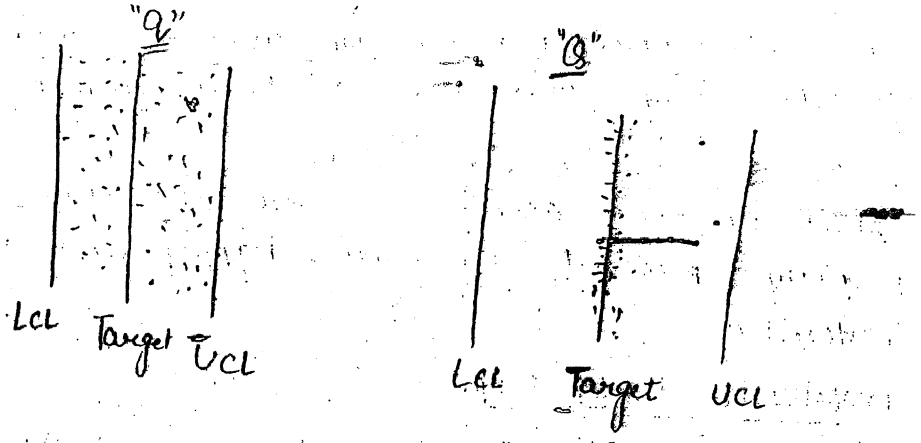
q = Traditional approach

Q = "TQM" approach

Bolt: 2 ± 0.003

UCL = 2.003

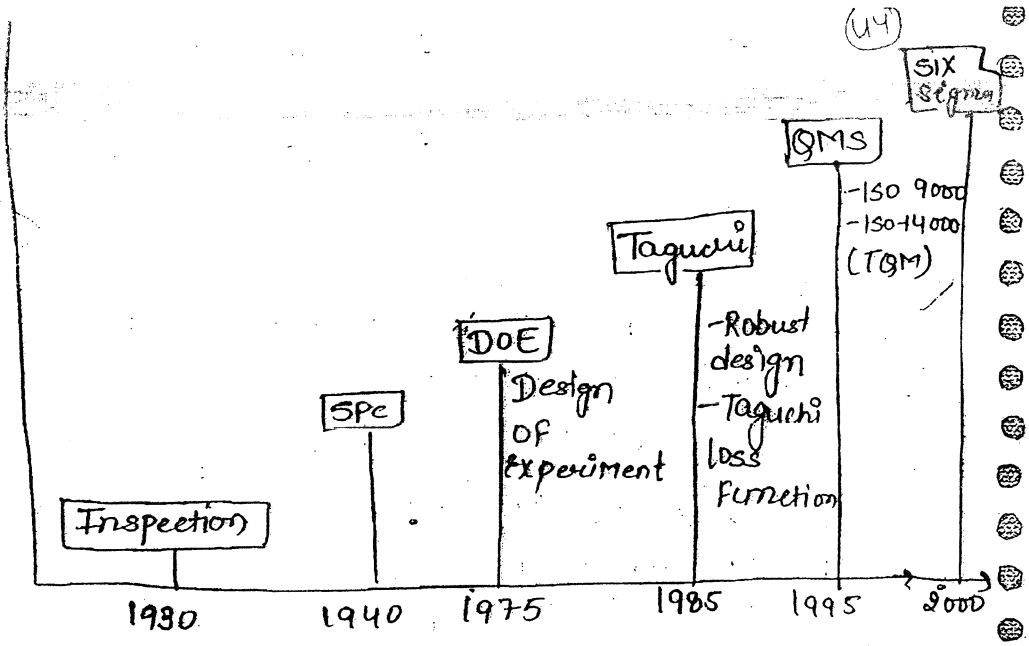
LCL = 1.997



q: It used to serve well under monopolastic situation Where both the organisation and market treated as black box.

Q: It focus with strong customer orientation that enhances the product quality by improving the process.

Evolution of Quality management:



Principle of TQM: 8 Principles.

1. Leadership:
The difference between An average company and Outstanding company in Leadership, they have.

2. Customer focus Organisation:-
Work on the expectation of the customer and keeping present customer happy and attract new customer.

3. Involvement of People:
Involvement of People at each level enables full utilisation of their ability for organisation benefit.

4. Process Improvement:
Draw the process mapping then analyse the process and redraw the process.
Redesign

5. System approach to Management:
Approach to identify, understand and manage a system of inter related process for given Objective.

6. Kaizen (Continuous improvement) :-
(45) The continuous improvement in all the factors related to process of converting input to output.

7. Factual Approach to decision Making:
It should be based on the facts. Effective decision or action are based on the analysis of data and information.

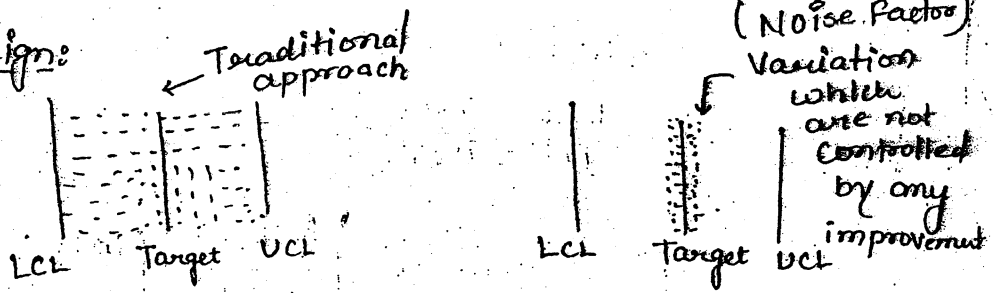
8. Mutually benifical supplier relationship:
Ability of organisation and its supplier to creat a value which inhanced by Mutually Beneficial Supplier Relationship.

—x—x—

• Taguchi approach: "Genichi Taguchi" (Quality Management Guruu)
Taguchi has an important influence on quality and developed specially in design area both product and process design.

— Robust design
— Taguchi loss function

Robust design:



Robust design means process continuous to produce good product with minimum deviation from target. Taguchi says that variation can be noise factor.

Noise Factor is source of variation that is impossible or difficult to control and affect the function characteristic of the product. These are of 3 types:

(1) Unit to unit Noise Factor: (UL)

These are the random variation in every process and product caused by variability in man, material and machine.

(2) Internal Noise Factor:

It is internal to process and product. Time dependent factor i.e. — wear of mechanical comp.

(3) External Noise Factor:

These are the variation that is external to product or process.

Example: Enviornmental variation, Humidity, outside temperature etc.

NOTE: Internal and external Noise factor previously known as assignable variation.

Taguchi loss function:

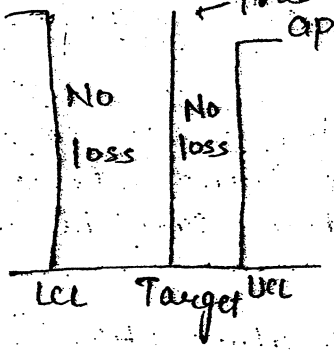
Bolt ⇒ 2±0.003

Cost ⇒ BRs 18

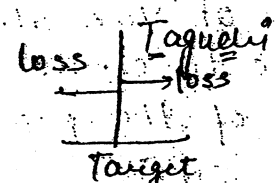
Target = 2

UCL = 2.003

LCL = 1.997



Bolt size	loss
2.001	0
2.004	18
1.998	0
1.995	18
2.002	0



- According to taguchi, there is loss even if the product is made within the specific limit. means there is loss as long as product deviate from the target.

- According to taguchi. loss is continuous fuction Varying from target to upper control limit or lower control limit. it can be linear, quadratic or can be higher order.

By Taguchi, it is quadratic.

$$L = k(y - y_0)^2$$

Where y = measured value of quality characteristics.
y_0 = Target value of quality characteristics
k = Taguchi constant.
L = loss.

Example: Bolt: 2 ± 0.003.

Cost = 18 Rupees

Target = 2

UCL = 2.003

LCL = 1.997

Boundary condition: At UCL = 2.003
Loss = 18 Rupees

At LCL = 1.997
Loss = 18 Rupees

at $y = 2.003$

$$\text{Loss} = k(2.003 - 2)^2$$

$$18 = k(0.003)^2$$

$$\frac{18}{9 \times 10^{-6}} = k \Rightarrow \boxed{k = 2 \times 10^6 \text{ Rupees/(dimension)}^2}$$

$$\boxed{L = 2 \times 10^6 (y - y_0)^2}$$

(i) At $y = 2.001$

$L = 2 \times 10^6 (2.001 - 2)^2$

$L = 2 \times 10^6 \times (0.001)^2$

$\boxed{L = 2}$ Rupees.

(ii) At $y = 2.002$

$L = 2 \times 10^6 (0.002)^2$

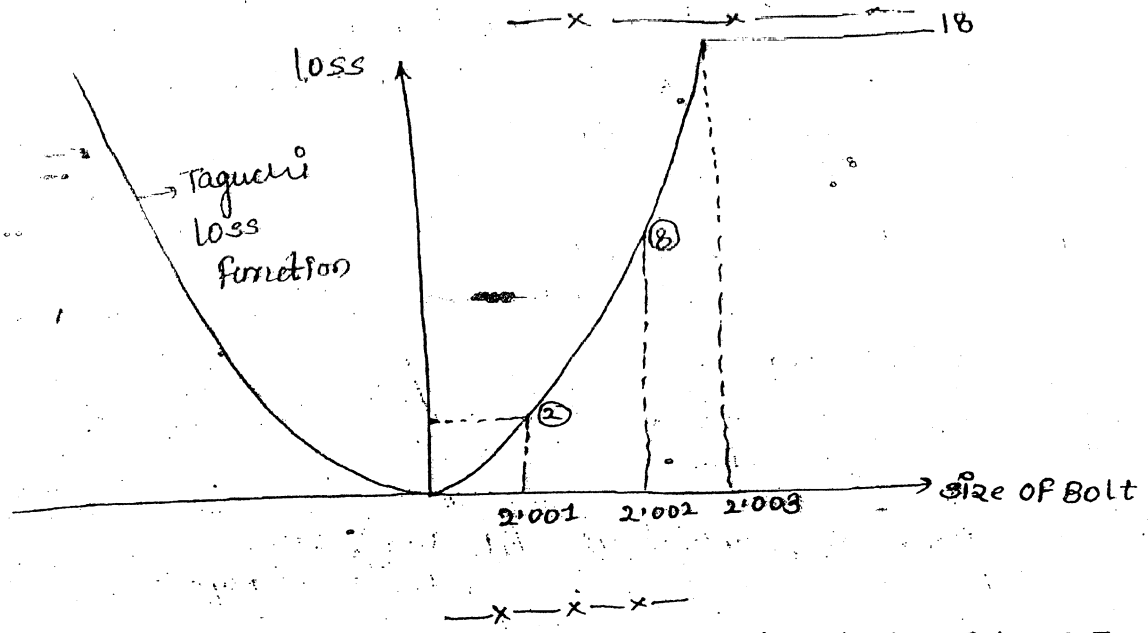
$\boxed{L = 8}$ Rupees

(iii) At $y = 2.004$ → This point "Taguchi" form is Not valid.

$L = 2 \times 10^6 (0.004)^2$

$\boxed{L = \text{Rupees } 32}$ ✗ Not possible

$\boxed{L_{max} = 18}$



Ques: A production process make bolt 9 ± 0.25. Applicable at cost of 75 Each determine

(1) Taguchi loss const.

(2) loss When bolt size 9.10

(3) " " " " 8.90

(4) " " " " 8.95

(5) " " " " 9.40

(49) Sol: (i) $L = K(y-y_0)^2$ $\quad y_0 = 9$

at $y = 9.25$ $\quad y_{upl} = 9.25$

$y_{lower} = 8.75$

$75 = K(0.25)^2$

$\frac{75}{0.25 \times 0.25} = K$

$\frac{3}{25} \times 10000 = K$

$K = 1200 \frac{\text{Rupess}}{\text{Ciment}^2}$

(ii) $L = 1200 \times (8.90 - 9)^2$ $\quad y = 8.90$

$L = 1200 \times (0.10)^2$

$= 1200 \times \frac{1}{10} \times \frac{1}{10} = 12$ Rs.

(iii) $L = 1200 \times (0.05)^2$ $\quad y = 8.95$

$L = 1200 \times \frac{5}{100} \times \frac{5}{100} = 3$ Rs.

(iv) $L = 75$ Rs. $\quad y = 9.40$

QFD: Quality Function Deployment:

↳ Yogi akao → Daming prize

↓ japan (shipyard)

It is the method of translating the voice of customer (VOS) into product design. QFD is actually started in shiping industries. A town in japan "Kube" is having two shipyard industries.

Difference between quality function deployment and Convential Product development:

QFD	Co. Method
1. Listen to customer	specification of internal demand

Lecture 14

Date: 10 July 2017 (50)

2. What is important?

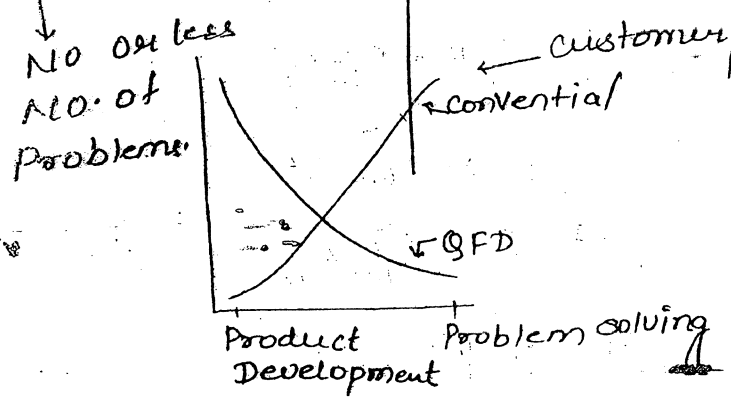
3. Developed and manufactured toward the majored goal

4. optimise product and process.

2. Everything is important?

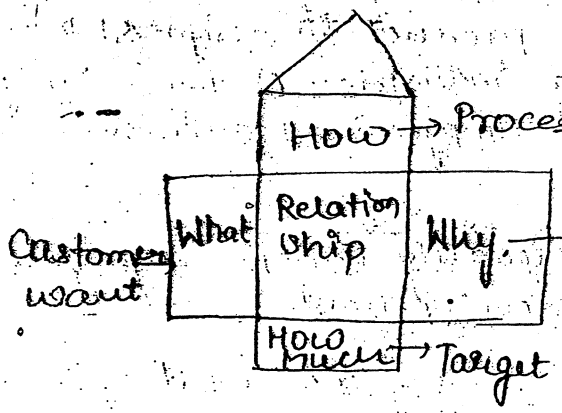
3. Developed and manufactured against specific tolerance

5. Passive relation to the customer.



House of quality:

QFD provide a cross function approach which uses planned total quality method, which is known as House of quality.



(51) in quality House it based on QFD. analyse customer requirements and compitators Assesment and then decide their quality target for particular product.

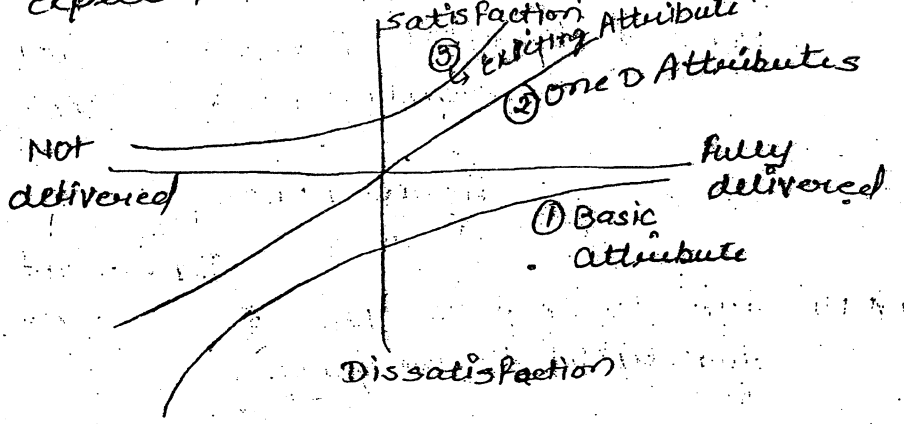
→ Kano Model: → An Japan Tool → customer satisfaction Model.
- Noriaki Kano - Japan
- Daming Prize

{ QFD → VOC (Voice of customer)
{ Kano Model → MOC (Mind " ")

Kano model: Performance on product/service attribute is not equal in the eye of customer. Performance on certain attribute produce Higher level of satisfaction.

Types of customer satisfaction:

1. Basic attributes / Dissatisfaction: → that customer Minimum required features normally Expected from product / services.



② one dimentional Attributes / performance: Produces Both satisfaction and dissatisfaction depending upon the performance level.

Example: Fuel consumption in a car. (52)

— Satisfaction is proportional to level of ~~that~~ attribute.

—x—x—x—

(3) Exciting attribute / satisfaction:

Produces satisfaction when delivered but cause no dissatisfaction. if Not delivered.

Example: When we placed in a company and when we get promotion, we get ejected and when we not get that still we are working there. is a condition of exciting attribute.

—x—x—x—

- Quality Award:

(1) - "Malcom" Baldrige National Quality Award [MBNQA]

Malcom — former US. Secretary of Commerce

- Given for TQM
- First Award "1988".
- Managed by NIST (National institute of standards and technology)

↓

Agency of U.S. → Department of Commerce.

{TQM — Use to improve the quality of US company.}

- MBNQA is performed by President of USA
- This award is given only for the Organisation
- Category — Manufacturing sector, Non profit organ, Service sector, Educational sector, Health " , small Business,

(2) Deming prize:

(53) - Instituted in 1951.

- It is managed by "JUSE" (Union of Japanese Scientist or Engineers)
- Dr. Edward Deming (Management Guru)
- Deming Prize available for both Organisation and individual.
- Deming Prize for individual available Every year.
- TO Japan Person.
- Deming Prize for Organisation, there is no condition Provide (Any country of Asia and time is not fixed)
- 2016 Deming prize → Given to Indian Company. Ashok leyland, Pantnagar.

(3) Rajeev Gandhi quality award:

- Indian quality award.
- Insistuted by. BIS (Buro of indian Standard 1991)

:ISO:

(54)

Full Form: International Organisation for Standardi-zation

- Founded in 23rd Feb @ 1947
- Headquater in "Geneva".
- 162 National Member.

Main objective: Main objective of Iso is to achieve, maintain, continuously improve the product quality. Also improve the quality of operation..

Iso has 3 types of membership catagory:

1. Memberbody:

Memberbody are the national body consider the most representative standard body in each country. These are the only member of "Iso" that have "voting rights."
↳ India is a Member body. (At present)

2. Correspondent Member:

" " are the country that do not have their own standard Organisation. These member are in formed of "Iso" work but do not part in standard changes.

3. Subscriber Member:

" " are the country with small economy. They pay reduced membership fee but can follow development of standards.

(55) Parties of Iso certificate :—

1. First Party : A Firm itself con- audit.
2. second " : A customer can audit.
3. Third " : A certifing ageney serve on audit.

Iso 9000 series:

Iso 9000 series of Quality Monagement. In 1979 BSI British Standard Institute submit a formal purposal for quality standard.

In 1987 : First edition of Iso 9000 published.
- Based on UK and ~~Kanad~~ Canadian Standards.

- It is management Methodology adopated by company to deliver product and services that meet the Customer satisfaction.
- Implimentation of Iso 9000 Standard does not mean higher level of quality but it forces a Company to deliver product as per ~~the~~ required Standards.

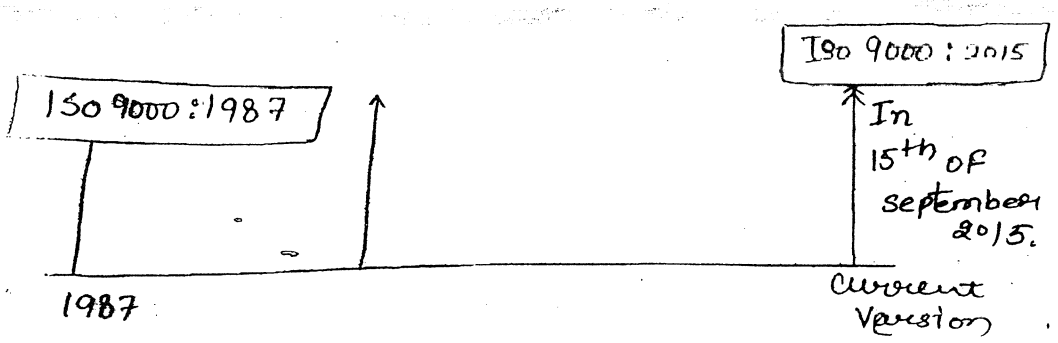
Why Company required Iso certification:

(1) customer satisfaction.
(2) Enter Global market
(3) Improve Organisation monagement and product service quality
(4) Exporting internationally.

NOTE: Iso 9000 series are based on 8 Quality management Principles.

Current Version of ISO-9000 :-

(56)



- Its revised version based on requirement or not based on fixed time interval.

Iso 9001 : Requirement — Current Version — ISO 9001 : 2015 (Sep. 2015)
Iso 9002 : Product standard
Iso 9003 : Final Inspection
Iso 9004 : Guide line.

Iso 14000 :-

- Series of Environmental Management.
- It provide standard in 3 major area:
  1. Management system
  2. Operational system
  3. Environmental system.

1. **Management system:**
System development and integration of Enviromental responsibility in business planning.

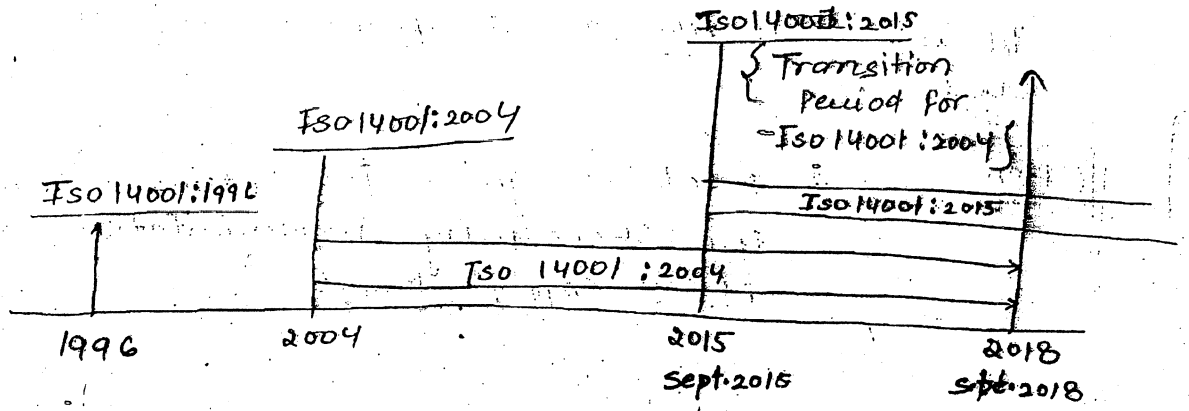
2. **Operation system:**
It is about Consumption of natural resource or Energy. Example: Wind energy, solar energy.

3. **Environmental system:**
It is about measuring and managing emissions and other wastage.

- Iso 14000 Based on British Standards Institute in 1992.
- Iso 14000 deal with How a company manage the Enviornment inside the facility and ~~eimidate~~ Immidate outside the company.
- Iso 14000 don't mandate a particular level of pollution or performance but forces on awareness of process and procedure that can effect the enviornment.

- Iso 14001 — about the EMS (Enviornmental Management System)
  - Main standard of 14000 series.
    - First published in 1996.
    - In 2016, it completed 20 years. (Birthday celebrate)

* Current version of Iso 14001:
  - Iso 14001:2015



- Key change in Iso 14001:2015
  - Digital documentation
  - Greater focus on leadership
  - Better communication
  - Better Environmental performance.

Iso 14004 :— Guide line
  - Iso 14004:2016 → 1st March 2016

OHSAS 18000:

(58)

Full Name: "Occupational Health and safety assesment series"

- It is an International standard which provide a frame work to identify, control and decrease the risk associated with health and safety within company.
- Implimenting this standard give clear signal to management that Employee health and safety it is the prineiple priority within the Company. (construction related → Not used in agriculture field)
- OHSAS 18001 :- about occupational Health and safety management.
- Based on Iso 9001 and Iso 14001.
- It uses a management approach tool PDCA cycle

OHSAS: 18002 :- about guide line (demonstauting the succesfully implementation of OHSAS 18001)

—x——x——x—

Emission Standard:
adopted by Government of Nation.

BS Norms: {Bharat stage Norms}

① Introduced in 2000.
and decided in "Mashelkar Committee"

② It is set of central government (CPCB)
(Central pollution control Board)

(59) It is ministray of Enivornment and Forest and climate change.

- Bs Norms based on Europion Norms.
- Each stage has certain limit on pollution release.

- Bs-III was ~~inte~~ ~~inf~~ enforced across the country in ~~2005~~ Oct 2010.
- Bs-IV introduced in April' April 2010. in (13) ~~maj~~ major city.

Bs-V planned in 2019.

Bs-VI introduce in 2024.

imp due to Heavy pollution Bs-V skip and Bs-VI introduced directly in 2020. after Bs-IV.

—x———x———x——

(09)

-: NDT :-

{Non Destructive Testing}

↓ Without disturbing position of object / system Find problem / defect.

- Acostic emission testing
- Electromagnetic testing
- Laser testing
- leak testing
- Magnetic Flux leakage
- liquid Pentrant testing
- Magnetic particle testing
- Radiography testing
- Thermography "
- Infrasonic "
- Ultrasonic "
- Addy current "
- X-ray
- Microwave Testing
- Vibration analysis
- Visual inspection
  - VT-I
  - VT-II
  - VT-III

Quality in Construction and services:-

- Iso 9000 standard is refered as main standard for construction company.

A construction project has 4 different Phase

(1) conceptual planning — Feasible study
(2) Design — Procurement (small project / Model)
(3) construction — Acceptance
(4) Operation — Maintenance.