BT3751-DOWNSTREAM PROCESSING

UNIT – I

PART – A

DOWNSTREAM PROCESING

1. Introduction to downstream processing principles characterstics of biomolecules and bioproceses.
2. Cell discriptiont for product release –mechanical, enzymatic and chemical methods.
3. Pretorcal and stabilization of bio products.

1. Name any three molecules manufactured by fermentation.

Antibiotics, Aminoacids, Enzymes, organic acids.

2.Write the spectrum of separations used in biotechnology.

1. Physical separtions.
2. Equilibrium controlled separations
3. Rate controlled seperations.

3. Write any two design questions to improve the sepcoution process.

1. What is the value of the product?
2. What is an acceptable product quality?

4. Write the foursteps in the bioseparation process.

1. Removal of insolubles
2. Isolation of products.
3. Purification
4. Polishing

5. What is the principle used in Osmotic shock and enzyme digestion?

Osmotic shock – Osmotic repture of membrane

enzyme digestion -Cell wall digisted providing disruption

6. Name any two chemical methods for cell disruption.

1. Osmoticshock
2. Enyzmedigestion

7. Name any two mechanical methods for cell disruption.

1. Homogenization
2. Grinding

8. Give two examples for solubilization and liquid dissolution.

1. Bile salts acting on E-coli
2. Toluenc disruption of yeast

9. Name the layers of gram negative all.

1. Outer layer
2. peptidoglycan
3. Plasmamembrane

10. Write short notes on solubilization.

A concentrated detergent solution is added to about half the solution's volume of cells. The detergent disrupts the cell membrane. The resulting suspension can be centrifuged to remove cell fragments.

11. Explain Schmidl number.

$$\boxed{N_{sc} = \mu / \delta D}$$

It gives the relative speed of momentum transport to diffusive transport.

12. Explain Sherwood number.

$$N_{sh} = \frac{kd}{D}$$ It is used to correlate results in extraction and chromotagraphy

13. Define Reynold's number.

$\frac{D \gamma \delta}{\mu}$ It describes the nature of flow, whether it is laminar or turbulent.

14. What is principle of alkali treatment?

Saponification of lipids solubilizers membrane.

15. What is Cell disruption?

Bioseperations usually begin with the separation of biomass from the broth and the trapped material is released by rupturing the cell wall which is also called as cell disruption.

16. What are the solvents used in lipid dissolution?

1. Chlorobenzene
2. Cumene.

PART – B

1. Briefly explain the characteristics of Bioseparations.

CHARACTERISTICS OF BIOSEPARATIONS

A chief characteristic of biotechnology is the tremendous variety of products which are produced. A typical petrochemical company makes about 10 products, but a typical drug company will make more than 200. To be sure, all 200 products may not be exclusively made biochemically, but many will be partially biological converted.

The diversity of these products can be illustrated in Table. Even this list is 10 years old, older than many current biotechnology companies. If we made a more current list, we would add genetically engineered insulin, human and bovine growth hormones, and interferons. The lists get longer daily.

The diversity of products spawns the broad spectrum of separation methods used. Comparison of separation processes used in the fermentation industry with more exhaustive classifications gives the result in table. This table shows that 80% of all separations classified are practical in biotechnology. All common modes of operations are used: steady and unsteady states: batch and continuous equipment :cocurrent and counter-current contacting.

Molecular Type	**Number of Species**
Antibiotics	85
Amino acids	18
Enzymes	15
Organic acids and solvents	11
Vitamins, yeast, growth factors, nucleotidies	6
Miscellaneous –dextrans, steroid biooxidations	8
	143

The scale of operation varies tremendously. In the early stage of development the objective will be demonstrate the proposed process, to gain processing information, and to prepare relatively small quantities for subsequent clinical trails and marketing evaluations. This work will be conducted in the laboratory and the pilot plant. Later, the objective will be scale-up and

introduction of the process to large scale production. This effort will be conducted in the pilot plant and the commercial facilities.

2. Write the design questions to improve the separation process.

1. What is the value of the product?

2. What is an acceptable product quality?

3. Where is the product in each process stream?

4. Where are the impurities in each process stream?

5. What are the unusual physicochemical properties of the product and the principal impurities?

6. What are the economics of various alternative separations?

3. Briefly discuss the four steps used in the bioseparation process.

1. Remote of insolubes.

Filtration and centrifugation are the principal unit operations used in this segment. Relatively little product concentration or improvement of product quality occurs.

2. Isolation of Products.

The steps, which are relatively nonspecific remove materials of widely divergent properties compared to the desired product. Appreciable concentration and product quality increases usually occur. Adsorption and solvent extraction are typical.

3. Purification.

These processing techniques are highly selective for the product and remove impurities of similar chemical functionally and physical properties. Chromatography, electrophoresis, and precipitation are good examples.

4. Polishing.

The end use of the product dictates the final sequence utilized. Crystallization is often key. Most products must also be dried.

4. Tabulate the processing profile and characteristics of antibiotics.

Processing Profile, Characteristic of Antibiotics:

	Product		
Step	**Typical process**	**Conc.(g/liter)**	**Quality (%)**
Harvest broth	Fermentation	0.1-5	0.1-1.0
Removal of insolubles	Filtration	1.0-5	0.2-2.0
Isolation	Extraction	5-50	1-10
Purification	Chromatography	50-200	50-80
Polishing	Crystallization	50-200	90-100

The concentration and quality shown are relative measures, intended as illustrations. The quality may refer to chemical purity, to activity, or to efficacy.

5. Draw the flowchart for ethanol fermentation.

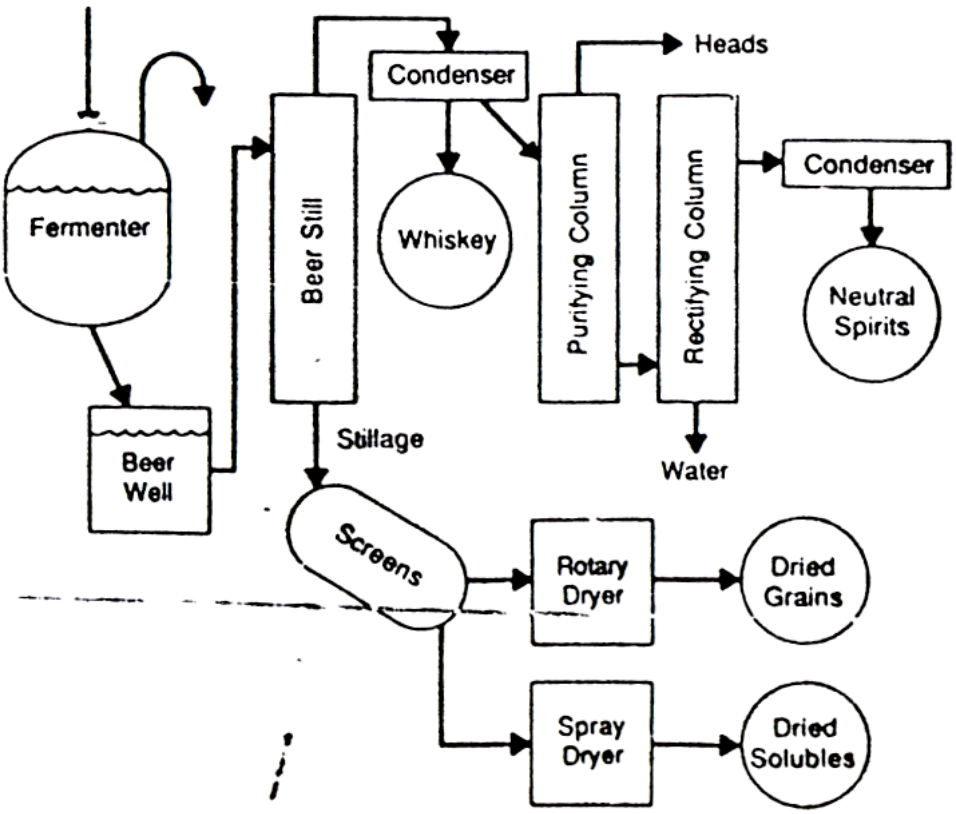


Figure: Ethanol from fermentation. In this process, ethanol and water are removed from a fermentation beer. This initial distillate is then further purified.

PART - C

1. Draw the flow chart for penicillin productions.

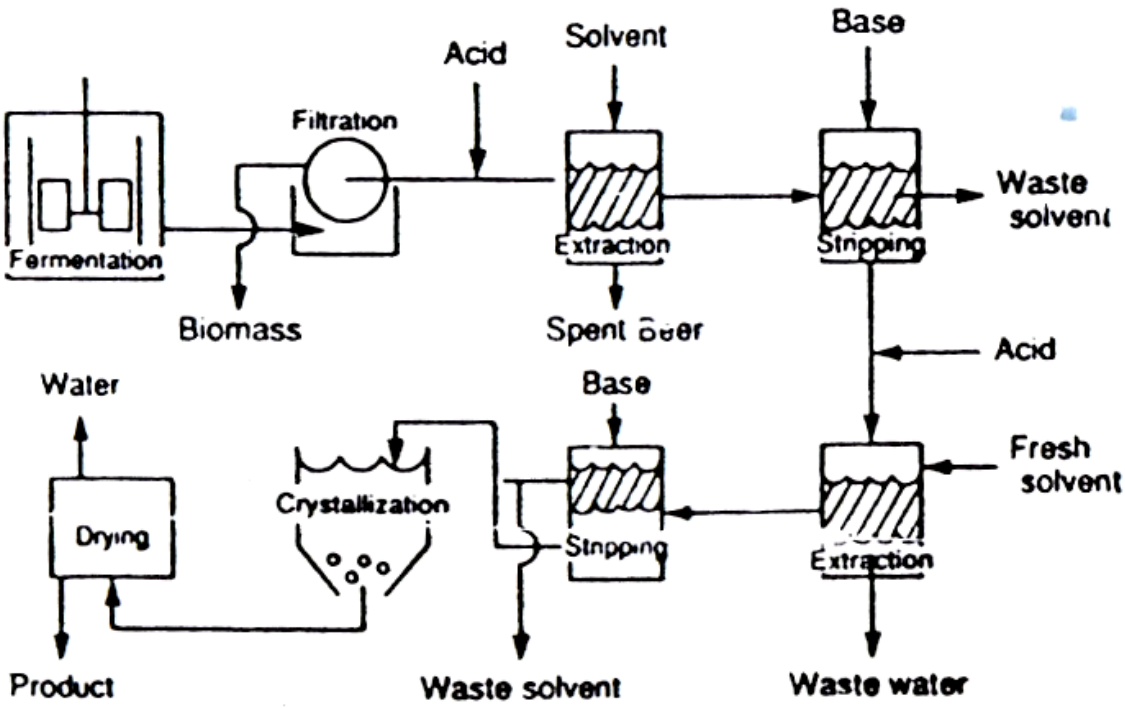


Figure: Penicillin production. After fermentation, the biomass is separated by filtration. The antibiotic which is in the filtrate, is isolated and purified by extraction. If then is polished by crystallization and dried.

2. Explain in detail about Cell Membrane.

At this point, we pause briefly to explore the physical structure of microbial membranes and the complexity of the problems which we face. At present, knowledge of this general structure does not provide a direct guide to methods of cell rupture. In the future, it may. As a result, we feel that a synopsis has merit. In this synopsis, we emphasize Gram-negative prokaryotes. Such cells have no nuclei: Their genetic factors are carried in a single strand of DNA. The best example of this type of cell is Escherichia coli, the host organism for many efforts in biotechnology. This is the cell which produces most recombinant products developed to date.

The basic cell envelope for Gram-negative cells, shown in figure has three layers. The outer

layer, about 8 nm thick, consists of a polymer containing both protein and lipopolysaccharide. The second thinner layer of peptidoglycan, exists in one form or another in virtually all species. Below this second layer is a gap, called the periplasmic space, which is also 8 nm thick. Enzymes are often located in this gap. Gram-positive procaroytes, shown in figure are missing the first outer layer, but have both the second peptidoylycan layer and the periplasmic space.

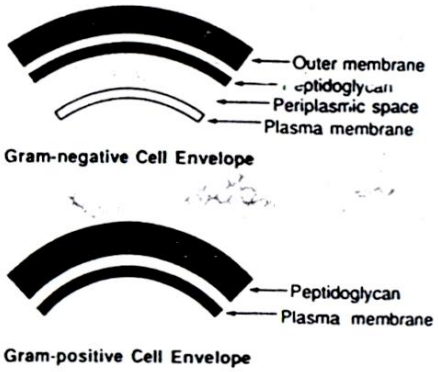


Figure: A schematic picture of the cell wall. Procaryotic cells with wall like these have no nucleus, but carry their genetic information in a single strand of DNA.

The third membrane layer, called the plasma membrane or the inner membrane, is common to both Gram-positive and Gram-negative organisms. It consists largely of phospholipids, but also contains dispersed proteins and metal ions. These lipid molecules have two pars, a hydrophobic part and a hydrophilic part. The hydrophobic part or "tail" often contains two alkyl groups; and the hydrophilic part of "head" often includes a charged group, a zwitterions, or an alcohol. In this inner membrane, the phospholip id group, a zwitterions, or an alcohol. In this inner member, the phospholipids tails aggregate, and the heads are exposed to the water, as shown in figure. The result in a lamellar bilayer.

These three layers have different functions. The outer membranes and the peptidogylycan layer provide mechanical strength; it is their rupture which is a central subject of this chapter. The weaker plasma membrane – the innermost layer-controls the permeability of the cell, including transport of nutrients into the cell's interior and export of metabolites into the surrounding solution.

This cell interior, called the cytoplasm, is an aqueous solution of salts, sugars, amino acids, and biopolymers. The biopolymers include proteins many of them enzymes; ribonucleic acid (RNA) ; and deoxyribonucleic acid (DNA). In naturally occurring prokaryotes, the proteins are in solution; but in many genetically modified prokaryotes, excess protein is synthesized and precipitated within the cytoplasm. Often, we seek to rupture the cell wall solely to recover this protein. In other cases, we want to remove only some of the layers to release specific enzymes.

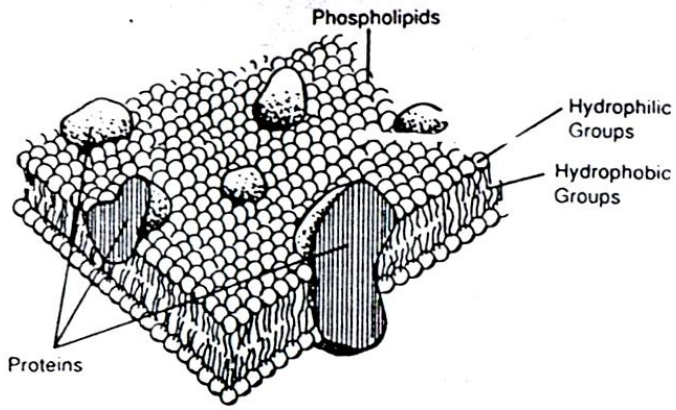


Figure: A more detailed picture of the plasma membrane. The membrane consists largely of zwitterionic phospholipids, but it also contains a significant amount of protein.

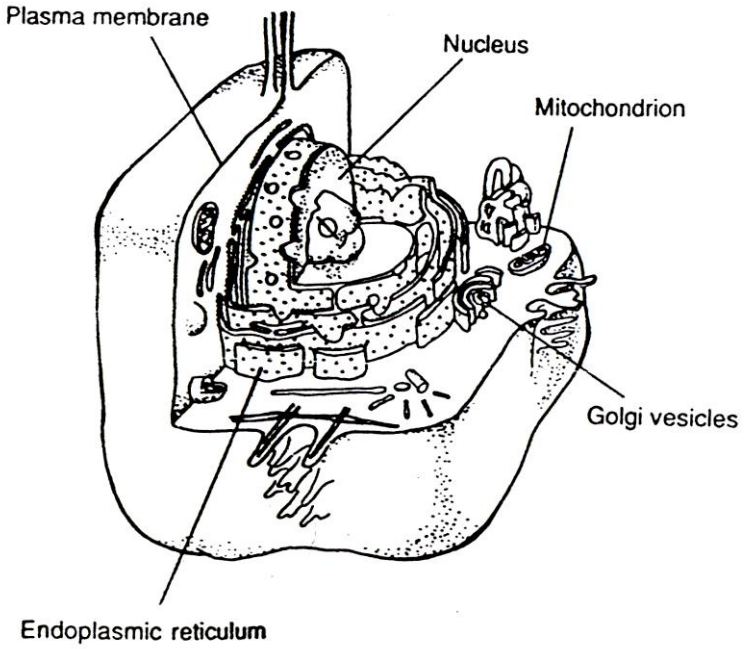


Figure: A curcaryotiuc cell like these carry their DNA in a nucleus and have more complex walls than those in prokaryotic cells.

Eucaryotic cells, those with true nuclei, are structurally more complicated than prokaryotes. These cells exemplified by the yeast in figure have a membrane surrounding the cell which is similar in structure to the prokaryote membrane. Eucaryote membrane apparently do contain steroids, which are absent in prokaryote membranes. In addition to this surrounding membrane, the cells contain organelles. Each organelle has a specialized function: for example, the mitochondria are responsible for respiration and the nucleus contains the DNA (as chromosomes).

Each structure is surrounded by a membrane which is similar to the inner plasma membrane of prokaryotes. The increased structural complexity of the eukaryotes is not mirrored by increased chemical complexity.

3. Explain any one chemical methods for cell disruption in detail.

Osmotic Shock:

The simplest of the three major chemical is osmotic shock. This is nothing more than dumping a given volume of cells into pure water- often about twice the volume of cells. The cells swell because they contain solutes which cause an osmotic flow of water into the cells. In some cases, they swell so much that they burst. Their contents, released into the surrounding solution, can now be separated using the methods in following chapters. The susceptibility of cells to lysis depends strongly on their type, Red blood cells are easily lysed. Animal cells often can be lysed, but only after animal tissue has been mechanically minced or homogenized, as described in section. Plant cells are much more difficult to lyse, for their cell walls often contain strong woody material which is relatively impermeable to osmotic flow.

The osmotic flow involved comes from the osmotic pressure, which is surprisingly large. To estimate the size of this pressure, we turn to the definition of chemical equilibrium, which states that the chemical potential of water μ_{H_2O} must be constant.

$$\mu_{H_2O} \text{ (outside)} = \mu_{H_2O} \text{ (inside)} \qquad \ldots(1)$$

The chemical potential of the pure water outside must include a reference value and a pressure correction; the corresponding potential inside involves a reference value, pressure correction, and a correction for solution concentration. For an ideal incompressible soluble, these corrections convert into the following:

$$\mu^0_{H_2O} + \overline{V}_{H_2O} p_{out} = \mu^0_{H_2O} p_{in} + RT \ln(1-x_1) \qquad \ldots.(2)$$

Where $\mu^2_{H_2O}$ is the reference value, $\overline{V}_{H_2O}$ is the partial molar volume of water, and x_1 is the total mole fraction of solutes inside the cell. If they cell's contents are a dilute solute , $\overline{V}_{H_2O}$ is almost equal to the molar volume of water V_{H_2O}, and x_1 is small. Thus

$$P_{out} - P_{in} = \frac{RT}{\overline{V}_{H_2O}} \ln(1 - x_1)$$

$$= \frac{RT}{V_{H_2O}} (-x_1 - .....)$$

$$= -RT_{c_1} + ... \qquad ...(3)$$

This relation is called van't Hoff's law.

Thus at equilibrium, the pressure outside the cell must be less than that inside. If this is not the case, then water will flow into the cell and potentially lyse the cell. We can use Equation (3) to estimate the size of the pressure. Many cells have a solute concentration roughly equivalent to 0.1 M NaCl, or 0.2 M solutes. Thus from the processing.

$$p_{out} - p_{in} = -RT_{c_1}$$

$$= -82 \frac{cm^3 atm(300°K)}{g\ mol °K} \frac{0.2\ g\ mol}{1000\ cm}$$

$$= -5\ atm \qquad ...(4)$$

This osmotic pressure is, for us, always surprisingly large. This large pressure is what can lead to cell repture.

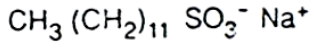
4. Explain the Solubilization method of all disruption.

The second major method of chemically rupturing cells is solubilization by detergents. Typically, a concentrated detergent solution is added to about half the solution's volume of cells. The detergent disrupts the cell membrane. The resulting suspension can be centrifuged to remove cell fragments, and then run through an adsorption column or an extractor to isolate the product.

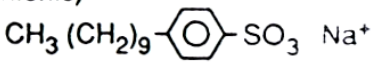
The reason that solubilization is effective lies in detergent chemistry. This chemistry depends on detergent structures like those in figure. All these structures have a hydrophilic portion, which is often ionic, and a hydrophobic part, which is frequently a hydrocarbon. As a result, these detergents are all amphipathic, capable of interacting with both water and lipid.

This amphipathic nature holds whether the detergents are anionic, cationic, or nonionic. All types are illustrated in the figure. Sodium dodecylsulfate (SDS), which is the example given, is the most widely studied of the anionic detergents. The anionic materials also include the soaps, which are the salts of fatty acids. Because soaps depends on a carboxylic acid group, they are effective detergents only at high pH, where this group remains ionized. They are ineffective in hard water, where calcium ions can react with them to form insoluble precipitates.

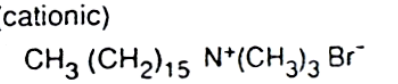
Sodium Dodecylsulfate (SDS)
(anionic)



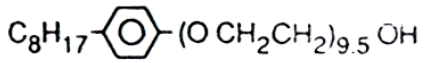
Sodium Sulfonate
(anionic)



Cetyltrimethylammonium Bromide (CTAB)
(cationic)



Triton X-100
(nonionic, polydisperse)



Sodium Taurocholate
(anionic)

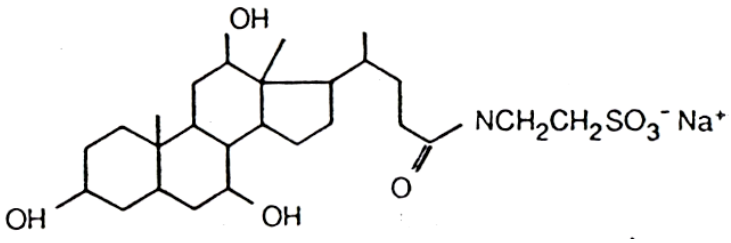


Figure: Chemical structures of selected surfactants. The first four can be easily synthesized, and are basic to a variety of commercial detergents. The taurocholate, bile salt, is available from material sources, and is much more expensive.

The disadvantages of conventional soaps can be avoided by replacing the carboxylic acid group with a sulfate. The sulfate is most current laundry detergents, again those purchased at the supermarket, is attached to a liner alkyl chain. The sulfate can also be attached to a benzene ring, making a sulfonate like that shown in Figure. Such sulfonates are more effective at cell rupture than alkyl sulfates are; perhaps because of this, sulfonates are not easily degraded microbiologically and so are no longer commonly used in laundry detergents.

Cationic detergents largely are based on tetralkylammonium salts. Cetyltrimethylammonium bromide, the example in figure, is typical: It contains one long alkyl tail (the 16 carbon "cetyl) and 3 methyl groups all attached to a positively charged nitrogen atom. The counterion is often a halide. In the supermarket, these detergents are most frequently found in shampoos, correctly suggesting that they will offer a more gentle means of cell rupture. In passing we should note that cationic detergents with two longs chains are often oil soluble, and are implicated in the formation of membrane pores. They are rarely been tested as a route to cell rupture.

5. Explain Lipid dissolution.

Lipid dissolution

We have procrastinated writing the few paragraphs on this last chemical topic because we are frustrated by it. Our frustration comes from knowing that this method is important and yet being unsure how to describe it in general terms. Please do not take our resultant brevity as an implication that this method is not of major value. Its value is great, and will become greater; but it requires experimentation.

The method is simple: Add to a cell suspension a volume of toluene about equal to 10% of the biomass. The toluene is absorbed into the cells wall lipids. Swells the wall, ruptures it. The cell's contents are released into the surrounding broth, and hence can be separated.

Solvents other than toluene are also effective. Benzene works well, but it is caricionGenic and of high volatility. (Toluene is also carcinogenic, but is les volatile). Chlorobenzene, cumene, and xylenes are also effective. Alkanes like decane work less frequently, but higher alcohols like octanol can be effective.

There are not substitutes for experiment. One good way in choosing solvents for experiments is to look at their solubility parameters, which are tabulated in handbooks. In theory, these parameters will reflect the solvent-lipid interactions, and underlie such concepts as the heat of mixing. In practice, solvent with similar solubility parameters should attack cells in a similar way. Ideally, we should choose solvents whose solubility parameters match those of the wall lipids but are far from those of desired products locked within cells, but we rarely know how to do this. Again, there are not substitutes for experiment.

6. Explain mechanical method of cell disruption.

The mechanical method shown in table can be divided into two groups, those appropriate for small scale and those suitable for larger scale. The small scale methods are the first three given: homogenization in a Waring blender, grinding with abrasives, and ultroasonication. The first, homogenization, is effective with mycelial organisms and with other animal cells or tissues. The remaining two, grinding and ultrasonication, are effective with most cell suspensions. All represent laboratory methods which are easily and quickly tested by experiment.

The remaining two methods, homogenization and crushing, are both more easily adopted to larger scales. Both are common unit operations in the chemical process and food industries. And so have been the subject of extensive engineering. One application to biological material is illustrated in figure. This figure shows particle size and enzyme activity plotted versus time.

Apparent cell size drops from its initially high value to a constant lower value after 30 min of homogenization. This drop is caused by cell wall rupture. The activity is solution of the enzyme fumarase starts near zero, and then rises to a high constant value, mirroring the drop in particle size. In the product is fumarase, then 30 min of homogenization is reasonable.

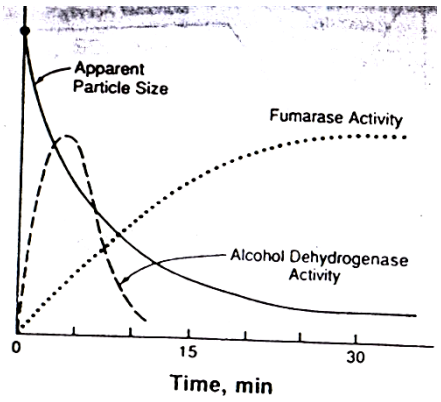


Figure: Homogenization versus time. Mechanical disruption of cells reduces particle size but may also denature some of the product in the cells.

The conclusions are very different for alcohol dehydrogenase. The activity of this enzyme also starts at zero and rises quickly, but it reaches a maximum around 5 min and then drops precipitously. The reason for this is unknown. On guess would be that the enzyme is weakly bound near the cell exterior and so is easily removed by shear; it is then irreversibly denatured by continuing shear. In any case, if the product is this dehydrogenase, then 30 min of homogenization is folly.

In most cases, we will have made some experiments on mechanical cell rupture, and will want to extrapolate these results to other times and process conditions. To do so, many assume that the data in figure fit the equation.

$$\frac{[\text{product concentration}]}{[\text{maximum concentration}} = 1 - e^{-t/\tau} \qquad \ldots(1)$$

where τ is a time constant for cell rupture or for product release.

UNIT – II

PART – A

1. What is depth filtration?

Solids are trapped in the interstices of the medium. As solids accumulate, flow approaches zero and the pressure drop across the bed increases (Eg) Sand and cartridge filtration.

2. Write the Poiseuille's equation.

$$\frac{dv}{A.d\theta} = \frac{P}{\mu\left[\alpha\left(\frac{W}{A}\right)+r\right]}$$

V= volume of filtrate
A= filter are a surface
θ=time
P= pressure across filter medium
α= average specific cake resistance
w= weight of cake
r= resistance of filter medium
u= viscosity

3. Write the formula for Poiseuille's equation.

$$\frac{\text{Flow Rate}}{\text{Unit Rate}} = \frac{\text{Force}}{\text{Viscosity}\left[\begin{array}{l}\text{Cake Resistance +}\\ \text{filter medium resistance}\end{array}\right]}$$

4. What is cake compressibility?

The specific cake resistance is a function of compressibility of the cake.

$$\boxed{\alpha = \alpha' P^{s}}$$

$$\alpha' = \text{constant}$$

5. Short note on Diaphragm pumps.

1. Diaphragm pumps offer very gentle handling of slurries and are in expensive and mobile.

2. The pulsating flow can cause fading and distribution problem in some filtration systems.

6. Short note on centrifugal pumps.

- Most common source of particle attrition problems is the centrifugal pump.
- The high shear forces inherent to these pumps, Particularly in the eye of the impeller, make some crystal damage inevitable in all but the toughest crystals.

7. Short notes on Positive displacement pumps.

The minimal shear operation of progressive cavity or lobe pumps make them ideal for slurries.

8. What is porosity?

$$\text{Porosity} = \frac{\text{Volume of voids}}{\text{Volume of filter cake}}$$

9. Short notes on filter aid.

Slurry additives such as diatomaceous silica or perlite (pulverized oock) are employed to aid filtration.

Diatomite is a scdimentary oock containing skeletons of unicellular plant organisms (diatoms).

10. Filter media.

Filter media are required in both cake filtration and depth filtration.

Essential to selection of a filter medium is the solvent composition of the slurry and washes, and the particles size retention required of the solids.

11. Short notes on equipment selection.

Every – increasing environmental concerns may make it necessary to evaluate the existing process to reduce emissions, operator exposure, limit waster disposal of filter aid, or reduce wash quantities requiring solvent recovery or wash treatment.

12. How will you use continuous and Batch filtration together.

Continuous and batch equipment can be used in the same process by incorporating holdup tanks, vessels or hoppers between them.

13. Short notes on Rotary vacuum filter.

Raw fermentation booth is an example of large volume production Rotary drum vacuum filters hare traditionally ban found in this service. Slow – setting materials or more difficult filtrations with larges cake production requirements are typical application.

14. Short notes on Nutsches.

The nutsche filter is increasingly prevalent in post crystallization filtrations. Relatively fast filtrations with predictable crystal structures often found in the intermediate and final step purifications of antibiotic drugs.

15. Short notes on cross flow filtration.

Cross flow filtration also known as tangential flow filtration. The technique was applied to the concentration and fractionation of macromolecules commonly recognized as ultra filtration.

16. Short notes on factors affecting the characteristics of filters.

1. The nature of the membrane material
2. Pore dimensions.
3. Pore size distributions
4. porosity

17. What is continuous mode?

When large volumes processed the batch feed and bleed system is replaced with a continuous system. The size of the feed tank is much smaller compared to that of batch system.

18. What is Dia filtration?

The product purification or recovery objective in most ultra filtration operations is achievable by concentrating the suspended particles or micro solutes retained by the membrane while allowing almost quantitative permeation of soluble products into the permeate.

19. What are the parameters which affect for filter performance?

1. Membrane Pore Diameter or Molecular weight cut off
2. Cross flow velocity
3. Concentration of solute or particle loading
4. Membrane fouling

20. Explain trans membrane pressure.

It is the average driving force for permeation across the membrane. Neglecting osmotic pressure effects for most MF/UF applications, it is defined as the difference between the average pressure on the feed side and that on the permeate.

PART – B

1. Briefly explain the theory of filtration.

CAKE FILTRATION

Rates of filtration are dependent upon the driving force of the piece of equipment chosen and the resistance of the cake that is continually forming. Liquid flowing through a cake passes through channels formed by particles of irregular shapes.

THEORY

Flow Theory

Flow rate through a cake is described by Poiseuilles' equation:

Eq(1) $$\frac{dV}{Ad\theta} = \frac{P}{\mu\left[\alpha\left(\frac{W}{A}\right)+r\right]}$$

V= volume of filtrate
A= filter area surface
θ = time
P= Pressure across filter medium
α =average specific cake resistance
w= weight of cake
r= resistance of the filter medium
u= viscosity

In other words,

$$\frac{\text{Flow Rate}}{\text{Unit Area}} = \frac{\text{Force}}{\text{Viscosity}[\text{Cake Resistance} + \text{Filter Medium Resistance}]}$$

Cake Compressibility

The specific cake resistance is a function of the compressibility of the cake.

Eq(2) $\alpha = \alpha' P^s$
Where α' = constant

As s goes to 0 for incompressible materials with definite right crystal line structures, α′ becomes a constant.

For the majority of products, resistance of the filter medium is negligible in comparison to resistance of the cake, thus Equation (1) becomes

Eq(3) $$\frac{dV}{d\theta} = \frac{AP}{\mu\alpha(W/A)}$$

Incompressible cakes have flow rates that are dependent upon the pressure or driving force on the cake. In comparison, compressible cakes, i.e., where s approaches 1.0, exhibit filtration rates that are independent of pressure as shown below.

Eq(4) $$\frac{dV}{d\theta} = \frac{A}{\mu\alpha(W/A)}$$

The above equations are detailed in Perrry's chemical Engineer's Handbook[1]

Compressible cakes are composed of amorphous particles that are easily deformed with poor filtration characteristics. There are no defined channels to facilitate liquid flow as in incompressible cakes.

Fermentation mashes are typical applications of compressible materials, usually having poor filterability in contrast to purified end products that are posterystallization. These products precipitate from solutions as defined crystals.

2. Briefly discuss about three pumps used in filtration.

Diaphragm pumps. These offer very gently handling of slurries and are in inexpensive and mobile. However, the pulsating flow can cause feeding and distribution problems in some types of filtration system, e.g., conventional basket centrifuges. They can also interfere with process instrumentation e.g.. flow meters and load cells.

Centrifugal pumps: Probably the most common source of particle attrition problems is the centrifugal pump. The high shear forces inherent to these pumps, particularly in the eye of the impeller, make some crystal damage inevitable in all but the toughest crystals. This damage is exacerbated on recirculation loops, which involve multiple passes through the pump. Recessed impellers will reduce this damage, but will often still degrade particles to the point where filtration becomes very difficult.

Positive displacement pumps. The minimal shear operation of progressing cavity or lobe pumps make them ideal for slurries. The non-pulsating flow is beneficial in most processes, but they are significantly more expensive and less portable than diaphragm pumps.

3. Briefly discuss about filter aid and filter media.

FILTER AID

For amorphous materials, sludges or other poor filtering products improved filtration characteristics and/or filtrate clarity are enhanced with the use of filter aids. Slurry additives such as diatomaccous silica or perlite (pulverized rock), are employed to aid filtration. Diatomite is s sedimentary rock containing skeletons of unicellular plant organisms (diatoms)[2]. These can also be used to increase porosity of a filter cake that has a high specific cake resistance.

$$\text{Porosity} = \frac{\text{Volume of Voids}}{\text{Volume of Filter cake}}$$

Addition of filter aid to the slurry, in the range of 1-2% of the overall slurry weight, can improve the filtration rates. Another rule of thumb is to add filter aid equal to twice the volume of solids in the slurry. By matching the particle size distribution of the filter aid to the solids to be filtered. Optimum flow rates are achieved. One should also use 3% of the particles above 150 mesh in size, to aid in filtration.[3].

Precoating the filter medium prevents blinding of the medium with the product and will increase clarity. Filter aid must be inert material. However, there are only a few cases where it cannot be used. For example, waste cells removed with filter aid cannot be reused as animal feed. Filter aid can be significant cost, and therefore, optimization of the filtration process is necessary to minimize the addition of filter aid or precoat. Another possible detriment is that filter aid may also specifically absorb enzymes.

A typical application for these filter aids is the filtration of solids from antibiotic fermentation broths, where the average particle size is 1-2 micron sand solids concentration are 5-10%. Being hard to filter and often slimy, fermentation broths can also be charged with polymeric bridging agents to agglomerate the solids, thereby reducing the quantities of filter aid required.

FILTER MEDIA

Filter media are required in both cake filtration and depth filtration. Essential to selection of a filter medium is the solvent composition of the slurry and washes, and the particle size retention required of the solids.

Choice of the fabric, i.e., polypropylene , polyester, nylon , etc. is dependent upon the resistance of the cloth to the solvent and wash liquor used. Chemical resistance charts should be referenced to choose the most suitable fabric. The temperature of the filtration must also be considered.

Fabrics are divided into three different types of yarns: monofilament, multifilament, and spun. They can be composed of more than one of these types of fabric. Monofilaments are composed of single strands woven together to form a translucent or opaque fabric. Very smooth in appearance its weave is conducive to eliminating blinding problems.

Multifilament cloths are constructed of a bundle of fibers twisted together. Only synthetic materials are available in this form, since long continuously extruded fibers must be used. Spun fabrics are composed on short section of bound fibers of varying length. Retention of small particles is increased as the number of fibers or filaments in a bundle increases. The greater the amount of twist in the yarn, the more tightly packed the fabric which contributes to retention. The twist will also increase the weight of the fabric and frequently extends filter cloth lifetime.

4. Briefly explain Membrane fouling.

Membrane Fouling.

Pretreatment of the membrane of feed solution prior to filtration may be desirable within allowable limits. The various treatment options are discussed in. At the start of a filtration run, the solute or solids concentration is relatively small and progressively builds as the permeate is removed from the system. If a substantial flux decline is observed at low solids concentration, membrane fouling aspects are believed to be important. A flux decrease with an increase in solids concentration is efficient fluid hydrodynamics and/or backpulsing. [3][22][23]

Several approaches have been developed to control membrane fouling. They can be grouped into four categories☹a) boundary layer control;[20][24]-[26] (b) turbulence inducers/generators;[27] (c) membrane modifications;[28]-[30] (d) use of external fields.[31]-[34] In CFF membrane, fouling can be controlled utilizing a combination of the first three approaches (a, b and c). The external field approach has the advantage of being independent of the hydrodynamic factors and type of membrane material.[35]

Membrane fouling is primarily a result of membrane-solute interaction.[36] These effects can be accentuated or minimized by proper selection of membrane material properties such as hydrophobicity/hydrophilicity or surface charge, adjustment of pH, ionic strength and temperature leading to solubilization or precipitation of solutes. Increased solubilization of a foulant will allow its free passage into the permeate. If this is undesirable, precipitation techniques may be used which will enhance the retention of foulants by the membranes. Membrane fouling is generally irreversible and requires chemical cleaning to restore flux.

It is important to recognize that fouling in bioprocessing differs from that occurring with chemical foulants. Biofouling originates from microorganisms. Microbes are alive and they actively adhere to surfaces to form biofilms. Thus, in addition, to flux decrease there may be significant differences in solute rejection, product purity, irreversible membrane fouling resulting in reduced membrane life. For economic viability of CFF it is imperative that a good and acceptable cleaning procedure is developed to regenerate fouled membranes without sacrificing membrane life.

5. Briefly explain concentration polarization.

Concentration Polarization.

The concentration of the species retained on the membrane surface or within its porous structure is one of the most important operating variables limiting flux. Concentration effects in MF/UF can be estimated by using the following most commonly used correlation.[12][37]

$$J = k \ln [C_g/C_b]$$

where

J = flux
k = mass transfer coefficient
C_g = gel concentration of at the membrane surface
C_b = bulk concentration of solute retained by the membrane

In membrane filtration, some components (dissolved or particulate) of the feed solution are rejected by the membrane and these components are transported back into the bulk by means of diffusion. The rate of diffusion will depend on the hydrodynamics (laminar o turbulent) and on the concentration of solutes. If the concentration of solute at the surface is above saturation (i.e., the solubility limit) a"gel" is formed. Thus increases the flow resistance with consequential flux decrease. This type of behavior, for example, is typical of UF with protein solutions.

In practice, however there could be differences between the observed and estimated flux. The mass transfer coefficient is strongly dependent on diffusion coefficient and boundary layer thickness. Under turbulent flow conditions particle shear effects induce hydrodynamic diffusion of particles. Thus, for micro filtration, shear-induced diffusivity values correlate better with the observed filtration rates compared to Brownian diffusivity calculations.[5]. Further, concentration polarization effects are more reliably predicted for MF than UF due to the fact that macro solutes diffusivities in gels are much lower than the Brownian diffusivity of micron-sized particles. As a result, the predicted flux for ultra filtration is much lower than observed, whereas observed flux for micro filters may be closer to the predicted value.

Typically MF fluxes are higher than those for UF due to their higher pore diameter values which contribute to higher initial fluxes. However, polarization effects dominate and flux declines with increase in concentration (or% recovery) more sharply in MF than in UF, in general accordance with Eq.(4) under otherwise similar conditions. Figure show the typical dependence of flux on concentration.[4] Higher the concentration of the retained species on the membrane compared with its initial value, the higher % recovery will be dependent on the ratio of the batch volume to its final value for batch filtration or the ratio of concentration in permeate to that in the feed for continuous filtrations.[38][39].

PART – C

1. Explain Rotary Vacuum drum filter with a neat diagram.

ROTARY VACUUM DRUM FILTER:

Operation and Applications

Raw fermentation broth is an example of a large volume production Rotary drum vacuum filters (RVF's) have traditionally been found in this service. Slow-settling materials or more difficult filtrations with large scale production requirements are typical applications for this type of equipments. For an overview of filter selection versus filtering rate. Which is excerpted by special permission from Chemical Engineering Deskbook. Issue, February 15,1971, by McGraw Hill Inc., New York, NY 10020.

The basic principle on an RVF is a hollow rotating cylindrical drum driven by a variable speed drive at 0.1-10 revolutions per minute. One-third of the drum is submerged in a slurry trough. As it rotates, the mycelia suspension is drawn to the surface of the drum by an internal vacuum. The surface is the filter medium mounted on top of a grid support structure. Mother liquor and wash are pulled through the vacuum line to a large chamber and evacuated by a pump.

Applicable to a broad range of processes, e.g., pharmaceutical, starch ceramics, metallurgical, salt, etc., many variation of the RVF have been developed, however, the fundamental cylinder design remains the same. The cylinder is divided into compartments like pieces of a pie (see figure) and drainage pipes carry fluid from the cylinder surface to an internal manifold.

Filter diameters range from three to twelve feet, with face lengths of one to twenty-four feet, and up to 1000 ft^2 of filtration area.[5]. Filtration rates range from 5 GH per square foot to 150 GPH per square foot. Moisture levels are, of course dependent upon particle size distribution and tend to range from 25% to 75% by weight and cake thickness tends to be in the 1/8-1/2 inch range, as most applications are for slow-filtering materials.

With the exception of the precoat applications, RVF's do not usually yield absolutely clear filtrate. Although still widely used, rotary vacuum filters are, in some cases, being replaced by membrane separation technology as the method of choice for clarification of fermentation broths and concentrating cell mass. Membranes can yield more complete filtration clarification, but often a wetter cell paste.

The drum is positioned in a trough containing, the agitated slurry, whose submergence level can be controlled. As the drum rotates, a panel is submerged int eh slurry. The applied vacuum draws the suspension to the cloth, retaining solids as the filtrate passes through the cloth to the inner piping and subsequently, exiting the system to a vapor-liquid separator with high/low level control by a pump. Cake formation occurs during submergence. Once formed, the cake dewaters above the submergence level and is then washed, dewatered and discharged.

Discharge mechanisms will vary depending upon cake characteristics Friable, dry materials can use a "doctor" blade as in figure. Difficult filtrations requiring thinner cakes incorporate a string discharge mechanism. This is the primary method for starch and mycelia applications. A series of 1/2inch spaced strings rest on the filter medium at the two o' clock position. The cake is lifted from the drum as shown in figure. Fermentation broths containing grains, soybean hulls, etc., ar applications for this type of discharge mechanism. The solids may be used for animal feed stock, or incinerated. String or belt discharge mechanism facilitate cake removal and, therefore, can eliminate the need for filter aid.

Continuous belt discharge is employed for products that have a propensity for blind the filter medium. A series of rollers facilitate cake removal in this case.

Precoated rotary vacuum drum filters, are used by filtering a slurry of filter aid and water first, then subsequent product filtration. Difficult filtering materials, which have a tendency to blind, are removed with a doctor blade. Precoat is removed along with the slurry to expose a new filtration surface each cycle.

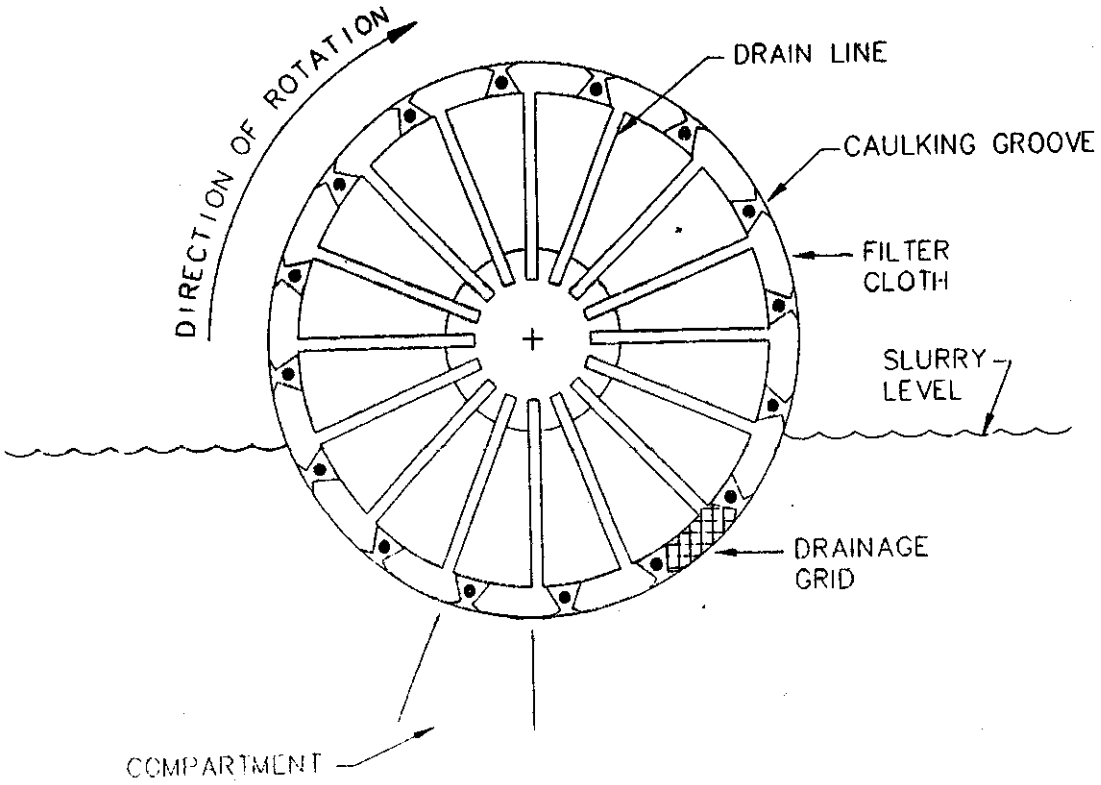


Figure 2. Rotary vacuum filter schematic.

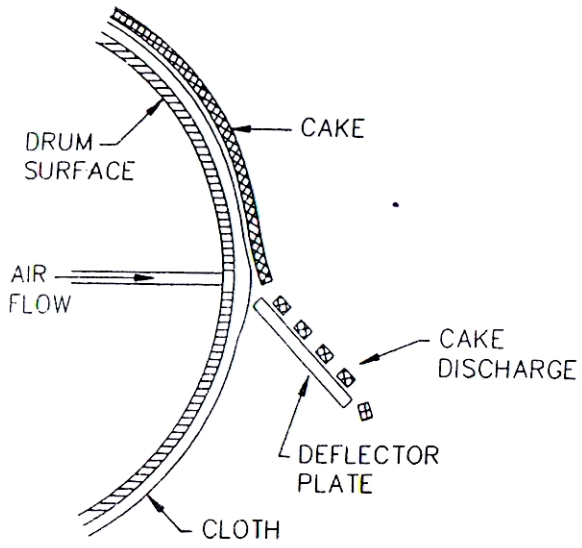


Figure: cake discharge mechanism

The progressively advancing blade moves 0.05 to 0.2 mm per-revolution . Vacuum is maintained throughout the cycle, instead of just during submergence, so that the precoat is retained. Once the precoat is expanded, the RVF must be thoroughly cleaned, and a fresh coat reapplied.

2. Explain Nutsches with a neat diagram.

NUTSCHES

Applications

The nutsche filter is increasingly prevalent in postcrystallization filtrations. It would not be used directly from the fermenter. Relatively fast filtrations with predictable crystal structures, often found in the intermediate and final step purification of antibiotic drugs, work well on this batch filter. Batch sizes range from 100 to 7500 gallons.

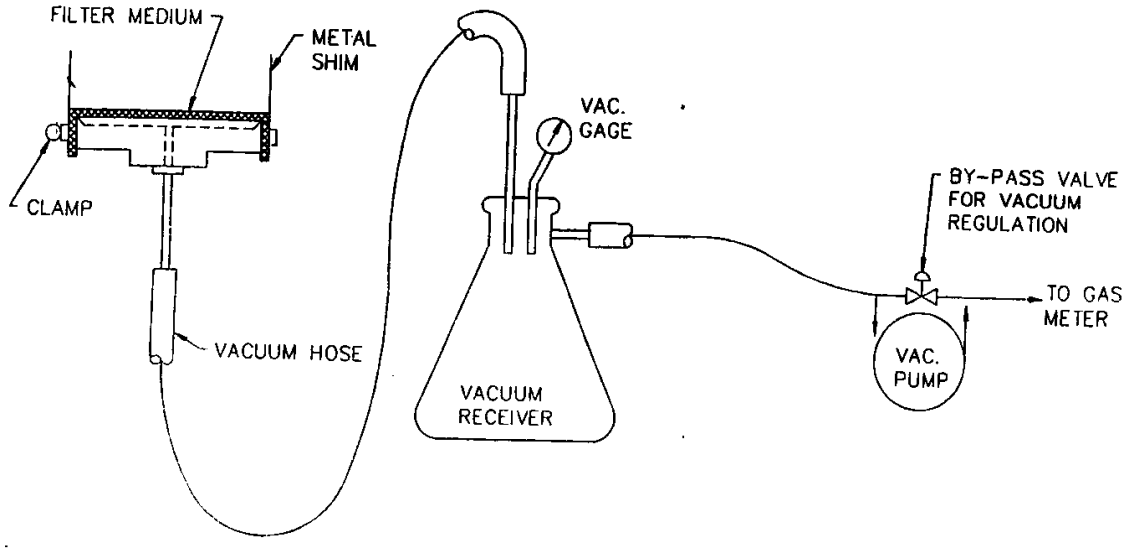


Figure: Pressure leaf test:

Operation:

The tem nutsche is derived from the German word for sucking. Vacuum is applied at the bottom of a vessel that contains a perforated plate. A filter cloth, screen , perforated plate, or porous ceramic plat may be the direct filtration medium. Subsequently, product should have lower cake resistance and well-defined crystal structures to facilitate separation. The driving force for the separation is vacuum and/or pressure.

With an agitated vessel, the blade can be used to smooth or squeeze the cake, eliminating cracks, when rotated in one direction or for reslurrying and/ or discharging the cake when rotated in the opposite direction. The rotation of the agitator can be by electric motor with variable speed drive; however, the translational movement is achieved by a separate hydraulic system. The agitator requires a stuffing box or mechanical seal for pressure or vacuum operation of the unit.

Filling is accomplished by a gravity feed or pump. Large cakes, in the 10-12 inch range, are developed. When plug flow displacement washing is not effective and as diffusion of impurities through the cake becomes difficult , reslurrying is the required method. Displacement washing is more efficient and minimizes wash quantities, however, may not always be possible. Filtering, reslurrying and refiltering can all be accomplished in the same unit. Thus achieving total containment.

The vessel can also be jacketed for heating and/ or cooling and the agitator blade heated. This design can now be reactor in combination with a filter-dryer or alone as a filer-dryer. This is particularly advantageous for dedicated production of toxic materials requiring an enclosed system. Operator exposure and product handling are minimized.

The nutsche can have limitations for difficult filtrations, as the thick filter cakes can impede filtration. A two-stage system for filtration and drying can offer greater flexibility in plant operations, especially if either the filtration of drying step is rate-limited. Predictable crystals that filter and dry well are the best applications for this all-encompassing system.

Mechanical discharge incorporating the agitator facilitates solids removal centrally or a side discharge is possible. A residual heel of product will be left as the agitator is limited on how close to the screen or filter medium it can go. Residual heels can be reworked by reslurrying or remain until the campaign changes. For frequent product changes, the nutsche can be provided with a split-vessel design. Upon lowering the bottom portion , free access to the inside of the vessel and the filter bottom itself for cleaning purposes is possible. Some manufacturers have air-knife designs that remove the residual heel. Heels as low as one-quarter inch can be obtained.

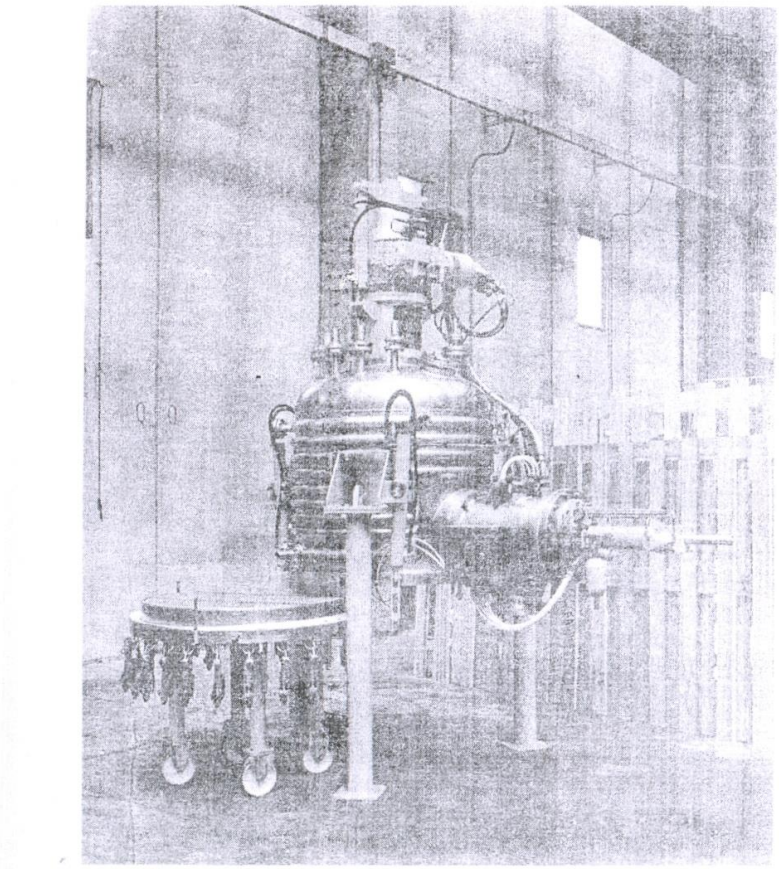


Figure 8. Agitated nutsche type pressure filter. *(Courtesy of COGEIM SpA)*

Figure: Agitated nutsche type pressure filter. (courtesy of COGEIM SpA).

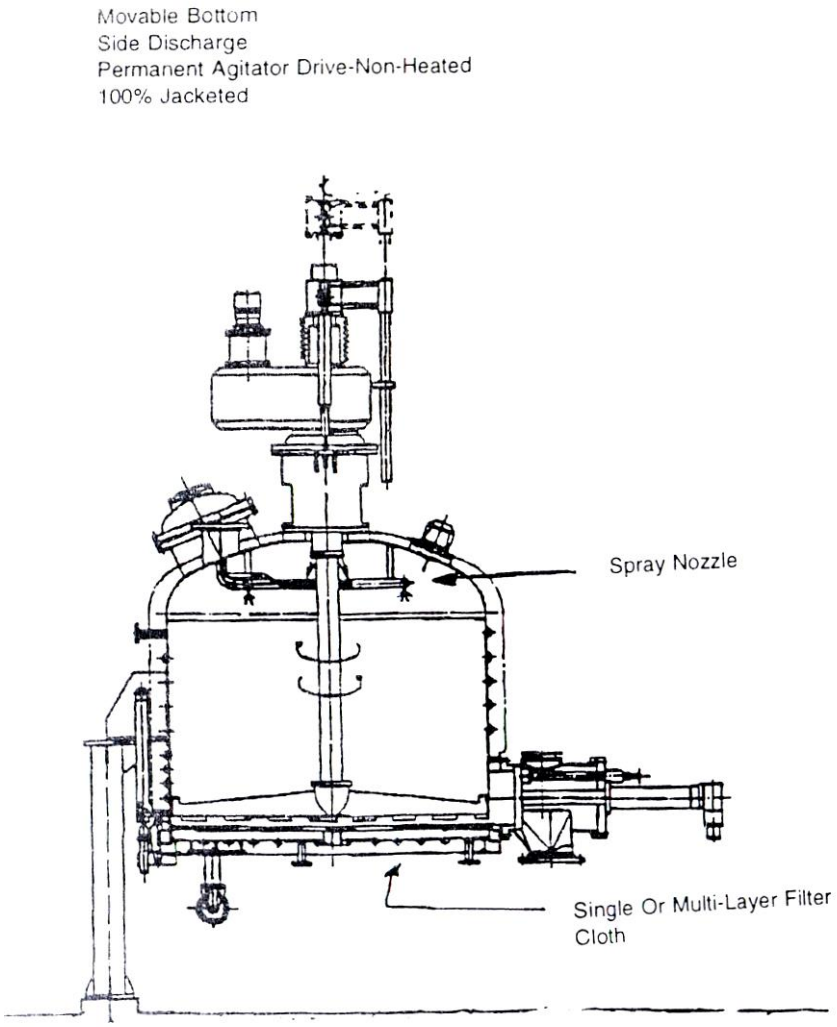


Figure: Agitated nutsche type pressure filter. (courtesy of COGEIM. SpA)

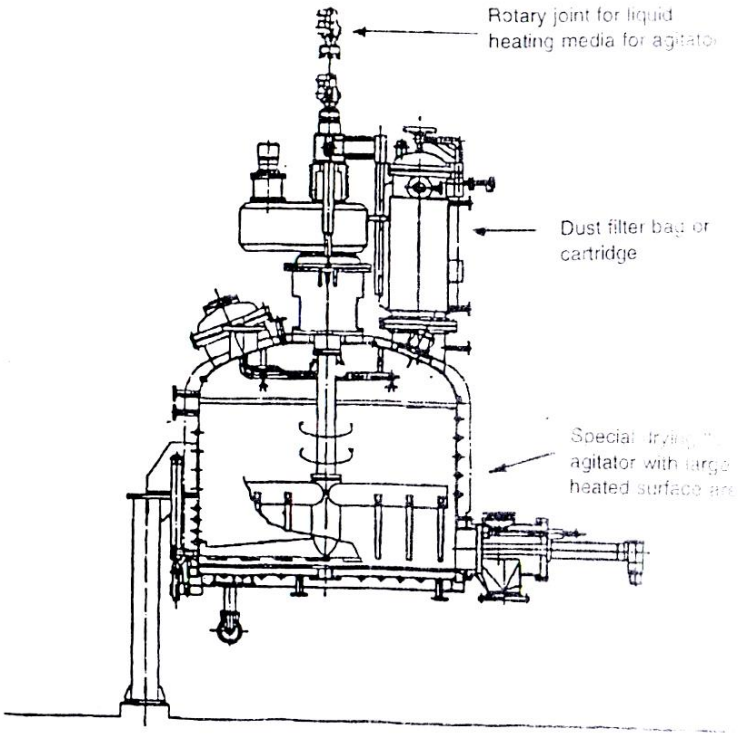


Figure: Agitated nutsche type filter/dryer (courtesy of COGEIM, SpA)

Materials of construction can vary widely depending upon the application. Typically, 304 or 316 stainless steel, and Hastelloy are supplied although many other types of material of construction are available. Metal finishes, in keeping with good manufacturing practices (GMP) particularly for areas inc contact with final products, required welds to be ground smooth. Finishes can be specified in microns, Ra. Or grit. The unit Ra. Is the arithmetical average of the surface roughness in microinches, the rms is the root mean square of the surface roughness in microinches: rms = 1.1 Ra.

A mechanical finish of 400grit is an acceptable pharmaceutical finish, however, mechanical polishing folds the surface material over itself. When viewed under a microscope, jagged peaks and crevices are visible. Product on the microns level can be accumulated in these areas. Electropolishing of the surface is often used to eliminate these peaks and valley to provide a more cleanable surface. A layer of the surface material is removed in this case. A mechanical finish of 400 girt is achieved by progressively increasing the grit spec from 60 up to 400. If a 400 girt surface was to be electropolished, the amount to material removed would result in an equivalent 180-220 grit surface roughness. Therefore, a mechanical finish a approximately 180-220 grit need only be specified when electropolsihsing. A considerable cost saving is realized. It is always advisable to specify the Ra value of the surface whether electropolishing is specified or not.

Filter areas will range from 0.5 to 16 m^2. For large-scale processing, significant floor area is occupied per unit area of filtration.[1] Those products that tend to blind filter media, i.e., colloidal slurries, gelatinous and protein compounds will require alternate equipment, filtration or centrifugation.

3. Distinguish between Cross flow filtration and dead end filtration.

CROSS-FLOW vs. DEAD END FILTRATION

The distinction between cross-flow and dead end (also known as through-flow) filtration can be better understood if we first analyze the mechanism of retention. The efficiency of cross-flow filtration is largely dependent on the ability of the membrane to perform an effective surface filtration, especially where suspended or colloidal particles are involved. Table shows the advantages and versatility of cross-flow filtration in meeting a broad range of filtration objectives. [1]-[3][6] Figure illustrates the differences in separation mechanisms of CFF versus dead end filtration.

High recirculation rates ensure higher cross-flow velocities (and hence Reynold's number) past the membrane surface which promotes turbulence and increases the rate of redispersion of retained solids in the bulk feed. This is helpful in controlling the concentration polarization layer. It may be of interest to note that polarization is controlled essentially by cross-flow velocity and not very much by the average transmembrane pressure (ATP). It should also be noted that higher particle or molecular diffusivity under the influence of high shear can enhance the filtration rates. Since diffusivity values of rigid particles (MF) under turbulent conditions are typically much higher than those for colloidal particles or dissolved macromolecules (UF) microfiltration rates tend to be much higher than ultrafiltration rates under similar conditions. [5]

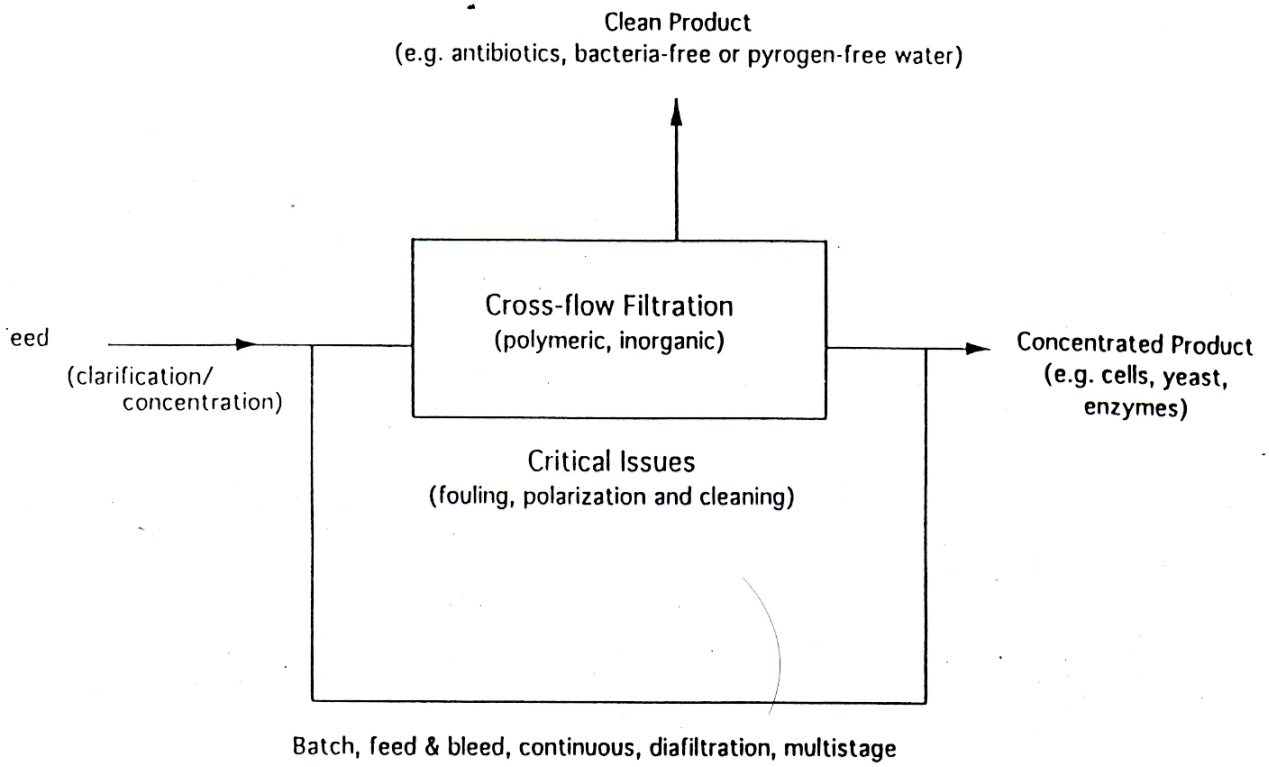


Figure. Schematic of cross-flow filtration

Table : Cross-Flow Filtration: Key Advantages

Process Goal	Cross-flow Filtration	Dead end Filtration
Ability to handle wide variations in particle size	Excellent	Generally poor
Ability to handle wide variations in solids concentration	Excellent	Poor or unacceptable
Continuous concentration with recycle.	Excellent	Poor or unacceptable
Waste minimization	Superior	Can minimize waste if handling low solids feed where cartridge disposal is infrequent.
High product purity or yield	Excellent; but may require diafiltration to overcome excessive flux loss at higher recovery.	Performance is generally acceptable except in situations involving high solids or adsorptive fouling.

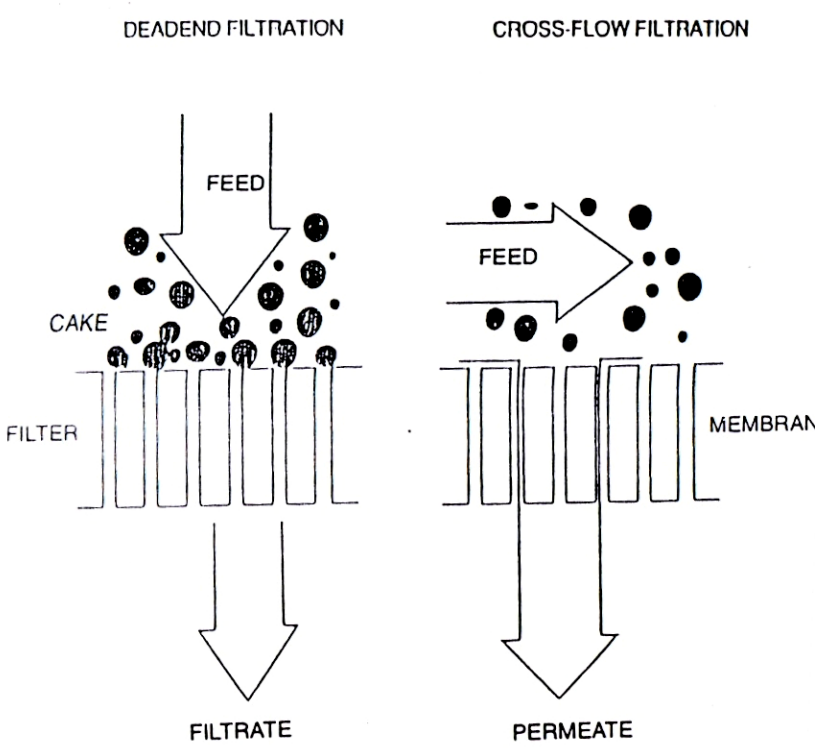


Figure. Cross-flow versus dead end filtration

On the other hand, in dead end filtration the retention is achieved by particle or gel layer buildup on the membrane and in the pores of the medium such as when a depth type filter is used. This condition is analogous to that encountered in packed-bed geometries.

In dead end filtration, the applied pressure drives the entire feed through the membrane filter producing a filtrate which is typically particle free while the separated particles form a filter cake. The feed and filtrate travel concurrently along the length of the filter generating one product stream for every feed. In CFF, one feed generates two product streams, retentate and permeate. Per pass recovery in through-flow mode is almost 100% (since only the solids are removed) whereas in the cross-flow mode the per pass recovery typically does not exceed 20% and is often in the 1 to 5% range. Recirculation of retentate is thus necessary to increase the total recovery at the expense of higher energy costs.

As the filtration progresses, the filter cake becomes increasingly thicker which results in a reduced filtration rate (at a constant transmembrane pressure). When the flow or transmembrane pressure (depending on the control strategy) approaches a limiting value, the filtration must be interrupted in order to clean or replace the membrane filter. This discontinuous mode of operation can be a major disadvantage when handling process streams with a relatively high solid content.

Cross-flow filtration can overcome this handicap by efficient fluid management to control the thickness of the concentration-polarization layer. Thus, feed streams with solid loading higher than 1 wt. % may be better suited for CFF whereas feed streams containing less than 0.5 wt. % solids may be adequately served by dead end filtration. However, if the retained solids constitute the product to be recovered or when the nature of solids is the cause of increased fouling, cross-flow filtration should be considered. CFF is also the preferred mode when particle size or molecular weight distribution is an important consideration, such as in the separation of enzymes, antibiotics, proteins and polysaccharides from microbial cell mass, colloidal matter and oily emulsions. Tubular cross-flow filters are being used to continuously concentrate relatively rigid solids upto 70 wt.% and up to 20 wt.% with gelatinous materials.

4. Explain the theory of centrifugations.

The solids-liquid separation process can be accomplished by filtration or centrifugation. Centrifuges magnify the force of gravity to separate phases, solids from liquids or one liquid from another. There are two general types of centrifuges.

Sedimentation Centrifuges – where heavy phase settles out from a lighter phase, therefore requiring a density difference and

Filtering Centrifuges – Where the solid phase is retained by a medium like a filtercloth, for example, that allows the liquid phase to pass through.

Theory

Centrifuges operate on the principle that a mass spinning about a central axis at a fixed distance is acted upon by a force. The force exerted on any mass I equivalent to the weight of the mass times its acceleration rate in the direction of the force.

Equation (1) $F = ma$

Where

m = mass
a = acceleration rate
F = force

This acceleration rate is zero without a force acting upon it, however, it will retain a certain velocity, v if forced to move in a circular path, a vector velocity v/r exists as its direction is continually changing.

Equation (2) $a_c = v\ v/r$

Where

a_c = centrifugal acceleration

Equation (3) $a_c = w^2r$
v = velocity
r = radius
w = angular velocity

should a mass be rotated within a cylinder, the resulting force at the cylinder wall is called a centrifugal force, F_c.

equation (4) $F_c = mw^2r$
is the centripetal force. this is the force required to keep the mass on its circular path.

If a cylindrical bowl holding a slurry is left to stand, the solids will settle out under the force of 1 g or gravity. By spinning the bowl the solids will settle under the influence of the centrifugal force generated as well as the force of gravity which is now negligible. Solids will collect at the wall a liquid layer on top. This is an example of a sedimentation in a solid bowl system.

By performing the bowl or basket and placing a filtercloth on the inside wall, one has now modeled a filtering centrifuge similar in principle to an ordinary household washing machine.

This amplification of the force of gravity is commonly referred to as the number of g's. The centrifugal acceleration (a_c) referenced to g is w^2r/g which is given by the equation.

Equation (6) Relative Centrifugal Force (G) = $1.42 \times 10^{-5}\ n^2\ D_i$

Where

n = speed in revolutions/minutes
D_i = diameter of the bowl in inches

The driving force for separation is a function of the square of the rotational speed and the diameter of the bowl; however, there are restrictions in the design of centrifuges that will limit these variables.

An empty rotating centrifuge will exhibit a stress in the bowl called a self-stress, S_s.

Equation (7) $S_s = w^2 r_i^2 \rho_m$

Where

w = angular velocity
r_i = radius of the bowl
ρ_m = density of the bowl material

The ontents of the bowl also generate a stress or pressure on the inner wall of the bowl. Assuming the radius of the bowl (r_i) is equal to the outer radius of the bowl contents (r_2), we have

Equation (8)

t = thickness of the bowl
ρ_c = density of contents of the bowl
r_1 = inner radius of the bowl contents (solids and liquid)
r_2 = outer radius of the bowl contents (solids and liquid)

the total stress in the bowl wall is :

$$S_T = S_s + S_c$$

$$S_T = w^2 r_2 \left[r_2 \rho_m + \frac{\left(r_r^r - r_1^2\right)\rho_c}{4t} \right]$$

With $D_i = 2r_i$ and in common units.

Equation (9) $$S_T = 4.11 \times 10^{-9} n^2 D_i \left[D_i \rho_m + \frac{\left(D_i^2 - D_1^2\right)\rho_c}{4t} \right]$$

Centrifuges are designed such that S_s is 45 to 65% of S_T.

D_i, D_1, t	(inches)
n	(rpm)
S_T	(lb/in^2)
ρ_c	(lb/ft^3)

Increasing the bowl speed and its diameter increases the g force, but also increases the self and the stress induced by the process bowl. The design is, therefore, really limited by the material of construction available, however, for a given bowl stress, the centrifugal acceleration is an inverse function of bowl diameter. For example, doubling the rotational sped, ad having the bowl diameter, doubles the acceleration while keeping the total stress relatively constant. It is for this reason that the smallest diameter centrifuges operate at the highest g forces. Tubular centrifuges operate at 2-5 inches diameter with g forces over 60,000. disk centrifuges operate at 7-24 inches at 14,000 to 5500 g's, while continuous decanter centrifuges with helical conveyors are designed with bowl diameters of 6-54 inches and g forces of 5,500 – 700 g's. filtering centrifuges with diameters of 12 to 108 inches have corresponding g forces of 2000 to 260.

5. Explain continuous decanter centrifuges with a neat diagram.

CONTINUOUS DECANTER CENTRIFUGES (WITH CONVEYOR)

Typical applications in fermentation are thick fermentation broths with high solids concentrations where a relatively drier cake is required. However, protein precipitate can not be sedimented and animal cell debries, due to their slimy nature, can render scrolling ineffective.

Solids and liquid are discharged continuously in this type of design which can process coarse particles that would blind the discharge system and disks of disk bowl machines. The principle of operation is shown in fig.1.

This unit, often referred to as a decanter, is constructed with a conical bowl and an internal rotating scroll conveyor to propel solids or beach them along the inclined wall bowl to then be discharged.

The scroll rotates slower than the bowl at a differential speed of 1/20 to 1/60 of the bowl speed, this differential speed causes translation of the solids along the bowl. Particularly, soft solids can be conveyed with low conveyor differential speeds should higher differential speeds cause resuspensions. Units will have g forces up to 6000 and range in diameter from 6" to 48"[(1)]. The solids discharge outlet is usually smaller than the liquid discharge outlet at the opposite end.

By varying the liquid discharge outlet size the pool level or depth of the pond can be controlled. The lower the level, the greater the length of the dry beach section. These units operate below their critical speeds between fixed bearings attached to a rigid frame. Mechanical seals are available for pressure operation up to 150 psig. Operation temperatures are from -87^{o}C to +260^{o}C.

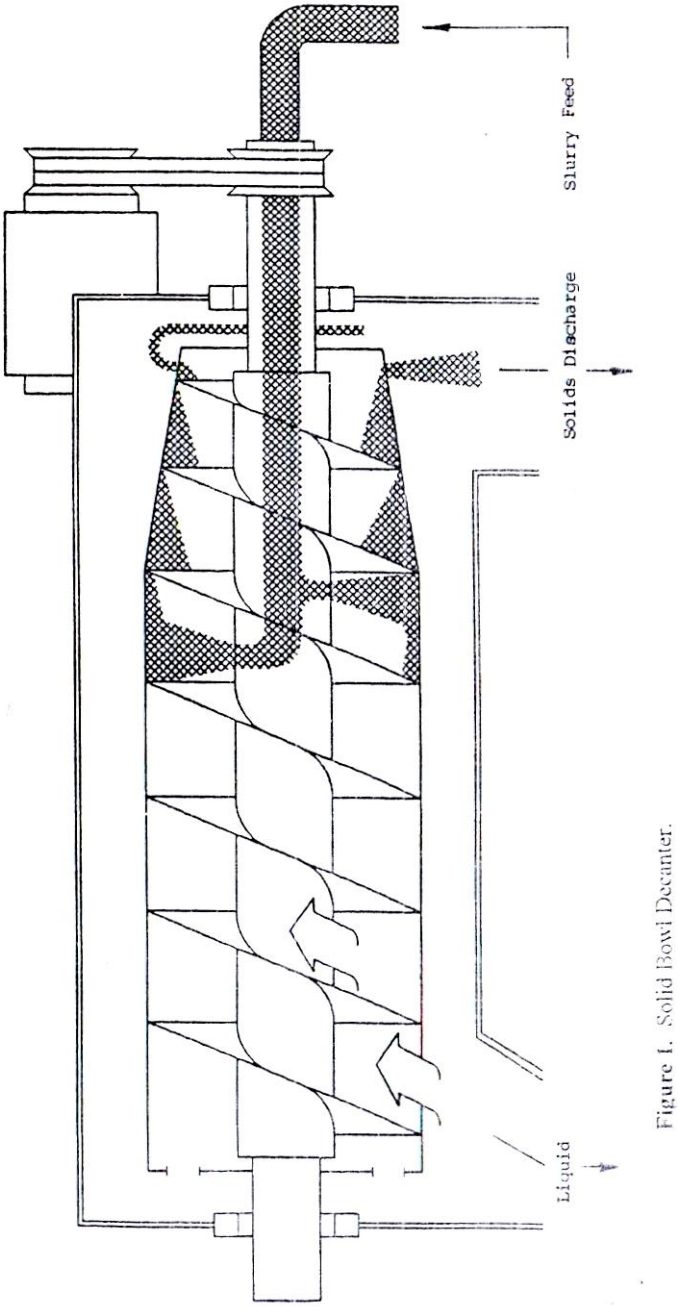


Fig. Solid Bowl Decanter

Maintenance

Bearings are the primary concern in this design, however, lifetime will depend upon the service and hours of operation. Abrasive materials can cause excessive wear along the feed zone, the conveyor leading to the beach, and the solids-discharge ports. Refacing with replaceable hard surfacing materials such as Hastelloy or tungsten may be required. [1]

A variation on this design is screening bowl machine. After the solids have been pulled form the pool of the liquid they will pass under a section of a wedge – bar screen to allow for additional dewatering as well as washing the solids more effectively. This design can of course only be used with particles of 80-100 microns or great as smaller solids will pass into the effluent.

6. Explain Disc centrifuges with a neat diagram.

Disk centrifuges

Applications for the disk centrifuge (Fig.) can overlap the continuous decanter, but will typically be lower in solids concentration and often finer in particles. Examples are:

1. Cell harvesting, broth clarification for recovery of antibiotics and hormones from the culture medium, for example, mycelia
2. Fractionation of human blood plasma
3. Separation of microorganisms and their fragments when processing fermentation products such as: bakers yeast, single cell proteins, vaccines, amino acids and enzymes
4. Isolation and purification of cell proteins
5. Bacterial cells (E Coli) for enzymatic deacylation of penicillin G
6. Mammalian cells

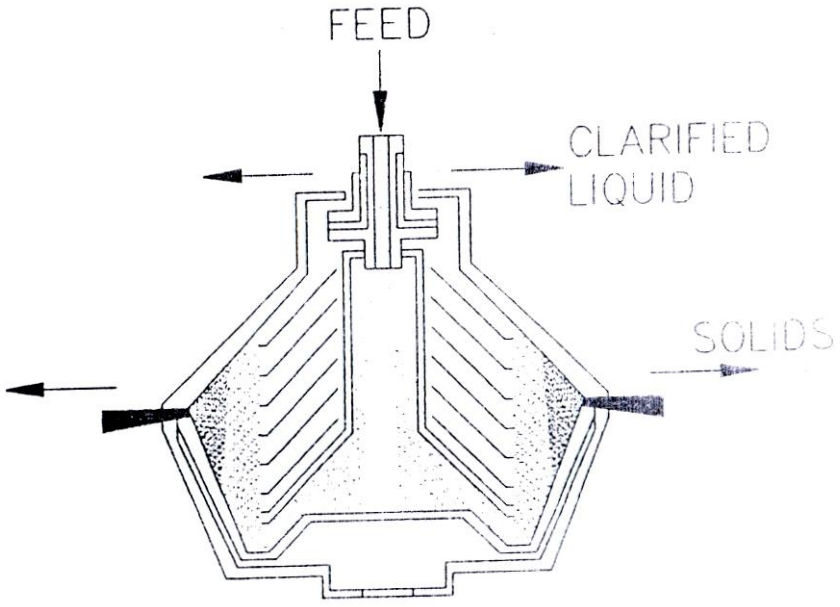


Fig. Disk – bowl centrifuge

Operation

Solid wall disk centrifuges were designed initially as cream separators. It is a solid bowl design containing a set of stacked disks.

Bowl diameters in a standard disk centrifuge range from 7 to 24 inches and centrifuge g-force of 14,200 to 5,500. A continuous nozzle discharge centrifuge has diameters from 10 to 30 inches and g-forces of 14,200 to 4,600. The unit rotates on a vertical shaft as slurry is introduce and pumped down a central pipe beneath the disk stack in close proximity to the bowl wall. The slurry then flows into the disks as particles settle on the underside of the slurry then flows into the disks as particles settle on the underside of the inclined disks and slide to collect along the bowl wall liquid continuous to move upwards until it overflows a weir and exits the unit.

In a manual design, the bowl is one piece and the system must be stopped and opened upto discharge the collected solids. In a continuous operation, such as wall-valve- discharge centrifuge, the bowl is made of two cones a top and a bottom, which periodically separate to release the solids at full rotational speed.

In a nozzle discharge centrifuge, the bowl is a solid, two – cone design. Orifices are located along the maximum diameter to allow solids to flow continuously Liquid loss must be minimized and orifice sizes are therefore closely matched to the solids capacities. Thickened solids can be recycled to satisfy nozzle flow to maintain a dry effluent. This also circumvents plugging when using larger than usual orifices.

Solids concentrations can range from 15 to 50%. For smaller machines where solids content varies, the intermediate solids discharge design (wall-valve), is preferred. Solids must be of wet toothpaste consistency to flow from these types of disk machines. With the intermittent discharge, however, the solids can be wetter as it is mechanically feasible to open and close the bowl quickly enough to avoid liquid passage.

7. Explain pressure added centrifugation with a neat diagram.

PRESSURE-ADDED CENTRIFUGATION

It is more efficient to mechanically dewater solids than thermally, due to costly energy requirements. Filters such as pressure or vacuum units are used for solids/liquid separation, providing high forces to drive the liquid through the cake. Recently, equipment designed to combine both centrifugation and pressurization has lead to increased dewatering of solids beyond what either process would do alone.

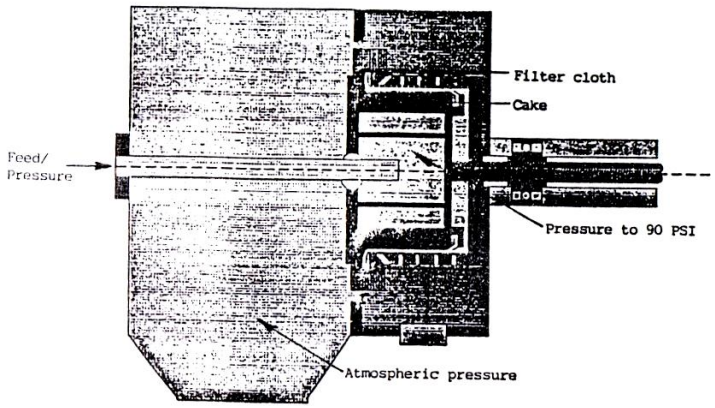


Figure. Inverting filter centrifuge with pressurization

A centrifugal field achieves mechanical separation of slurries by emptying the liquid in the capillaries between the solids. Larger particles will exhibit faster drainage of these capillaries.

Liquid in the interstices of the solids is retained due to high capillary forces in the micron pores and cracks in the particle. These capillary forces are so high that they can only be removed thermally. This contributes to a certain capillary height of liquid that is independent of the packed bed weight. After dewatering for an extended time, an equilibrium point is reached. Only changing the driving force by increasing centrifugal force will overcome and reduce this equilibrium saturation point. Product with a smaller particle size distribution will have higher capillary forces and thus a higher equilibrium saturation point. Product with a smaller particle size distribution will have higher capillary forces and thus a higher equilibrium saturation point or residual moisture.

By addition of the driving force pressure, or pressure differential across the packed bed, additional liquid is forced through the capillaries below the equilibrium saturation point, thus reducing the residual moisture.

Initial pressurization of the basket alone, thus avoiding pressurizing the entire centrifuge, can decrease final dewatering steps by as much as 80%. By blowing through the cake at a certain temperature, volume of gas, and pressure, drying will be achieved. Products that are crystalline and easy to filter can be dried in a relatively short period of time, not adding significantly to the overall cycle. Difficult filtering, amorphous materials may see overall cycle times reduced or products previously wet and sticky now easily handled at lower moisture levels going into a dryer. Downstream drying equipment can then be reduced in size, or possible eliminated.

The Inverting Filter with Pressure-Added Centrifugation has proved to dry products to 0.008% residual moisture using hot gas.

With heated gas, it is possible to break the upper surface of the moisture film, aiding in dewatering, or to dry or strip solvents. Steam washing can reduce wash quantities required.

UNIT – III

PART – A

1. What is Isolation?

Isolation is one of the aspects which make bio-separations unlike commodity chemical separations. Isolation involves taking a highly dilute aqueous feed and removing most of water. The resulting concentrate can be purified by a variety of methods.

2. What is partition coefficient?

The solute concentration increases in the first liquid phase as a result of depletion from the second liquid phase. This partitioning is conveniently summarized as a partition coefficient 'K'

$$\boxed{K = \frac{x}{y}}$$

3. Write the logarithmic equation for the partition coefficient.

$$\frac{x}{y} = K = \exp\left(\frac{\mu^{\circ}(H) - \mu^{\circ}(L)}{RT}\right)$$

4. Write the partition coefficient equation in terms of partial molar volumes.

$$\ln K = \frac{\overline{V}_H\left(\delta_A - \delta_H\right)^2 - \overline{V}_L\left(\delta_A - \delta_L\right)^2}{\left(RT\ \overline{V}_A\right)}$$

$\overline{V}_i$ = Partial molar volumes

H = Heavy solvent

L = Light solvent

A = Solute

δ_i = Solubility parameter

5. Name any four solvents used for extraction process.

Amyl acetate, Benzene, Butanol, Butyl acetate

6. Name any three counter ions for Ion paired extractions.

Acetate, Butytrate and cholate

7. Write the PKa values for acetic acid and propionic acid.

Acetic acid = 4.76

Propionic acid = 4.87

8. Write the PKa values for any two antibiotics.

Celesticetins = 7.7

Novobiocin = 4.3

9. Write short notes on Equilibrium constraint.

The equilibrium constraint for dilute solution,

$$\begin{pmatrix}\text{Solute Concentration}\\ \text{in light phase L}\end{pmatrix}\times\begin{pmatrix}\text{Solute concentration}\\ \text{in heavy phase H}\end{pmatrix}$$

$$\boxed{x = Ky}$$

10. Write the formula for extraction factors.

$$\boxed{E = \frac{KL}{H}}$$

11. Write short notes on Chemistry of adsorption.

Adsorption requires adsorbents, solid materials to which solutes of interests bind reversibly.

12. Name any four adsorbents used in extraction process.

Styrene, divinyl benzene, hydrogels and synthetic polymers

13. Name any three adsorption isotherm.

1. Freundlich isotherm
2. Langmuir isotherm
3. Linear isotherm

14. Write the empirical equation for freundlich isotherm.

$$q = K\ y^n$$

n – constant

k – Partition coefficient

q – amount of solute adsorbed per amount of adsorbent.

15. Write the empirical equation for the Langmuir isotherm.

$$q = \frac{q_o y}{K + y}$$

k, q_o – constants determined experimentally.

16. Write the equation explaining the theory of langmuir isotherm.

Solute + Vacant Site = Filled site

PART – B

1. Discuss about the Chemistry of extraction.

THE CHEMISTRY OF EXTRACTION

The extraction processes described later in this chapter take advantage of the partitioning of a solute between immiscible liquid phases. For example, citric acid is more soluble in methyl amyl ketone than in water at pH 4. Penicillin dissolves more readily in amyl acetate than in water at pH 5.5. Catalase has a higher concentration in polyethylene glycol rich solutions than in dextran rich solutions. In each of these three cases, the solute concentration increases in the first liquid phase as a result of depletion from the second liquid phase.

This partitioning is conveniently summarized as a partition coefficient K

$$K = \frac{x}{y}$$

where x is the solute concentration in the lighter liquid L, and y is the same solute's concentration in the heavier liquid phase H. In many cases, the light phase will be an organic solvent, and the heavier phase will be water. Often, the values of K will be constant independent of solute concentration for a given solvent pair. A constant K reflects the fact that most biochemical extractions take place in dilute solution.

Values of K must be found by experiment. From the selection of values in Table, we see that values scatter, without obvious trends. However, the trends are there, skeletons of chemical generalizations that are hidden yet familiar. It is these chemicals skeletons which are the subject of this section.

In discussing these values of K, we begin with a quick review of thermodynamic equilibria. We next discuss manipulating the chemistry of the solutes, which is often hard. We then describe changing the solvents' chemistry, which is easier. The results supply a perspective of the chemistry responsible for extraction.

2. Tabulate the distribution coefficient for amino acids.

Type	Solute	Solvent[b]	K[c]	Remarks
Amino acids	Glycine	n-butanol	0.01	25°C
	Alanine	n-butanol	0.02	
	Lysine	n-butanol	0.2	

	Glutamic acid	n-butanol	0.07	
	α-aminobutyic acid	n-butanol	0.02	
	α-aminocaproic acid	n-butanol	0.3	

3. Tabulate the distribution coefficient for Antibiotics.

Type	Solute	Solvent[b]	K[c]	Remarks
Antibiotics	Celesticetin	n-butanol	110	25°C
	Cycloheximide	Methylene chloride	23	
	Erythromycin	Amyl acetate	120	
			0.04	
	Lincomycin	n-butanol	0.17	at pH 4.2
	Gramicidin	Benzene	0.6	
		Chloroform-	17	
	Novobiocin	methanol	100	at pH 7.0
		Butyl acetate	0.01	at pH 10.5
	Penicillin F		32	at pH 4.0
		Amyl acetate	0.06	at pH 6.0
	Penicillin K		12	at pH 4.0
		Amyl acetate	0.1	at pH 6.0

4. Briefly discuss about the changes in solvent.

Changes in Solvent

The most obvious way to change $\mu^0(L)$ is to choose a different extraction solvent. There is no reliable thermodynamic theory which can quantitatively predict the best choice, but there are several which can serve as a qualitative guide. We discuss one of these, the concept of solubility parameter.

According to this theory, the partition coefficient K can be written as

$$\ln K = \frac{\mu^0(H) - \mu^0(L)}{RT}$$

$$= \frac{\overline{V}_H(\delta_A - \delta_H)^2 - \overline{V}_L(\delta_A - \delta_L)^2}{\left(RT\overline{V}_A\right)}$$

where the $\overline{V}_i$ are the partial molar volumes of the heavy solvent H, the light solvent L, and the solute A, respectively, and the δ_i are the corresponding solubility parameters. Some of these parameters, listed in the surprising units of $cal^{1/2}/cm^{3/2}$, are given in Table. When no single solvent has the desired solubility parameter, mixed solvents can be effective.

Table:- Solubility Parameters for Some Common Solvents[a]

Solvent	$\delta(cal^{1/2}\ cm^{-3/2})$
Amyl acetate	8.0
Benzene	9.2
Butanol	13.6
Butyl acetate	8.5
Carbon disulfide	10.0
Carbon tetrachloride	8.6
Chloroform	9.2
Cyclohexane	8.2
Hexanol	10.7
Acetone	7.5
Pentane	7.1
Perfluorohexane	5.9
Toluene	8.9
Water	9.4

[a] Taken from J.H. Hildebrand, J.M. Prausnitz, and R.L. Scott, Regular and Related Solutions, Van Nostrand, New York, 1970: and from the Handbook of Chemistry and Physics. CRC Press, Boca Raton, FL. 1986.

To use this theory, we just make an extraction with two solvents whose δ_I are known. We use this experiment to find δ_A, the solutes solubility parameter. We then can estimate the partition coefficients for new solvents from their values ofδ_i. Such estimates are not quantitatively reliable, but they can be a good guide for new experiments.

5. Discuss about the changes in solute via Ion Pairs.

Changes in Solute via Ion Pairs

In many cases, we will not be able to change the extraction solvent. Alternatives may e expensive, volatile, flammable, or biohazardous. In these cases, we may be able to improve the extraction by changing the solute.

Changes in the solute may initially seem impossible. Surely, the solute is what we must isolate, and changing it chemically may destroy it. After all, if we are trying to separate lincomycin, it will no longer be lincomycin if we change it.

Changes in the solute depend on the fact that the solute can be ionic. If so, it must have a counterion which can be changed without changing the solute itself. Two changes in counterions are useful. First, the counterions can be replaced with those which are much more soluble in the extraction solvent. Second, and more commonly, the solute may be weakly acidic or basic, so that changes in pH will alter the degree of its ionization.

Changes in counterions rely on the fact that a solute which is ionic in water will form an ion pair of no net charge in an organic solvent. Such ion pair formation is exemplified by the extraction of the tetrabutylammonium cation. If the chloride of this cation is extracted with chloroform, we find

$$K = \frac{\left[N(C_4H_9)_4^+ \text{ in chloroform} \right]}{\left[N(C_4H_9)_4^+ \text{ in water} \right]} = 1.3$$

If sodium acetate is added to this chloride solution and the extraction is repeated, we find

$$K = \frac{\left[N(C_4H_9)_4^+ \text{ in chloroform} \right]}{\left[N(C_4H_9)_4^+ \text{ in water} \right]} = 132$$

In the first case, we extract a dilute solution of $N(C_4H_9)_4^+Cl^-$ ion pairs; but in the second, we obtain a more concentrated solution of $CH_3COO^-N(C_4H_9)_4^+$ ion pairs.

Such ion pair extractions require choosing organic soluble counterions. Possibilities, listed in Table, produce what some call greasy salts". Such salts are an underused method of improving extractions.

6. Discuss the changes in solute via pH.

Changes in Solute via pH

Many of the solutes which we want to isolate are weak acids or bases whose extraction can be dramatically altered by changes in pH. We will develop the analysis for weak acids; that for weak bases is analogous. A weak acid can partly ionize in water, but it will not ionize significantly in organic solvents. The apparent partition coefficient lumps both ionized and unionized forms, i.e.,

$$K = \frac{[RCOOH]_L}{[RCOOH]_H + (RCOO^-)_H}$$

where $[R]_L$ and $[R]_H$ are solute concentrations in the light organic and the heavy aqueous phases, respectively.

PART – C

1. Explain the changes in solute via pH with necessary equations.

Changes in Solute via pH

Many of the solutes which we want to isolate are weak acids or bases whose extraction can be dramatically altered by changes in pH. We will develop the analysis for weak acids; that for weak bases is analogous. A weak acid can partly ionize in water, but it will not ionize significantly in organic solvents. The apparent partition coefficient lumps both ionized and unionized forms, i.e.,

$$K = \frac{[RCOOH]_L}{[RCOOH]_H + (RCOO^-)_H}$$

where $[R]_L$ and $[R]_H$ are solute concentrations in the light organic and the heavy aqueous phases, respectively. The concentration of un-ionized and ionized solutes in water are subject to the equilibrium

$$RCOOH \rightleftharpoons RCOO^- + H^+$$

so that

$$K_a = \frac{[RCOO^-]_H [H^+]_H}{[RCOOH]_H}$$

where K_a, the association constant of the weak acid, is usually tabulated in units of moles per liter. In some idealized experiments. $[RCOO^-]_H$ and $[H^+]_H$ may be closely related, but in practice, $[H^+]_H$ is treated as an independent variable. As such, equations can be combined to give

$$K = \frac{K_i}{1 + K_a / [H^+]_H}$$

where the "intrinsic partition coefficient" K_i is given by

$$K_i = \frac{[RCOOH]_L}{[RCOOH]_H}$$

Combining Equations leads to

$$\log_{10}\left[\left(\frac{K_i}{K}\right)-1\right] = pH - pK_a$$

where the pK_a (= - $\log_{10}K_a$) values are given in the literature. The corresponding result for weak bases is

$$\log_{10}\left[\left(\frac{K_i}{K}\right)-1\right] = pK_b - pH$$

These results show how the partition coefficient of a weak acid or base can be manipulated by changing the concentration of $[H^+]$ in the aqueous solution.

Values of K_a for a variety of solutes of biological interest are given in Table. The changes in partition coefficients implied by this table can be used to purify as well as isolate a solute of interest. For example, for solutes A and B, the selectivity of the separation is given by

$$\beta = \left(\frac{K_i(A)}{K_i(B)}\right)\left(\frac{1+K_a(B)/[H^+]}{1+K_a(A)/[H^+]}\right)$$

In some cases, the selectivity at moderate pH is much better than that at extreme pH.

2. Separation of Penicillins. For the system water-amyl acetate, penicillin K and penicillin F have values of K_i of 215 and 131 respectively. They have pK_a's of 2.77 and 3.51. If Penicillin F is the desired product, will an extraction at pH 3.0 give a purer product than one at pH 4.0?

Solution:-

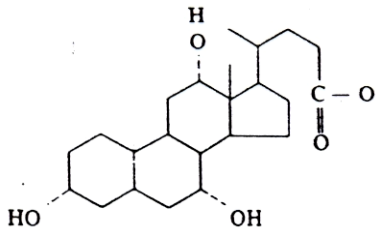
From the values given, we can use equations to find the following values for each of the components:

	K_K	K_F
pH 3	80	100
pH 4	12	32

Thus β = 1.3 at pH 3, but β = 2.7 at pH 4. The extraction at pH 4 may require more stages to isolate penicillin F, but the isolated solute will be purer.

3. Tabulate typical counterions for Ion Paired Extractions.

Table:- Typical Counterions for Ion Paired Extractions

Ion	Chemical Structure	Remarks
Acetate	CH_3COO^-	Simple; not high soluble in organic solvents
Butyrate	$CH_3(CH_2)_2COO^-$	More soluble in organic solvents than previous ion.
Tetrabutylammonium	$(C_4H_9)_4N^+$	A solid choice
Hexadecyltributylammonium	$CH_3(CH_2)_{15}(C_4H_9)_3N^+$	May form micelle
Perfluorooctanoate	$CF_3(CH_2)_6COO^-$	May stay ionic in organic solvents
Dodecanoate	$CH_3(CH_2)_{10}COO^-$	May form micelle
Linolleate	$CH_3(CH_2)_4CH=CHCH_2CH=(CH_2)_7COO^-$	May form liquid crystals
Cholate		Based on bile acids
Tetraphenylboride	$B(C H_5)_4^-$	Can degrade in many solvents

4. Explain the analytical methods for the Batch extraction.

Analytical Methods

We want to calculate the concentrations at equilibrium from the concentrations in the initial feed. To do so, we need two relations: an equilibrium constraint and a mass balance on the solute. The equilibrium constraint for dilute solution will often be

$$\begin{pmatrix}\text{solute concentration}\\ \text{in light phase L}\end{pmatrix}\alpha\begin{pmatrix}\text{solute concentration}\\ \text{in heavy phase H}\end{pmatrix}$$

$$x = Ky$$

where x is the product concentration in the extraction solvent L, y is the product concentration in the feed solvent H, and K is an equilibrium constant. The extraction solvent is called L because as an organic material it is usually the lighter of the two. The feed solvent is called H because it is commonly water, and hence the heavier.

The units of the concentrations x and y can vary, which will change the values of K. For example, x and y can be in moles / liter or mole fractions.

In some cases, one concentration will be in one kind of unit (e.g., a mole fraction) and the other will be in some other unit (e.g., a partial pressure). Such an annoying variety of units is not difficult, but requires care.

The second of the two relations required for extraction isa mass balance on the solute

$$\begin{pmatrix}\text{solute into}\\ \text{the extraction}\end{pmatrix}=\begin{pmatrix}\text{solute out of}\\ \text{the extraction}\end{pmatrix}$$

$$Hy_F + Lx(=0) = Hy + Lx$$

where y_F is the solute concentration in the heavy feed. Note that this equation tactfully assumes that the extraction solvent initially contains no solute and that both L and H are constant.

We can combine equations to find the concentrations after the extraction:

$$x = \frac{Ky_F}{1+E}$$

$$y = \frac{y_F}{1+E}$$

where the quantity E, called the extraction factor, is given by

$$E = \frac{KL}{H}$$

Obviously, if K is large, most of the solute winds up in the extraction solvent. Other useful quantities are also easily found. For example, the fraction extracted p is

$$p = \frac{Lx}{Hy_F} = \frac{E}{1+E}.$$

5. Explain the graphical methods for Batch extraction.

Graphical Methods

Batch extraction problems can also be solved by graphical methods. To be sure, such a solution for the preceding specific case is trivial because the analytic method is so straightforward. However, such graphical methods are important for two reasons. First, they are easy to apply when the equilibrium is complex, and not just the simple linear relation given in equation. Second, graphical methods are the norm of advanced engineering analysis, the currency in which the literature is reported.

The graphical methods also depend on the same two basic relations, the equilibrium constraint

$$X = x(y)$$

and the mass balance

$$x = \left(\frac{H}{L}\right)(y_F - y)$$

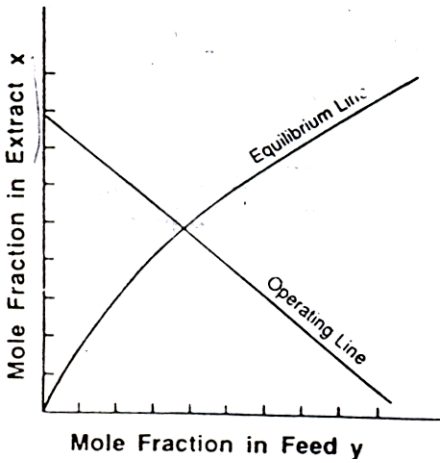


Fig. A batch extraction. The concentrations in the product are the intersection between the equilibrium line and the mass balance conventionally called an "operating line"

The first of these relations, analogous to equation, need not be linear and may be a table of experimental values. The mass balance is a rearrangement of equation.

Equations can be plotted on the same coordinates, as shown in figure. Their intersection gives the values of x and y after the extraction. These values are found without the trial and error which may be required when the equilibrium data are no more than tabulated values.

Such graphical methods are much more useful in the staged extractions. Because of the methods' utility, the lines in figure are cloaked in jargon. The equilibrium curve is called, sensibly, the "equilibrium line". The mass balance is referred to as the "operating line" You should remember that they are nothing more than energy and mass balances, respectively.

6. A Batch Steroid Extraction. Water containing 6.8 mg/ liter of a steroid is extracted with initially pure methylene dichloride. The equilibrium constant of the steroid is 170 and the ratio of water to solvent is 82. What is the concentration in the organic after the extraction? What fraction of the steroid has been removed?

Solution: From the values given, the extraction factor E is

$$E = \frac{KL}{H} = \frac{170}{82} = 2.07$$

From Eq. we find

$$x = \frac{K_{yF}}{1+E} = \frac{170(6.8)}{1+2.07}$$
$$=377\text{mg/liter}$$

From Eq. the fraction extracted p is

$$p = \frac{E}{1+E} = \frac{2.07}{1+2.07}$$
$$=0.67$$

Even though the equilibrium constant is large, the fraction extracted is modest because there is so much more water than organic.

7. Amino Acid Stripping. For a nonessential amino acid, the equilibrium relation between toluene and pure water is

$$x^2 = \left(\overline{0.001}\text{mol/liter}\right)y$$

We plan to contact 4.7 liters of toluene containing 0.006 M amino acid with 1 liter of water. What fraction of the amino acid can we extract?

Solution:

Because the equilibrium is not in the form of Eq. we cannot use the usual analysis in Eq. Instead, we plot the equilibrium relation, as shown by figure. We also plot the mass balance or operating line, which is,

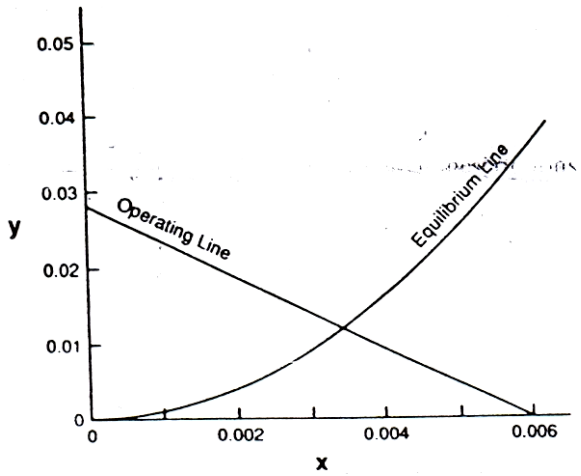


Fig. Amino acid stripping. This graph, used in solving example illustrates the simple ideas for batch extraction.

Y= 4.7(0.006-x)

The intersection of these lines gives the desired concentration

Y=0.012 mol / filter

The fraction extracted p is then

$$p = \frac{Hy}{Lx_F} = \frac{1.0(0.012)}{4.7(0.006)}$$

$$=0.43$$

A good exercise is to calculate the additional amount removed in a second extraction with 1 liter of water. Such repeated extractions are the subject of the next section.

8. Explain staged extraction with a neat diagram.

Staged Extractions

This section is concerned with extractions which are repeated again and again to isolate a desired product. The repeated extractions take place in a chain or cascade of separation equipment; the elements of this cascade are called stages. Staged extractions are important when one extraction does not give enough isolation or when the fraction of the product recovered is inadequate.

The topics in this section parallel those covered in the previous discussion of batch extraction. We begin with a paragraph outlining available separation equipment; detailed descriptions may be obtained from equipment manufactures. This paragraph introduces the vocabulary by which extraction and other staged operations are described. We then describe staged extraction, first via difference equations and then using graphical methods. Such equations and graphical methods are redundant. We have included both because the former are most useful for bioseparations, but the latter are the engineering norm in which most results are given. We conclude with examples.

The ideas in this section are important, basic to the rest of this chapter. For those trained in the sciences, they may seem hard to grasp; for engineers, they may appear in unfamiliar ways. Work to understand them; doing so makes the rest of the book easier.

Equipment

The apparatus used for extraction varies widely. All variations involve repeating batch extractions, as suggested by the example in figure. In many cases, the heavy feed contains the solute dissolved in water, and the light extractant is organic. The two phases are mixed together to provide a large surface area across which extraction can occur rapidly. After the two phases have come close to equilibrium, the phases flow into a second unmixed chamber where droplets of dispersed phase settle out.

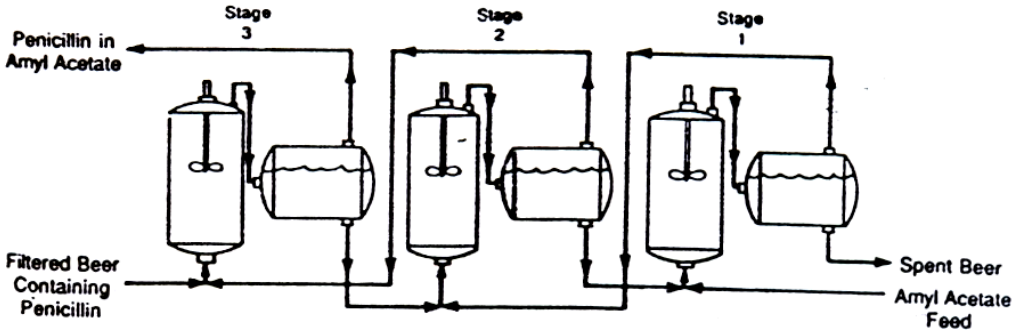


Fig. Separating pencillin with armyl acetate. In this three stage, countercurrent separation, penicillin is recovered from clarified beer by extraction with amyl acetate. (After R.E. Treybal, Mass Transfer Operations, McGraw-Hill,1980.)

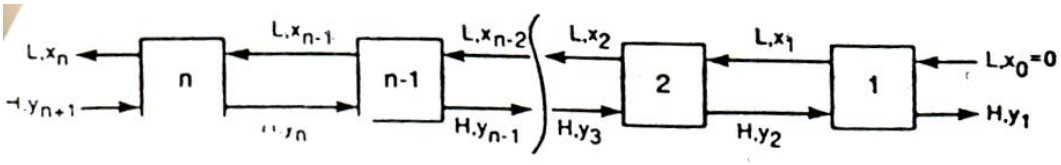


Fig. An idealized staged countercurrent extraction. The feed H and extractant L are assumed to flow at constant rates, a reasonable assumption for the dilute solutions common here. The concentrations in these streams are identified by the stage where each originates.

The design of this equipment requires compromise. If the two liquids are mixed too much. They may form small droplets which allow rapid extraction but delay settling. If the liquids are mixed too little, they form large blobs which do not have enough area for easy extraction, but which quickly separate.

To describe the performance of this equipment, we assume that the staged extraction is effectively designed and can be idealized as shown in figure In this figure, each stage is identified by a number, starting with stage # 1 at the right. Heavy solution (commonly water) enters the cascade from the left hand side and pure light solvent (usually an organic) enters from the right. Concentrations are identified by the stage from which they are leaving. For example, the light liquid L leaving the first stage has a solute concentration x_1 and the heavy liquid leaving the second stage and flowing into the first has a concentration of y_2. Note that the heavy liquid entering the cascade of n stages has a concentration of y_{n+1}. This mode of operation is often called "end feed".

9. Explain differential extraction with a neat diagram.

Differential extraction

Differential extraction occurs when a heavy liquid and a light liquid continuously flow past one another. Solute is transferred from one phase to the other phase, but never fast enough to reach equilibrium. The result is significant product isolation, but without the potentially tedious settling times which characterize the staged extractions described in the previous section.

At present, differential extraction is not commonly used for isolation of biologically important molecules. However, differential processes are successfully used in the chemical industry.

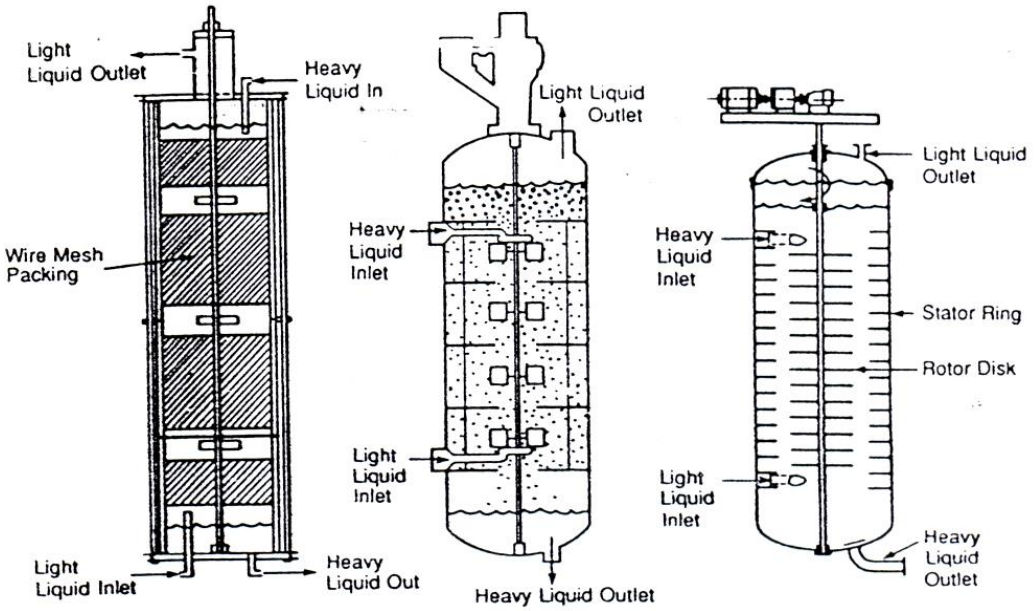


Fig. Differential extractors. The heavy and light liquids move counter currently, as in mixer – settlers. The concentrations in these liquids are not near equilibrium, unlike those in mixer-settlers.

One example is the "gas scrubber" used to treat flue gas and thus reduce pollution by sulfur oxides. We believe that this type of differential process will become more important in the future, and is have included a brief description of differential extractors here.

Types of equipment used for differential extraction are exemplified by those shown in fig. In its simplest form, the equipment is not more than a vertical tube. Heavy liquid flows slowly down the tube, and lighter liquid rise counter currently past it. One phase is dispersed; for example, the heavy liquid will be sprayed into a continuous phase of lighter liquid. The flow of one liquid past the other will depend on the density difference between them. It this density

difference is small, the process will be difficult to operate. This is why some of these extractors are contained within centrifuges.

The analysis of the differential extractor depends on three keys equations. The first two are very similar to those used in staged extractions. One is a statement of equilibrium

$$X=ky^*$$

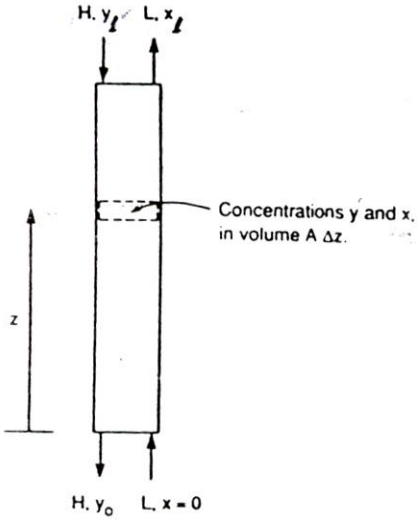


Fig. An idealized differential counter current extraction. The heavy and light liquids flow past each other, but are never in contact long enough to reach equilibrium.

Where y* is the concentration in the heavy liquid which would be in equilibrium with the concentration x in the light liquid at that position in the column. Like Eq. or, this relation is called an equilibrium line; unlike thee equations, it does not relate concentrations actually present within the column.

The second key equation is a mass balance, just as it was in the staged extraction case. The mass balance is written over the bottom length z of the differential extraction, as shown in fig. the results is

$$H_y+L(0)=Hy_0+L_x$$

Or

$$x = \frac{H}{L}(y - y_0)$$

where y_0 is the concentration at z=0. Note that both x and y are concentration at position z which are not in equilibrium. Like eq. this relation is called an operating line.

10. Explain Ion exchange Isotherms with necessary equations.

Ion Exchange Isotherms

Isotherms for ion exchange are rationalized in a similar way. For example, consider an ion exchange reaction on a resin, for which

$$Na^{+}+HR \rightleftarrows NaR+H^{+}$$

Where HR and NaR represent ion exchange sites filled with a proton and a sodium ion, respectively. This implies that all sites are filled, with either a proton or a sodium ion. We then postulate the equilibrium

$$K=\frac{[NaR][H^{+}]}{[Na^{+}][HR]}$$

The total concentration of ionic groups $\bar{R}$ on the resin is fixed:

$$[\bar{R}]=[NaR]+[HR]$$

Thus

$$[NaR]=\frac{K[\bar{R}][Na^{+}]}{[H^{+}]+K[Na^{+}]}$$

In a buffered solution where [H+] is constant, we see that sodium adsorption on the resin will imitate the Langmuir isotherm. A second example is the reaction

$$Ca^{++}+2NaR=CaR_2+2Na$$

Where again we are assuming that sites are always filled with either Na^{-} or Ca^{++}. Again, at equilibrium,

$$K=\frac{[CaR_2][Na^{+}]^2}{[Ca^{++}][NaR]^2}$$

The stoichiometry of this equilibrium implies that [C_aR_2] is favoured in highly dilute solution, but that [NaR] is favored when the salts concentrations are higher. It is the basis of water softening. As before, the total number of sites on the resin is fixed:

$$\left[\overline{R}\right] = \left[NaR\right] + 2\left[CaR_2\right]$$

When we combine Eqs. And we get an algebraically complex result which is surprisingly well fitted by a Freundilich isotherm.

UNIT – IV

PART – A

1. Write short notes on elution chromatography.

Elution chromatography commonly uses a packed column of adsorben particles, which can be solid, porous solid or get. As a result, elution chromatography is similar to fixed bed adsorption.

2. Name some adsorbents used in elution chromatography.

In organic materials like alumina, activated carbon and Diat amaceous carth.

3. Write short notes on yield and purity.

Yield and purity involves infecting a pulse of mixed solutes in to a packed column and then washing these solutes out of the column. The elute solutes are collected as fractions.

4. Write the material balance equation for elution chromatography.

Solute accumulation in liquid and packing =

Solute dispeosion in – out + solute convection in-out

5. Explain NTU.

By analogy with differential extraction, we call the quantity [ν/ka] the height of a transfer unit and the integral the number of transfer units NTU.

$$l = HTU.NTU$$

6. What is nucleation?

Nucleation is that part of the process where small particles appear and being to grow. In inorganic systems, nucleation can be slow and super saturation can pesist for long periods.

7. What is diffusion limited growth?

After nucleation, the precipitated particles grow as dissolved solute diffuse to them from the surrounding solution.

8. Write the second order equation for the diffusion limited growth.

$$\left(\frac{dy_i}{dt}\right) = -xy_1^2$$

9. What is flow influenced growth?

Diffusion limits the growth of small particles, but it is less important for the growth of larger particles. For those larger particles, growth usually involves collisions between species which are swept together by the mixing.

10. Write the equation to calculate the yields.

$$y = yo \exp\left(-\frac{\left(t/t_0 - 1\right)^2}{2\sigma^2}\right)$$

y_0 = maximum concentration
t_0 = time at which this concentration exists.
$t_{0\sigma}$ = standard deviation of the peak

11. Write the equation to find the purity of solute.

$$\text{Purity of solute i} = \frac{y_o(i)\,\text{yield}(i)}{\sum \text{jyo}(i)\,\text{yield}(i)}$$

12. Write the yield equation in teams of eluted volume 'v'.

$$y = y0 \exp\left(-\frac{\left[v/v_0 - 1\right]^2}{2\sigma^2}\right)$$

V_0 = volume require to clute the maximum concentration

$V_0\sigma$ = Standard deviation

13. Write any three typical stationary phases.

1) Polymers of dextran
2) Enzymes bound to polymer supports
3) Alumina
4) Silical gel

14. Write any two advantages of ION exchange chromatography.

1) Good selectivity
2) In expensive.

15. What are the Ionic groups in the Ion exchange resins?

1) $-SO_3^-$
2) $-NH_2$
3) $-NH_3^+$
4) $-COO^-$
5) $-PO_3^=$

PART – B

1. Explain elution chromatography in detail.

The first purification method which we discuss is elution chromatography. This type of chromatography commonly uses a packed column of adsorbent particles, which can be solid, porous solid, or gel. As a result, elution chromatography is similar to fixed bed adsorption, a similarity echoed by that technique's alternate name, frontal chromatography.

Elution chromatography involves injecting a pulse of solute into one end of the column, and then following the pulse with solvent. Eventually, the pulse comes out the other end of the column. The pulse will have entered as a narrow, concentrated peak, but it will exit dispersed and diluted by the additional solvent. In this sense, elution chromatography is different from fixed bed adsorption, where the goal is to capture the solute on the adsorbent and then elute it as a concentrate. In elution chromatography, the goal is to purify the product even while it is diluted.

Pulses of different solutes all leave the bed diluted, but they leave at different times, as suggested schematically in figure. Three solutes, shown as circles, squares, and triangles are injected as a pulse into one end of a column, shown as the horizontal lines. Solvent flows from left to right in the column, displacing the original (shaded) contents. The solute shown as triangles is not adsorbed much, so it is swept along quickly; the solute shown as circles is most strongly adsorbed, so it is most retarded.

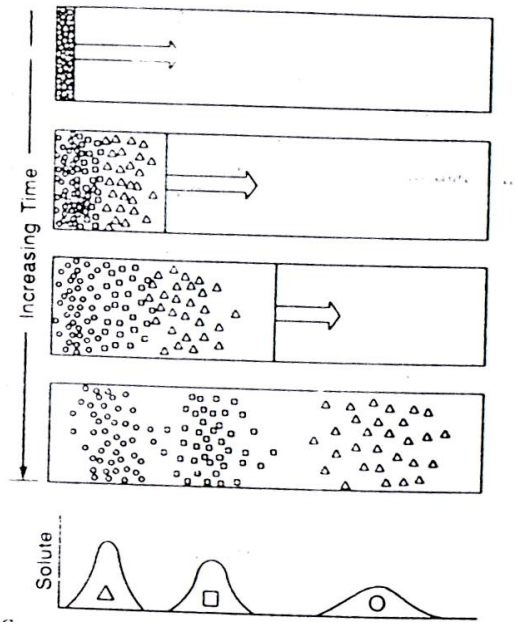


Figure: Concentrations in elution chromatography. Three solutes, shown schematically as circles, and triangles, are injected into one end of a packed bed. When solvent flow through the bed from left to right, the three solutes move at different rates because of different adsorption. They exit at different times, and hence are separated.

The triangles reach the end of the column first, and so are eluted first as shown in the graph at the bottom of the figure. The squares and circles exit later. This difference in elution is the source of the purification. The price of this purification is dilution with solvent.

This synopsis parallels that for adsorbents in Section so we emphasize the differences from adsorption. We next turn in Section 7.2 to descriptions of the yield and purity obtained in elution chromatography. The yield can be described in terms of two parameters, a time or volume at which the solute peak exits and a standard deviation of the peak. The purity depends on the same parameters as the yield, but for more than one solute.

Section 7.2, which is basic to this chapter, assumes that the exiting solute peaks have a roughly Gaussian shape. This Gaussian shape in two ways. The first, given in Section 7.3, assumes that the adsorbent column consists of a discrete number of stages, each of which is at equilibrium. The peaks are predicted to emerge from these hypothetical stages in a Gaussian from, similar to that obtained for the Craig extractor described in Section 7.4, uses concepts of mass transfer like those for differential contacting (Section 5.4) or for fixed bed adsorption (Section 6.4). Since both the discrete stage approach and the mass transfer analysis lead to the same final equation, we may have little reason to choose between the two approaches. In fact, those who view mathematics as masochism may prefer to skip from Section 7.2 directly to Section 7.5.

In Section 7.5, we discuss the scale-up of elution chromatography. This section is more speculative than many others in this book, for chromatography has been most widely used as an analytical technique. Efforts to extend chromatography to larger scale purifications have frequently ended in disillusion and dismay. Those working in this area have learned from these failures, so that more large scale successes are now being reported. The risk is worth the substantial purifications which are possible.

2. Explain various adsorbents used in chromatography.

Adsorbents

As explained in the introduction, elution chromatography involves a pulse of solutes swept through a packed column by excess solvent. The packed column contains solid adsorbents which retard specific solutes and hence effect the separations. These packings are similar to those sued for adsorptions, discussed in Section 6.1. However, the mechanisms of adsorption differ sufficiently to merit a separate description.

The solid packing commonly used for elution chromatography are summarized in Table. Those tested at large scale are most similar to the packing used for adsorptions. Inorganic materials like alumina are more commonly used than activated carbon, the common choice for

adsorption. Diatomaceous earth impregnated with organic liquids like propylene glycol has also been commonly used. This packing usually has a low selectivity, and so is in disrepute as an analytical method. Nonetheless, its low cost makes it a benchmark for large scale separations.

Table: Solid phases Used for Elution Chromatography

Scale	Type	Typical Stationary Phases	Mechanism	Remarks
Large	Adsorption	Alumina silica gel	Vander Waals forces	Low selectivity but inexpensive
	Partition	Diatomaccous earth impregnated with glycol	Distribution between liquid phases	Low selectivity, so poor analytically; inexpensive
	Ion exchange	Polymers of sulfonated styrene; dextran	Weak ionic or covalent bonding	Good selectivity, an important method at any scale
Moderate Gel	Filtration	Dextrans: Polyacrylamides	Differences in absorption	Good selectivity with potential for large scale
	Affinity	Enzymes bound to polymer supports	Specific chemical reactions	Exceptional selectivity so the most rapidly expanding type
Small	Thin layer (TLC)	Alumina: hydroxyapatie	Weak vander Waals forces	A standard laboratory method: difficult larger scale
	Paper	-	Weak van der Waals forces	An analytical tool only.

Ion exchange resins remain an important method at any scale. These resins may contain a wide variety of ionic groups, including $-SO^{-}_{3}$, $-NH_2$, $-NH^{+}_{3}$, $-COO^{-}$, and $-PO^{-}_{3}$. Curiously, the solutes often do not bind to these ionic groups, but may be adsorbed on other hydrophilic or hydrophobic sites within the resins. Often, binding occurs on more than one site; often, binding is competitive or cooperative between different solutes. These complexities are especially important for proteins.

The major caution in planning large scale ion exchange chromatography is that manufacturers' claims for their resins are often exaggerated. We do not mean to imply that these claims for their resins are often exaggerated. We do not mean to imply that these claims are not

made in good faith; we believe that they are. However, ion exchange resins may be poisoned by the particular impurities which we want to remove. Such poisoning reduces the, separation. Removing the poison can destroy the resins, a disaster for an expensive custom made material. We urge both caution and skepticism.

The best current method for moderate scale chromatography uses gels as the solid phase. Two common types of gels are detrains and polyacrylamide. The dextrans, often sold as Sephadex, are made by crosslinking dextrin with epichlorohydrin. The polyacrylamides, which are easier to make in the laboratory, are sold as highly monodisperse spheres to minimize dispersion. Both gels are aggressively marketed in a wide variety of forms.

3. Explain yield and purity with necessary equations.

Yield and purity

In this section, we discuss both the yield and purity possible in elutin chromatography. As previously explained, this process involves injecting a pulse of mixed solutes into a packed column, and then washing these solutes out of the column. The eluted solutes are collected as fractions, some of which are enriched in a particular solute.

We want to know the yield and purity of the solutes in these fractions. To do so, we must the fractions. Two are common: time and number of bed volumes. The second, dictated by experiment, is the total volume of solvent eluted divided by the volume of solvent originally in the bed. Because both designations are common, we will give results in both terms.

We begin by calculating the yield. The total amount eluted between two times t′ and t is given by

$$[\text{amount eluted}] = \int_t^t yH dt$$

where y is solution concentration and H is the solvent flow. The total in the column is clearly

$$[\text{total solute}] = \int_0^\infty yH dt$$

The yield is no more than the ratio of these integrals

$$[\text{yield}] = \frac{\int_t^t yH dt}{\int_0^t yH dt}$$

The purity can be defined by similar arguments

$$[\text{purity of soltue i}] = \frac{\int_t^t y_i H dt}{\sum_j \int_t^t y_j H dt}$$

where the summation over j includes all solutes present.

These formal definitions can be made more useful by assuming a specific form for the concentration profiles in the column. One common practical forms is

$$y = y_0 \exp\left(-\frac{[t/t_0 - 1]^2}{2^{s^2}} \right)$$

where y_0 is the maximum concentration; t_0 is the time at which this concentration exits, and $t_0\alpha$ is the standard deviation of the peak. Such a Gaussian form is an obvious approximation, but one which is frequently as accurate as the chromatographic data. A similar equation in terms of the volume eluted V is also often assumed

$$y = y_0 \exp\left(-\frac{[V/V_0 - 1]^2}{2\sigma^2} \right)$$

where V_0 is the volume required to elute the maximum concentration y_0 and $V_0\sigma$ is now the standard deviation. Note that V equals Ht.

The parameters appearing in these equations can easily be determined from the experimental results. For example, if we use Eq, the maximum concentration and the time for this maximum are measured directly. The standard deviation can be found by plotting $(t/t_0\text{-}1)^2$ versus $2 \ln(y_0/y)$: the slope is σ^2. In our own research, we avoid computer programs which find these parameters without making a graph. A graph gives a quick test of how near the concentration profile is to the Gaussian approximation. If it is Gaussian, data from the ascending and descending portions of the profile will fall along the same line. In addition, we find that our data almost always contain obvious errors. Using a least squares program without looking at a graph can disguise these errors.

We now combine these assumed profiles with the previous formal definitions. For example, the amount eluted may be found from and

$$[\text{amounteluted}]\int_{t'}^{t} Hy_0 \exp\left(-\left[\frac{t/t_0 - 1}{2\sigma^2}\right]^2\right) dt$$

$$= Hy_0 \int_{t}^{t} \exp\left(-\left[\frac{t/t_0 - 1}{2\sigma^2}\right]^2\right) dt$$

$$= \left[\sqrt{\frac{\pi}{2}} Hy_0 t_0 \sigma\right] y_0 \left\{\text{erf}\left[\frac{t/t_0 - 1}{\sqrt{2}\sigma}\right] - \text{erf}\left[\frac{t'/t_0 - 1}{\sqrt{2}\sigma}\right]\right\}$$

in which

$$\text{erf } x = \frac{\sqrt{2}}{\pi} \int_0^x e^{-u^2} du$$

Values of this function are given in Table.

The approximations in imply that solute is eluted only over a small fraction of the total time. As a result, y_0 is essentially a constant value, and the lower limit of the integrals can be changed from zero time to a time of minus infinity. Both of these approximations are commonly accurate.

4. Gel Permeation Chromatography of Urease. We plan a large scale purification of urease a packed calcium of polyacrylamide beads. We obtain the following data:

Volume Eluted (liters)	Concentration (Arbitrary Units)
174	0.0063
190	0.0512 (maximum)

The bed volume is 20 liters. Find V_0, σ, and the yield at 190 and 200 liters.

Solution:

The value of σ can be estimated using:

$$\frac{y}{y_0} = \exp\left(-\left(\frac{174\text{liters}}{190\text{liters}} - 1 \right)^2 / 2\sigma^2 \right)$$

$$\frac{0.0063}{0.0152} = \exp\left(-\left(\frac{174\text{liters}}{190\text{liters}} - 1 \right)^2 / 2\sigma^2 \right)$$

$$\sigma = 0.063$$

The yield between zero volume eluted and a given volume can be found by writing the parallel of in terms of bed volumes:

$$\text{yield} = \frac{1}{2}\left[1 + \text{erf}\left(\frac{V/V_0 - 1}{\sqrt{2}\sigma} \right) \right]$$

The yield after 190 liters is obviously 50%; that after 200 liters can be found from

$$\text{yield} = \frac{1}{2} + \text{erf}\left(\frac{200/190 - 1}{\sqrt{2}0.063} \right)$$

$$\text{yield}=0.80$$

Waiting longer gives a higher yield but risks a lower purity.

5. Explain in detail about discrete stage analysis.

Discrete stage analysis

In the previous section, we discussed the yield and purity possible in chromatography. We described both yield and purity in terms of the exiting chromatographic peaks, which we assumed to be Gaussian. Such a Gaussian assumption is often justified experimentally, but merits some additional rationalization. One rationalization is supplied in this section; a second, different rationalization is given in the section which immediately follows.

The rationalization in this section assumes that the chromatographic column is not a continuous packed bed but a series of stages like those shown in Figure. Each stage is like a well mixed tank of fixed volume in which the solution and adsorbent are in equilibrium. Solvent flows from one stage to the next, but adsorbent remains within the same stage where it begins. Ironically, this picture is that commonly used by biologists and chemists, who rarely use it for other processes. It is eschewed by many engineers: they routinely use the concept of stages for distillation and extraction, but describe chromatography with the mass transfer theories given later.

We can use this model for chromatography by writing solute mass balances on each stage. For example, for example, for stage n. we have

$$\begin{bmatrix}\text{accumulation}\\ \text{in liquid}\end{bmatrix}+\begin{bmatrix}\text{accumulation}\\ \text{in adsorbent}\end{bmatrix}=\begin{bmatrix}\text{solute}\\ \text{flow out}\end{bmatrix}$$

or in symbolic terms.

$$\varepsilon V_S \frac{dy_n}{dt}+(1-\varepsilon)V_S\frac{dq_n}{dt}=H(y_{n-1}-y_n)$$

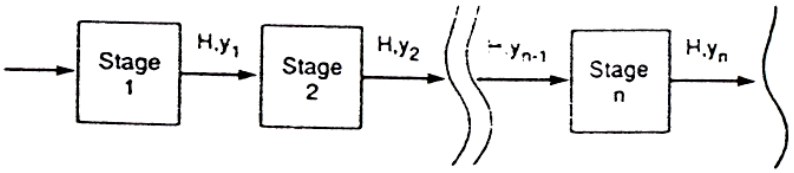


Figure: Modeling elution chromatography as equilibrium stages. The solvent flow H is assumed to be constant, just as in staged extraction. The solute concentrations are again identified by the number of the stage which they are leaving.

Where ε is the volume fraction of liquid in the stage, V_s is the stage volume, y_n is the solute concentration in the liquid in stage n (defined as source per volume solvent), q_n is the solute concentration in the adsorbent (defined as solute per volume of adsorbent), H is the solvent flow (taken as constant).

Solute concentrations in the solvent and the adsorbent are assumed to be in equilibrium, so

$$q_n = Ky_n$$

This isotherm is linear, and so is inconsistent with many actual adsorption isotherms. We argue here that chromatography dilutes all solutes and that at high dilution all isotherms become linear. Combining Eqs. And we obtain

$$\left[\left(\varepsilon+(1-\varepsilon)K\right)V_s\right]\frac{dy_n}{dt}=H(y_{n-1}-y_n)$$

Note that the quantity in square brackets has the physical significance of the hypothetical solvent volume which would be required to contain the solute actually present in both solvent and adsorbent.

Equation, the key to our analysis, must now be solved for all of the stage in our column. Originally, none of the stages contain solute

$$t < 0,\ y_n = 0, \qquad n=1.2,...,N$$

where N is the total number of stages in the column. Initially, we do inject into the column the contents of a feed stage:

$$t = 0, \quad y(\text{feed stage}) = y_F$$

We now can solve to find

$$y_n = y_F\left(\frac{J^{n-1}e^{-J}}{(n-1)!}\right)$$

in which the dimensionless time T is given by

$$T = \frac{Ht}{\left[\left(\varepsilon+(1-\varepsilon)K\right)V_s\right]}$$

We now replace the stage volume V_S with (V_B/N), where V_B is the bed volume. Thus

$$\tau = N\left\{\frac{Ht}{\left[\left(\varepsilon+(1-\varepsilon)\right)K\right]V_B}\right\}$$

The quantity in braces represents the volume of solvent flowing through the column divided by that hypothetical column volume which includes the effect of adsorbent.

This important result, which is a Poisson distribution, is illustrated by the distributions shown in Figure. When the number of stages is small, the distribution looks like a decaying exponential. However, as the number of stages becomes large, the profiles approach the Gaussian limit which is observed experimentally:

$$y = y_0 \exp\left[-\frac{(\tau-\tau_0)^2}{2\tau_0^2\sigma^2}\right]$$

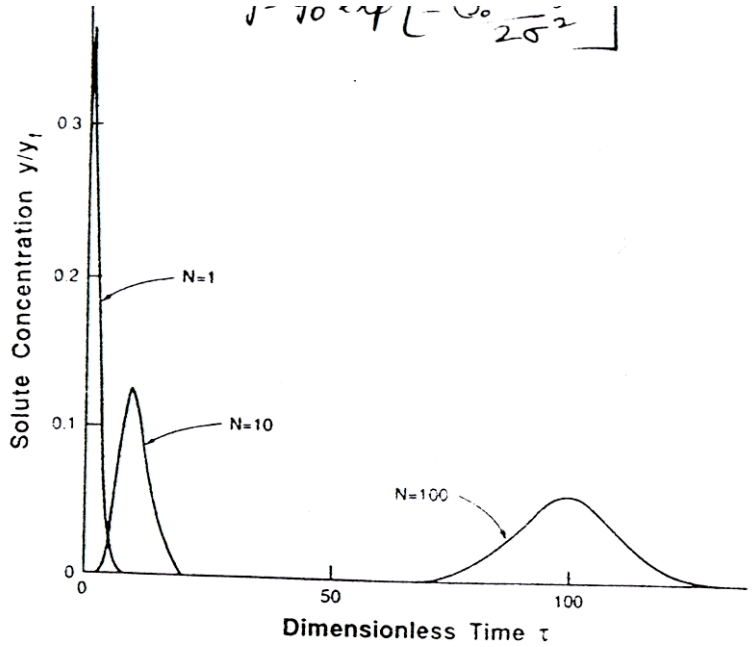


Figure: Concentration versus time. As the time increases, the concentration rises from zero to a maximum and then drops. As the number of stages becomes large, this variation of concentration becomes Gaussian.

6. Stage in Triglyceride Chromatography. High pressure liquid chromatography of stearic-oleic-stearic glyceride gives a peak leaving the column after 85 min. The width of this peak when the concentration is half the maximum is 5 min. Estimate the number of hypothetical stages in this column.

Solution: The number can easily be calculated from

$$\frac{y}{y_0} = \exp\left(-\frac{N}{2}\left(\frac{t}{t_0}-1\right)^2\right)$$

$$0.5 = \exp\left(-\frac{N}{2}\left(\frac{85+5/2}{85}-1\right)^2\right)$$

$$N = 1600$$

If the peak were wider, $(t/t_0 - 1)^2$ would be larger and N would be smaller.

7. Chromatography of Bovine Serum Albumin. 10 g of this albumin is eluted from an 80 liter Sephadex column which has a void fraction of 0.4. The concentration in the column peaks after 470 liters are elute; this maximum concentration is 1.8% of that originally in the column.

Estimate:

(a) the equilibrium constant for binding the albumin to the Sephadex;
(b) the number of stages in the column; and
(c) the concentration profile in the column.

Solution: (a) We can find the equilibrium constant K from

$$Ht_0 = \left[\varepsilon + (1-\varepsilon)K\right]V_B$$
$$470\,\text{liters} = \left[0.4 + (1-0.4)K\right]80\,\text{liters}$$
$$K=9.1$$

The packing holds almost 10 times more albumin than the solution.

(b) The standard deviation is not given, and so cannot be used to estimate the number of stages. However, from, we find

$$\frac{y_0}{y_F} = \frac{1}{\sqrt{2\pi N}}$$
$$0.018 = \frac{1}{\sqrt{2\pi N}}$$
$$N = 490$$

This number is characteristic of this column.

(c) To find the concentration profile, we insert these values into

$$\frac{y}{y_0} = \exp\left(-\frac{N}{2}\left(\frac{V}{V_0}-1\right)^2\right)$$
$$= \exp\left(-\frac{1.1\times10^{-3}}{\text{liter}^2}(Ht - 470\,\text{liters})^2\right)$$

This is the desired result.

8. Explain in detail about kinetic analysis.

Kinetic Analysis

The concentration profiles produced by elution chromatography may be rationalized in two ways. The first, described in the previous section, assumes the column contains equilibrium stages. The second, the focus of this section, assumes that the concentration profile is the result of diffusion and chemical reaction. The first way provides a quick characterization, useful for comparing columns; the second gives a somewhat more complex description which is nearer to what actually happens.

A Qualitative Introduction

To see the effects of diffusion and reaction, we imagine a solute pulse flowing into a packed column, as suggested in Figure. If there is plug flow without diffusion, reaction, or dispersion, then this pulse would come out of the column unchanged. It would leave at a time determined only by the flow rate and the column geometry; it would leave unaffected by any chemistry. Pulses of all solutes which entered at the same time would leave at the same time.

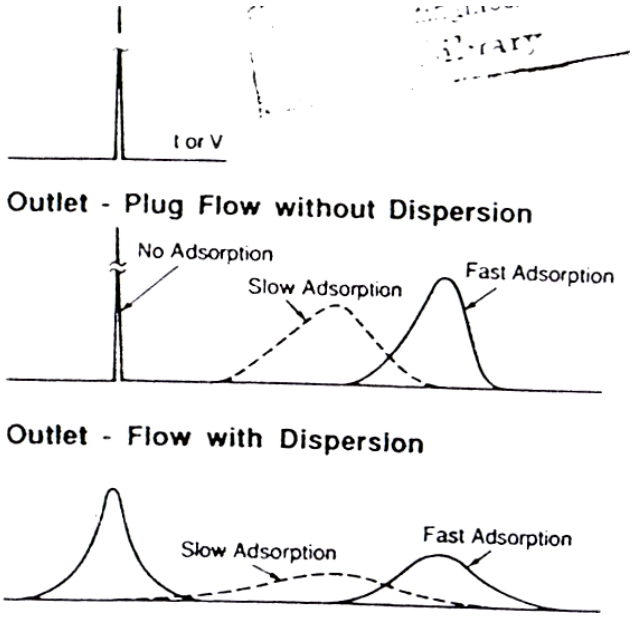


Figure: Modeling elution chromatography with rate processes. A sharpened pulse of solute will exit as sharp pulse only in the case of plug flow without dispersion. In all other cases, the pulse will be broadened and its maximum concentration reduced.

Pulses of all solutes which entered at the same time would leave at the same time.

If, on the other hand, the solute reacts with the column packing, it can be retarded. The amount of retardation depends on the nature of this reaction. If the reaction involves slow adsorption and fast adsorption, the fast desorption, the retardation may be slight; if it includes fast adsorption but very slow desorption, the retardation will be major. Pulses of different solutes will be retarded by different amounts, which is the basis of chromatographic separations.

It is the estimation of this retardation from the diffusion and reaction which is the subject here. Before turning to this estimation, we must recognize that dispersion also spreads any solute pulse. By "dispersion," we mean the axial mixing caused because the flow is diverted by the packing, because the flow may be laminar, and because the bed may not be uniformly packed. As a result, dispersion is a function of physical factors like velocity and column diameter, but not of chemical differences between solutes. Dispersion will spread both a pulse which reacts with the packing and a pulse which does not. Dispersion alone will not change the time at which the pulse exits. Reducing dispersion may more clearly separate concentration profiles and hence give a better separation. However, if there is not separation without dispersion, there will be no separation with dispersion.

The actual diffusion and chemical reaction between solute and packing is often analyzed in terms of a five step mechanism:

1. The solute is transferred from the bulk solution to the surface of the packing.
2. It diffuses into the packing.
3. It reacts reversibly with the packing; this reaction may include adsorption, any surface reaction, and eventual desorption.
4. The desorbed solute diffuses back out of the packing to the packing's surface.
5. It diffuses from the surface back into the bulk solution.

Such a five step model has its genesis in studies of heterogeneous catalysis, and so can be used to harvest a rich crop of earlier results.

In most cases, a single step in this sequence is much slower than the others, and so controls the overall rate. In particular, many bioseparations will be controlled by diffusion into and out of the packing. This is because the diffusion coefficients of biological macromolecules, which are slow in any case, will be further hindered within the packing.

9. Explain in detail about quantitative approximation.

A Quantitative Approximation

The quantitative description of elution chromatography is based on equations similar to those used for adsorption in a packed bed. The boundary conditions are, of course, different. As before the development begins with a mass balance on the solute:

Solute accumlaiton in liquid and packing =solute dispersion in-out+solute convection in-out

$$\varepsilon\frac{\partial y}{\partial t}+(1-\varepsilon)\frac{\partial q}{\partial t}=E\frac{\partial^2 y}{\partial z^2}-\nu\frac{\partial y}{\partial_z}$$

in which y is the concentration in solution. Q is the concentration per volume of solute, ν is superficial velocity, E is the dispersion coefficient and ε is the void fraction in the bed. In many cases, the accumulation in the solution is smaller than that in the packing and the dispersion is negligible. The equation the simplifies to

$$(1-\varepsilon)\frac{\partial q}{\partial t}=-\nu\frac{\partial y}{\partial z}$$

The initial conditions are that

$$t=0,\ \text{all } z,\quad y=\left(\frac{M}{A}\right)\delta(z)$$

$$\text{all } z,\quad q=0$$

Solving these equations also requires writing an equation for q as a function if y.

The exact relation between q and y depends on the controlling step in the mechanism outlined previously. If mass transfer between the bulk solution and the surface of the particle is controlling (i.e., step 1 or 5 is slowest), then

$$(1-\varepsilon)\frac{\partial q}{\partial t}=\sqrt{\frac{D}{t'}}a(y-y^*)$$

in which D is the effective diffusion coefficient in the pores and t′ is some characteristic time. If first order, reversible chemical reaction is rate controlling:

$$(1-\varepsilon)\frac{\partial q}{\partial t} = ky = k'q$$

where k and k' are the forward and reverse rate constants of this reaction. Each special case will give a somewhat different concentration profile.

In most cases, we are not able to measure the concentration profile accurately enough to differentiate between these mechanisms. We want only an approximate solution, something which is roughly a Gaussian. To get this, we assume that, for example is correct, and we combine it with:

$$ka(y - y^*) = -\nu\frac{dy}{dz}$$

This equation can be integrated to give the column length I:

$$l = \int_0^t dz$$
$$= \left[\frac{\nu}{ka}\right]\int_{y_0}^{\nu}\frac{dy}{y - y^*}$$

By analogy with differential extraction, we call the quantity [ν/ka] the height of a transfer unit, and the integral the number of transfer units NTU. Thus

$$l = HTU.NTU$$

We know l from our experiment; we can estimate the HTU; we can use this equation to find the NTU.

In a tremendous leap of faith, we now presume that the number of transfer units is (more or less) analogous to the number of stages. As a result, we can take a result like and substitute the number of transfer units for the number of stages:

$$y = y_0 \exp\left(-\left(\frac{t/t_0 - 1}{2\sigma^2}\right)^2\right)$$
$$= y_0 \exp\left(-\left(\frac{t/t_0 - 1}{2/NTU}\right)^2\right)$$

in which

$$NTU = \frac{1}{\sigma^2}$$
$$= \frac{l}{HTU}$$
$$= \frac{kal}{v}$$

10. Explain scaling up Chromatography.

Scaling up chromatography

Successful small scale chromatography often interest in larger scale chromatography. At the larger scale, we want a bigger capacity but with the same yield and purity. A bigger capacity means a larger throughput. The easiest way to increase the capacity is to increase the solute concentration in the feed. Such an increase often saturates the packing and reduces the purification. As a result, larger scale chromatography cannot often be achieved by increasing the solute concentration.

A more effective way to increase the capacity while maintaining purification is to increase the flow through the column. Maintaining the purification requires that the concentration profiles of each solute cannot be dramatically altered. These profiles are exemplified by

$$y = y_0 \exp\left(-\left(\frac{V}{V_0} - 1 \right)^2 \Big/ 2\sigma^2 \right)$$

as green in. Thus the concentration y is a function of three parameters: y_0, (V/V_0), and σ. If these three parameters are unchanged, the concentration profile will be unchanged.

The first two parameters, y_0 and V/V_0, can be kept constant in both small and large chromatographs. The maximum concentration y_0 is largely fixed by the inlet concentration. The ratio of volumes (V/V_0) (or alternatively, the ratio of times) is easily constant. If the bed is twice as long, the velocity in the bed is just set twice as fast.

11. Fumarase Chromatography. 10 g of the enzyme fumarase are being purified in an ion exchange column. At a velocity of 30 cm/hr. the peak in concentration exits the column in 93 min and the standard deviation of this peak is given as 12 min.

(a) How long must we purify for a 90% yield?
(b) If we increase the flow to 60 cm/hr how long must we run for this same yield if the process is controlled by diffusion and reaction?
(c) How long must we wait if the process is controlled by mass transfer?

(d) How long must we wait if Taylor dispersion controls?
(e) How long must we wait if the column actually contains equilibrium stages?

Solution: (a) From the values given, we see that the concentration profile is

$$\frac{y}{y_0} = \exp\left(-\left(\frac{t/t_0 - 1}{2\sigma^2}\right)^2\right)$$
$$= \exp\left(-\frac{(t - 93\,\text{min})^2}{2(12\,\text{min})^2}\right)$$

Thus $\alpha = 0.129$. The yield is given by:

$$\text{yield} = \frac{1}{2} + \text{erf}\,\frac{t - t_B}{\sqrt{2}t_B\sigma}$$
$$0.9 = 0.5 + \text{erf}\,\frac{(t - 93)}{\sqrt{2}93(0.129)}$$
$$t = 115\,\text{min}$$

We must wait 115/93 (=1.24) times longer than the peak time to get a 90% yield.

(b) In the rest of the problem, the velocity is doubled but the column length and packing diameter are unchanged. Thus the time to elute the peak is cut in half:

$$t_0 = 46.5\,\text{min}$$

From Table, we must see that for diffusion and reaction, σ is proportional to $v^{1/2}$, so

$$\sigma = 0.129\left[\frac{60}{30}\right]^{1/2} = 0.182$$

Thus, is now

$$0.9 = 0.5 + \text{erf}\left[\frac{t - 46.5}{\sqrt{2}46.5(0.182)}\right]$$
$$t = 61.8\ \text{min}$$

We must wait (61.8/46.5) or 1.33 times the peak time to get a 90% yield.

(c) If the process is controlled by mass transfer, the time to elute the peak is still 46.5 min but the standard deviation is now proportional to $v^{1/4}$. thus

$$\sigma = 0.129\left[\frac{60}{30}\right]^{1/4} = 0.153$$

Again, we use to find that t is 59.4 min. Now, we must wait only 1.28 times the peak time for a 90% yield.

(d) If Taylor dispersion is rate controlling, σ is again proportional to $v^{1/4}$ · As a result, the results are exactly the same as part (b).

(f) If the column really does consist of equilibrium stages, then t_0 at twice the velocity is 46.5 min. just as it is in parts (b)-(d). Unlike parts (b)-(d), σ will be uncitanged by the faster velocity: it will equal 0.129 as in part (a). As a result, the time for a 90% yield must have the same value of t/t_0 as in part (a):

$$\frac{t}{46.5\,\text{min}} = \frac{115\,\text{min}}{93\,\text{min}}$$

Thus t is 57.5 min, 1.24 times the time for the peak.

UNIT – V

PART – A

1. What is crystallization?

Crystallization, the formation of solid particles of defined shape and size from a homogeneous liquid phase, is the oldest and most common purification.

2. What is saturation?

Saturation is the maximum concentration of solute which is thcomodynamically stable in solution. Saturation is the result of phase equilibria.

3. What is purity?

The second concept basic to crystallization is that of purity can be quantified by using the factor (E).

$$E_A = \frac{\text{Weight of solute A in crystalcake}}{\text{Weight of solute A in filtrate}}$$

4. What is nucleation?

Nucleation is the formation of crystals from the liquid phase as result of sup co saturation only which concerns the genesis of new crystals.

5. What is single crystal growth?

The growth rate depends on the growth mechanism in nonagitated systems, the growth rate is limited by diffusion and the growth is described as "diffusion controlled growth".

6. What is crystal size distributions?

Crystal size distribution extends the mass and energy balances basic. The extension is necessary because crystallization produces not a single homogeneous lump of solid.

7. What is population density?

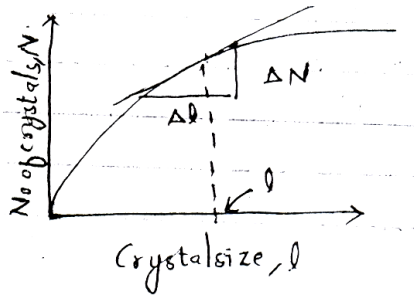


Figure:

A typical crystal size distribution is described by a population density. The abscissa in this plot is the characteristic size L. The ordinate N is the number of crystals per volume between size zero and l.

8. What is batch crystallization?

Batch crystallization is the most common method of polishing antibiotics and other bio molecules of moderate molecular weight.

9. What is Batch scale – up?

The scale – up of crystallization requires an estimate of the overall nucleation rate. This nucleation rate is affected by cooling, agitation and vessel geometry.

10. What is drying?

Drying biological materials can serve several purposes it can stabilize the bulk product until it con be formulated.

11. What is water content?

Water in most biological materials is present in two forms, free water and bound water free water is that held in spaces between cells or in capillaries of porous precipitates.

12. What is relative humidity?

$$\text{Relative humidity} = \frac{\text{Actual partial pressure of water}}{\text{Equilibrium vapor pressure of water}}$$

13. What is evaporation rate?

Evaporation rate per area j_i by means of the equation,

$$\boxed{j_i = k\left(C_{1i} - C_1\right)}$$

where C_{1i} and C_1 are water concentrations at the water – air interface and in the bulk air.

14. What is conduction dryers?

The simplest conductive dryer is a try. The tray is filled with wet solids and placed on an over shelf. Heat conducted from the shelf through the tray and into the solids evaporates the water to dry, the solids.

15. What is adiabatic dryers?

The second major type of dryer does not depend on conduction, but on a circulating gas. This gas enters warm and dry it evaporates liquid and so exits cold and wet.

16. Write the equation for constant rate drying.

$$\boxed{\frac{d}{dt}\left(\frac{\pi}{6} d^3 \delta_s . w\right) = -\left(\pi d^2\right) j1}$$

17. What is physical extraction?

The compound gets itself distributed between two liquid phases based on the physical properties. This technique is used for extraction of non – ionizing compounds.

18. What is Dissociation extraction?

This technique is suitable for the extraction of lonisable compounds certain antibiotics can be extracted by thus procedure.

19. What is reactive extraction?

In this case, the desired product is made to react with a carrier molecule (e.g., phosphorous, compound, aliphatic amine) and extracted into organic solvent. Reactive extraction proud or is quite useful for the extraction of certain compounds that are highly soluble in water e.g., Organic acids.

20. What is membrane adsorbers?

They are micro or macro porous membranes with lon exchange groups and / or affinity ligands membrane adsorbcos can bind to proteins and retain them.

PART – B

1. Explain crystallization process in detail.

Crystallization the formation of solid particles of defined shape and size from a homogeneous liquid phase, is the oldest and most common purification. Common salt was first recovered from sea water by the Chinese over 5000 years ago. Inorganic salts, like sodium and ammonium sulfates, and certain organic compounds, such as sucrose and glucose, are produced in quantities exceeding 100 million tons per year. Most bulk pharmaceutical and organic find chemicals are marketed as crystalline products.

The dominance of crystallization is not a historical accident, but the consequence of three important factors. First, crystals are usually of exceptional purity. This is especially important for our applications, where we have already purified the product until the level of impurities is low. Second, the production of uniform crystals facilitates subsequent finishing steps, like filtering or drying. Third, crystallization improves the product's appearance, an important aspect of consumer acceptance. These three factors make crystallization important.

Laboratory crystallization is a relatively simple operation. A clear, warm, concentrated solution of the solute, near its solubility limit, is cooled slowly in a dust – free environment until small crystals appear. These small crystals are often induced by adding still smaller crystals as "seeds". Upon further cooling, additional crystals appear and the original ones grow. After crystallization, the product is recovered by filtration or centrifugation and the residual mother liquor is removed by wasting. Drying completes the sequence.

Although laboratory crystallization is simple, using laboratory results to design large scale crystallization is formidable. Large scale crystallization is a process of ill – defined geometry. With simultaneous mass and heat transfer in a multiphase, multi component system that is thermodynamically unstable. It can be profoundly affected by trace impurities. In spite of its age and importance, large scale crystallization remains an art, not a science.

Crystallization is akin to precipitation discussed in chapter, and some of the concepts discussed there apply here also. A major difference is that crystallization yields particles of well defined shape and size, while precipitation results in amorphous solids of ill – defined shape and size. This difference is the reason why crystals are much purer than amorphous precipitates.

Basic concepts of crystallization are discussed in section including super saturation 1 and nucleation. The application of these concepts to crystal size distributions is developed in section 2. such size distributions are most easily applied to continuous crystallizers; unfortunately. Most bio separations use batch crystallizers. Models for batch crystallization are presented in section 3 and

strategies for recrystallization are discussed in section 4. The result is an overview of this important yet empirical separation.

2. Explain saturation process in detail.

Saturation:

Saturation is the maximum concentration of solute which is thermodynamically stable in solution. Saturation is the result of phase equilibria. As for precipitation, phase equilibra for crystallization result from equal chemical potentials between the solid crystal phase and the surrounding solution, called the "mother liquor". Such equilibrium data are usually presented as a temperature – solubility diagram like that shown in figure.

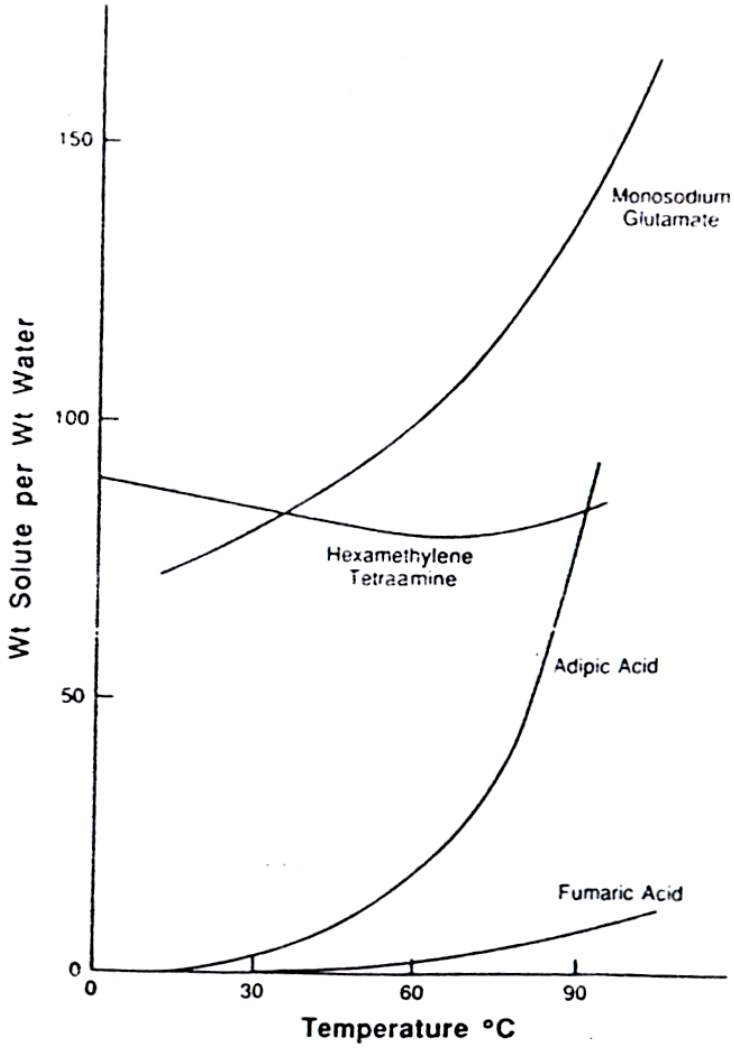


Figure: solubility versus temperature. Solubility almost always varies with temperature, but in widely different ways.

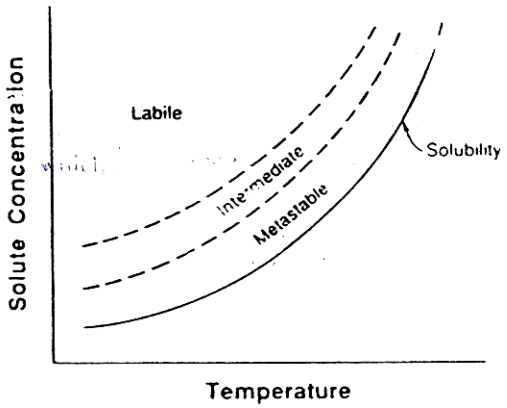


Figure: Regions of super saturation. The nature of crystal nucleation and growth is often different in the three regions shown above the solubility

These data show various concentration – temperature coefficients. Each coefficient is a property of the specific solute and solvent. While concentration of solute can be expressed in numerous units, we will use the ratio of solute mass per solvent mass throughout this chapter.

In many cases, solutions can contain more solute than that present at saturation. Such supersaturated solutions are thermodynamically unstable. However, they are often metastable, that is they can remain unaltered for long periods of time. This metastability is the result of the surface energy of small crystals. To be sure, a supersaturated solution has a higher total free energy than the saturated solution, but the free energy of a solution containing small crystals may be higher still. As a result there is a significant thermodynamic barrier stabilizing super saturation.

Studies of the super saturated state suggest that it can be divided into the three loosely defined zones illustrated in figure first. There is a metastable zone, where solute in excess of the equilibrium concentration will deposit on existing crystals but no new crystal nuclei are formed. Second, there is an intermediate zone where both growth on existing crystals and the formation of new nuclei occur simultaneously. Third, there is a labile zone where nuclei are formed spontaneously from a clear solution. Unlike the solubility – temperature relation, these three zones are controlled not only be equilibria, but also by process parameters like agitation.

3. Explain single crystal growth in detail.

In addition to the rate at which new crystals are formed, we must describe how existing crystals grow. This growth rate depends on the growth mechanism. In may instances, particularly in nonagitated systems, the growth rate is limited by diffusion. Such growth, described as "diffusion controlled" is expressed as

$$\frac{dM}{dt} = kA(c - c^*)$$

where k is a mass transfer coefficient, A is the crystal area, and c and c* are again the concentrations in solution and at saturation respectively.

Other mechanisms of single crystal growth also occur commonly. In particular, as agitation increases the relative velocity between the circulating solution and the crystal, the growth rate often, reaches a maximum. Such behavior is consistent with diffusion control at small relative velocities and surface reaction control at high relative velocities. If we assume a linear dependence of the reaction rate with super saturation, the growth rate is now given by

$$\frac{dM}{dt} = \left(\frac{A}{1/k + 1/k}\right)(c - c^*)$$

where k is a surface reaction rate constant. Note that k varies with solution properties like viscosity and agitation, but k does not. Note that k varies little with temperature, but k can change dramatically on cooling.

Rate equations like these are difficult to use because the crystal area A varies with the crystal mass M. We can connect these quantities if the crystal maintains geometric similarity during growth, that is, if any length remains in a constant ratio with all other lengths. In this case, the arbitrary selection of a single dimension can be used to characterize the size changes. Thus we define a characteristic crystal length.

$$l = \frac{6M}{\rho A}$$

The source of this definition can be seen for a cubic crystal of side s. for such a crystal, $M = \rho s^3$, $A = 6s^2$, and $l = s$. By similar arguments for a spherical particle, one can show that l equals the sphere's diameter. In general, I is close to the particle size found by screening. With this definition, we define

$$M = \rho \phi_v l^3$$
$$A = 6\phi_A l^2$$

where the ϕ, are geometric factors characteristic of the crystal shape. We now rewrite equation in terms of I:

$$\frac{d}{dt}\left(\rho\phi_v l^3\right)=\left[\frac{6\phi_A l^2}{1/k+1/k}\right]\left(c-c^*\right)$$

$$\frac{dl}{dt}=\left\{\frac{\left(2\phi_A/\phi_v\rho\right)}{1/k+1/k}\right\}\left(c-c^*\right)$$

$$=k_g\left(c-c^*\right)$$

$$=G$$

where k_g equation to the quantity in braces, is the rate constant for single crystal growth and G is that growth.

Equations are basis of our analysis of crystallization. The former describes the appearance of new crystals and the latter describes how they grow. Note that both the nucleation and growth rate depend on the super saturation, but are independent of the sizes of crystals which have already formed. We will use this independence in the analysis which follows.

4. Separation of Soy sterols. A mixture of stigmasterol and sitosterol weighing 2040 kg is divided into two fractions by crystallization. The original mixture contains 86.5% stigmasterol. The recovered crystals are 96.6% stigmasterol and weigh 1137 kg. The solids in the liquor contain 74.6% stigmasterol, found by evaporation to dryness.

Determine the β value for this separation.

Solution:

We first calculate the E value for stigmasterol and sitosterol using equation

$$E_{\text{stigmasterol}}=\frac{1137\text{kg}\times 0.966\text{kg stigmasterol/kg}}{(2040-1137)\text{kg}\times 0.746\text{ kg stigmasterol / kg}}$$

$$=\frac{1098}{673.6}=1.63$$

$$E_{\text{sitosterol}}=\frac{1137\text{kg}\times(1.000-0.966)\text{kg sitosterol / kg}}{(2040-1137)\text{kg}\times(1.000-0.746)\text{kg sitesterol/kg}}$$

$$=\frac{38.66}{229.4}=0.168$$

Thus we find

$$\beta = \frac{E_{stigmasterol}}{E_{sitosterol}} = \frac{1.63}{0.17} = 9.6$$

Remember that the β value is often a function of composition.

5. Explain Batch scale – up in detail.

The scale – up of crystallization requires an estimate of the overall nucleation rate. This nucleation rate is affected by cooling, agitation, and vessel geometry. Those whose research centers on this topic now generally agree that secondary nucleation rather than homogeneous or heterogeneous nucleation becomes the dominant factor at a large scale. Secondary nucleation, the generation of nuclei by crystals already present in suspension, can occur through crystal – crystal contacts, from crystal – wall contacts, and from crystal – agitator contacts. No unified theory exists for this effect; attempts to develop such a theory have been confined to continuous operations.

Scale – up when secondary nucleation is important has been suggested on several bases: constant power per volume, constant agitation, constant agitator tip speed, and even the minimum agitator speed to sustain suspension. Most studies have been conducted with inorganic salts and with small scale – up ratios (1-50 liters). Although the empirical data obtained from each study successfully correlate that study's results, agreement between studies does not exist. These approaches are helpful largely in identifying directions for future work.

In the absence of much reliable engineering, we urge those attempting these crystallizations to proceed empirically and cautiously. In our own work, we increase the scale of operation modestly, monitoring the results at each scale to insure that we have not changed the yield, the purity, and the permeability as we gain experience, we use the cooling curve suggested by equation to retain the original crystal size distribution. We are forced onto this track because reliable data from industrial crystallizations, especially for our type of product, do not exist in the open literature.

6. Explain recrystallization in detail.

Although in theory, pure crystals are obtained from solution, some impurity almost always remains in the crystalline product. This may occur for several reasons. The impurity may have a similar solubility to that of the desired product, and consequently, partially cocrystallize. Sometimes, the impurity is incorporated into the product matrix. In other cases, inefficient washing does not remove all of the mother liquor and causes contamination.

Recrystallization can often reduce impurity concentration. The sequence by which recrystallization is effected can take different forms. In the simplest case, the impure crystals are dissolved in a small amount of pure hot solvent and cooled to produce a fresh crop of crystals. These new crystals will be purer than the original ones. Such a step may be repeated until crystals of the desired purity are obtained.

This type of operation, called a simple recrystallization, is shown in figure. In this figure, fresh solvent is designated S, mother liquors are called L_1, and the original crystals are called AB. The crystal purity increase from X_1 to X_2 to X_3; the purity of the liquors also increases from L_1 to L_2 to L_3.

In a sequence of the kind, the yield of product can be low and only a small portion of the desired solute is recovered in the final "pure" crystals.

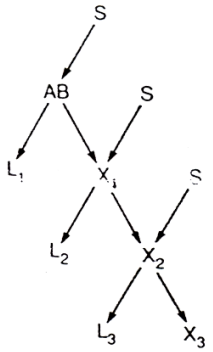


Figure: simple recrystallzation. This scheme, which uses fresh solvent for each recrystallization, gives a high purity but a low yield.

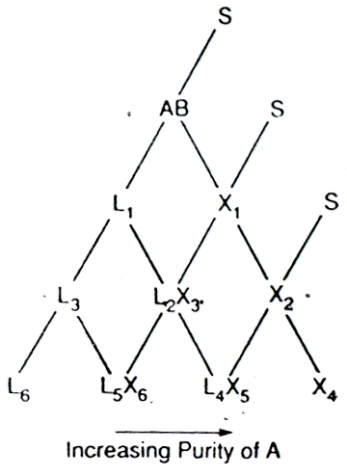


Figure: Fractional recrystallization. This scheme makes more efficient use of the various liquors, and hence gives a higher yield than that in the previous figure.

This is due to the fact that the system operates with only an enrighing section. By using purification factors like those given in equation we can shown that the yield of product a is given by

$$Y_A = (E_A / (1+E_A))^N$$

Where N is the number of recrystallization applied. A similar calculation may be made for impurities.

A better use of the mother liquors can be made with the triangular scheme shown in figure 2. As in figure 1 AB represents the original mixture; by convention A is taken as the less soluble solute and B is assigned to the more soluble solute. The AB mixture is dissolved in a small amount of hot solvent and cooled to produce crystals X_1 and a mother liquor L_1. After the crystals are separated from L_1, they are redissolved in a smaller amount of hot fresh solvent to produce a new crop of crystais X_2 and new liquor L_2. Up to this point the schemes of figures 1 and 2 are the same.

Stripping of additional a from the mother liquors is accomplished by other operations. The liquor L_1 is concentrated further to generate the crystals X_3 and the mother liquor L_3. The crystals X_3 are subsequently dissolved in the hot mother L_2. Crystallization from this newly formed solution yields another crop of crystals X_5 and a mother liquor L_5. the mother liquor L_3 is concentrated to obtain crystals X_6 and liquor L_6.

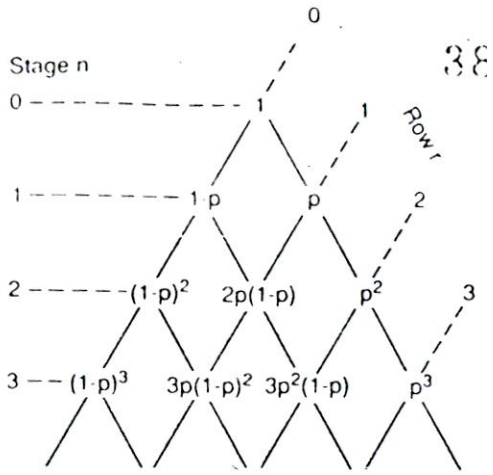


Figure: Fractional crystallization as a staged operation. This scheme produces very pure crystals by a process equivalent to that of Craig extraction detailed in section.

Such a scheme is detail in figure 2. In each step, purer crystals migrate toward the right of the diagram and imputer liquors towards the lift. Consequently, the less soluble product (A) is concentrated in fractions on the right side of the diagram and the more soluble solute (B) on the left side. Substances of intermediate solubility will accumulate in the center portion of the diagram.

We can make these ideas more quantitative using the notation suggested by figure. We define the operations depicted at the same level in the triangular scheme as stage n. We also identify any given operation by a second index, the row number r. If the initial feed contains a unit quantity of solute and each crystallization operation divides that quantity into a fraction p as crystals and (1-p) in the liquor, then the fractions of the solute for any given step in the triangle are those given in figure 3. These fractions f (r, n) are terms in the binomial expansion,

$$f(r,n) = \frac{n!}{r!(n-r)!} p^r (1-p)^{n-r}$$

equation is identical for solute distribution during craig extraction. For an effective recrystallization, the difference between the p values of the solutes should be a factor of 4 or more.

More elaborate schemes for recrystallization are not in general use. One exception is the figure scale separation of soybean sterols by a countercurrent crystallization. This system consists of six enriching stages and four stripping stages. It can be analyzed by the approaches given for fractional extraction in section.

7. Explain evaporation and heating rates in detail.

Evaporation and Heating Rates:

We now turn from these phase equilibria to the dynamic subject of mass and heat transfer. We are no longer interested only in how much water evaporates; we now want to know how fast it evaporates.

We will describe the evaporation rate per area j_1 by means of the equation

$$j_1 = k (c_1, - c_1)$$

Where $c_{1,}$ and c_1 are water concentrations at the water – air interface and in the bulk air, respectively, and k is a mass transfer coefficient, with the dimensions of velocity. Similar coefficients are used in chapter.

This coefficient is closely related to the diffusion coefficient D:

$$k = \frac{D}{l}$$

Where l is some characteristic length across which the vaporation is occurring. Usually, l is unknown. Often l is a function of D itself; only occasionally, l is an actual physical distance. Still, this relation between mass transfer and diffusion is useful to remember.

The difficult point in the definition of the mass transfer coefficient is the concentration difference. As suggests, this is a difference between the bulk and the interfacial concentrations, but only in one phase. Thus if pure water is evaporating into dry air, the concentration in the bulk is zero and that at the interface is the equilibrium vapor pressure divided by RT. The interfacial concentration is not that in the pure liquid, that is, not 1 g/cm^3 or 1 mol / 18 cm^3.

Because the evaporation rate is a function of the vapor pressure, it is also a function of temperature and hence of the rate of heating. We will describe heating rate q in terms of equations similar to those for mass transfer

$$\begin{aligned} q &= h\left(T - T_1\right) \\ &= \frac{h}{\rho C_p}\left(\rho \hat{C}_p T\left(\text{bulk}\right) - \rho \hat{C}_p T\left(\text{interface}\right)\right) \\ &= \frac{k}{l}\left(T\left(\text{bulk}\right) - T\left(\text{interface}\right)\right) \end{aligned}$$

in which T and T_1 are the air temperatures in the bulk and at the air – water interface, respectively h is called the heat transfer coefficient, ρ is the total mass concentration in the air, $\hat{C}_p$ is the specific heat capacity, k is the thermal conductivity, and l is a length across which heat is transferred. The first form equation defines the heat transfer coefficient h; it has the dimensions of mass / ((time)^3 temperature). The second from defines an alternative coefficient ($h/\rho \hat{C}_p$), not terms of a temperature difference, but in terms of a difference of energy per volume. This alternative coefficient has the dimensions of velocity, just like the mass transfer coefficient. The third form of this equation suggests how the heat transfer coefficient is related to the thermal conductivity, a more fundamental property. As in equation the price paid for this relation is the unknown length l.

In some drying processes, equation can be dramatically simplified, because

$$k = \frac{h}{\rho \hat{C}_p}$$

This astonishing quality, called the Reynolds analogy, says that the rate coefficient of mass transfer is equal to one form of the rate coefficient for heat transfer. The Reynolds analogy is accurate only for gases in turbulent flow, but this is commonly the case for drying. Its extension to liquids, called the Chilton – Colburn analogy, is not as useful here.

8. Use of Humidity – Temperature Chart. We air at 30^0 C and 70% relative humidity is to be heated to 60^0 C for use in a drying operation. If then flows into the dryer.

(a) What is the initial humidity of the wet air?
(b) What is its wet bulb temperature?
(c) What is the humidity of the air after it is heated and before it enters the dryer/
(d) What is the relative humidity of the air after it is heated and before it enters the dryer?

Solution:

(a) We can use the initial conditions of 30^0C and 70% relative humidity to find, from figure.

$$H = 18 \text{ g } H_2O \text{ / kg dry air}$$

(b) From this same figure

$$\text{(wet bulb temperature)} = 25^0 \text{ C}$$

(c) After heating, the humidity is unchanged:

$$H = 18 \text{ g } H_2O \text{ / kg dry air}$$

(d) The relative humidity can be found by interpolation in figure

$$\text{(relative humidity)} = 13\%$$

The relative humidity is changed by heating.

9. Wool Drying. 10 kg of dry wool are placed in a vessel containing 105 m^3 of air saturated with water vapor at 25^0 C. Under these conditions the wool absorbs water. What is the final relative humidity of the air?

Solution:

We first calculate the weight of the dry air:

$$\text{air volume} = \frac{0.0224 m^3}{0.029 \text{kg mol/mol}} \frac{298}{273} = 0.843 \frac{m^3}{kg}$$

$$\text{weight of air} = \frac{150 m^3}{0.843 m^3/kg} = 178 \text{ kg dry air}$$

From figure we see that saturated air at 25^0 C holds 0.02 kg water / kg dry air. Thus, the weight of water in the air is

(178 kg dry air) (0.02 kg water / kg dry air) = 3.56 kg water

we now make a mass balance for the water

(water in original air)

= (water remaining in air) + (water absorbed by wool)

(178 kd dry air) (0.02 kg water / kg dry air)

=178 (0.02 – Ħ) kg water / kg dry air
+ 10 kg dry wool (X kg water / kg dry wool)

178 Ħ = 10 X

we also know that the equilibrium between wet air and wool is given in figure solving these relationship by trial and error we find

Ħ = 0.006 kg water / kg dry air

Or 40% relative humidity.

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UNIT 1 NATURE AND SCOPE OF ETHICS

Contents

1.0 OBJECTIVES

This unit aims at introducing the students to the philosophical need for Ethics starting from a brief discussion of Moral law and how the human person in his or her process of growth intuits the ethical principles. Discussions pertaining to the dynamics of morality is undertaken to show how on the one hand new situations call for new responses from moral point of view and on the other hand certain fundamentals of ethics remain the same in so far as there is something of a common human nature adequately understood.

1.1 INTRODUCTION

Let us begin our study of Nature and Scope of Ethics by understanding what we mean by moral law. But two things need to be clarified before we raise the question with which we are concerned here. First, the moral law is called 'law' only metaphorically, or if one prefers, analogically. The primary meaning of law is "a rule of action, promulgated by him/her who is in charge of a community in view of the common good". This is called positive law. If the legislator is considered to be God, it is divine positive law; if the legislator is human person, and it is human positive law. Human positive law can further be subdivided according to what the common good aimed at. (e.g. civil law, criminal law, commercial law, etc.) In a case, a positive law lays down rules to be observed by human persons. It is prescription. Then there is another sense of 'law' which is quite different. In this sense it is a formula expressing a constant of behaviour of things and of persons. So we have physical law (including laws studied in physics, chemistry, biology, etc.), psychological law, sociological law, etc. (Since the constant of behaviour among human persons is less fixed and foreseeable than that among things it is more of a statistical constant). As distinct from positive law, this kind of law is called 'natural law'. It is descriptive. It can also be called prescriptive to the extent if it is considered as willed by God and includes the divine positive law, and descriptive to the extent that this divine will is the ultimate cause of the constant of behaviour in things and human persons. However, moral law corresponds exactly neither to the positive law nor to the natural law. On the contrary, the sense of the 'absolute should' is an immediate datum of the moral consciousness itself.

Secondly, in the language of Moral philosophers, moral law includes not only general and abstract rules of action (e.g. "do good and avoid evil"), or, in our language, the sense of the absolute should, but also particular and concrete precepts (e.g. help the poor, obey legitimate

authority, be truthful, do not kill the innocent, adultery is wrong, etc.). These particular and concrete precepts, we are here calling the specifications of the moral law.

Hence our question: How are the general data of the moral consciousness particularized and concretized in specific precepts and what is the cause of this difference among men? In terms of moral value, we can raise this question as follows. If the moral value par excellence is human person's self-realization as human how can this moral value determine specific moral values? And why is there disagreement as to whether such and such an action is a 'good' (moral value) or not?

1.2 MORAL INTUITIONISM

All 'deontological' theories agree that there must exist some rule or law which 'enforces' moral value and that it is natural to human person, intuitively known. There is then an element of 'intuition' in all of them – no matter how they conceive of it and the way they approach it, whether as 'conscience' (Ockham), 'Logos' (Stoics), 'moral sense' (Shaftesbury), the 'a-priori categorical imperative' (Kant), 'right reason' (Thomas Aquinas and Suarez). This element of moral 'intuition' is also found in the 'teleological' theories whether implicitly or even explicitly. It is implicitly found in the concept of '*autarxia*' (Epicurus), in that of '*eudemonia*' (Aristotle), and explicitly in the concept of 'right reason' (Hobbes), in the 'conscientious feelings of mankind' (Mill).

And in fact the more the idea of moral obligation is prominent in an ethical theory, the more explicit becomes the recourse to this element of 'intuition' (or 'direct perception'). This element of 'intuition' is strongly emphasized by meta-ethicists who maintain that moral language is 'objective' and therefore 'informative'. But here again, they differ as to what the 'object' of this moral intuition is. This difference is explainable by the difference in their meta-ethical theories regarding the meaning of moral 'good.' Hence for some, this object is the 'rightness of specific acts' (Carritt, Prichard) for others it is a kind of moral property, simple and indefinable in non-moral terms (Moore), for others, it is a general principle (e.g. the 'the principle of utility' itself – Sidgwick) or a set of principles (e.g. the 'Prima facie' duties of fidelity, reparation, gratitude, justice, beneficence, self-improvement and non-maleficence – Ross). In ethics the philosophy which insists on the necessity of moral intuition is called Ethical Intuitionism.

But even the most insistent of all moral philosophers on this element of intuition in the moral consciousness, namely Kant, not only does not deny, but, on the contrary, explicitly states that the moral judgment includes elements derived from experience (which are therefore '*a-posteriori*' as opposed to the '*a-priori*' element). Kant denies the possibility of deriving particular and concrete moral precepts from the concept of practical reason alone. For this the study of human nature is necessary.

Similarly, Thomas Aquinas distinguishes between the 'first principles' of the *synderesis* which are 'self-evident', intuitively known by all, and which cannot be deleted from the human heart, and the 'secondary and more specific principles' which are derived from the former 'as if by way of conclusion from premises' what is implied here is that this secondary principles require reflection. Thomas speaks of the difficulty involved in applying general principles to concrete cases. Even though principles whether theoretical or practical can be evident in themselves, they

may not be so evident to us. And this is due, according to Thomas, to wrong persuasions on the part of human person.

Saurez is perhaps even more explicit in his doctrine that even the secondary principles – which like the primary are self-evident in themselves – require a certain amount of thought and experience. This is truer of the tertiary principles which require study and discursive thought. But all moral principles can be derived from self-evident principles. One notable difference between Thomas and Saurez is that the former derives the concrete principles in a way corresponding to 'human person's natural inclinations,' the latter derives them in a way corresponding to a legal system. For Saurez these precepts have their immediate norm the 'good' of human nature. The need of experience and reflection is similarly – indeed even more insisted upon by contemporary ethicists. Why this greater insistence?

1.3 HUMAN PERSON IN SEARCH OF HIMSELF/HERSELF

What we are dealing with here is to see whether a general principle such as 'serious promises should not be lightly broken' is 'self-evident' and therefore be counted among the 'first principles' intuitively known by everybody. If yes, how is it derived from the very first self-evident principle that 'good is to be done, evil to be avoided?' Is it merely by a kind of logical deduction? And if it is 'self-evident' in itself but not known by all, is it because of some accidental reason such as ignorance or bad habit? Finally, if it is not 'self-evident' how is it that human person has today come to agree that such a general principle is correct (that it is amoral value)?

To speak more specifically of thinkers like Thomas Aquinas, Suarez and Ross are we to say that the examples they give of first principles (or of *pirma facie* duties) are meant to serve merely as examples or are we to say that they are meant to be included among the first principles themselves? In the first case we could perhaps disagree that the examples they give are good examples but still agree with their doctrine that there exist first principles intuitively known by every man. The question would be then which are these fist principles. In the second case to question the aptness of the examples would be to question their doctrine itself. Irrespective of what such thinkers actually mean we have got to study the problem in itself.

If there is any principle that cannot be denied, it is the immediate data of moral consciousness. If these data cannot be denied they are self-evident. They are self-evident not as principles, that is, as formulae but as data whether they are thematically formulated or not. The immediate ontological foundation of the moral obligation is human inter-relatedness and that the norm for moral good (as distinct from the moral right) is human person as a social being. We have also reflected how the only moral precept which is immediately given that is self-evident and cannot be justified on a mere moral level is that human person should be human (as an individual and social being). Hence all other precepts (what we are here calling specifications of the moral law) must somehow or other flow from this fundamental precept that a person should realize himself/herself as human.

Human consciousness is in a process of becoming. Human person is becoming moral and more himself and in the process his awareness of himself develops. He/she has been continuously asking himself the question what he is. Human person is in a never-ending search of

himself/herself. The more he/she grows the more he/she becomes conscious of himself/herself as human person the more he/she is himself/herself. Moral consciousness is a part or an aspect of human consciousness. The more human person becomes himself/herself the more he/she becomes conscious of what he/she should be. This leads to the emergence of moral precepts specifying evermore clearly the conduct of human person.

Hence the moral precepts (moral values) flow from the first fundamental moral precept that human person should be himself/herself (the moral value par excellence not by way of mere logical deduction or of mere mediate inference. The former are related to the latter not simply as logical conclusions or as implicitly correlated to their premises. Logic has got to do with ideas, with mere ideas. It cannot be denied that this relation of the explicit to the implicit of the clear to the unclear to the unclear of the concrete to the abstract is here present. But it is present in the sense that a continuously developing human consciousness is related to its stages past and future of its development. Existence is more than logic.

If what we are saying about the progressive development of human consciousness, and therefore of moral consciousness is true one can easily understand the development of morals from the cave-man to modern human person from ancient slavery to the Universal Declaration of Human Rights which was approved without a dissenting voice in the United Nations General Assembly in 1948.

Ignorance of the moral precepts is therefore not necessarily the result of perverse customs as if this result were accidental. It is a fact of experience that perverse customs not only weaken the will to pursue the moral good but darkens the mind to recognize what the moral good is. But this is more easily possible on an individual level. Here we are placing ourselves on the level of mankind and its historical progress. This ignorance and the variety of morals can be explained by human historicity itself, that is, by the historical progressive development of his human moral consciousness.

However, we must not easily take it for granted that this development has always and everywhere been a linear progress. It may have suffered setbacks, reverses and regress. We need not go into that. What is more pertinent here to ask is whether we should reasonably suppose that human person has now attained the some of his/her self-consciousness and of his/her moral consciousness. What is reasonable to suppose according to us is that he/she has not. Apart from the fact that one cannot predict the future, contemporary moral problem of the morality of abortion hinges to a great extent on whether one should consider the human foetus a human person. The so-called women's liberation movement indicates no matter what its merits and demerits are that women have not been treated as full human persons everywhere in the world. One could think of many other indications. If progress is still possible it can only be done by the passage of time and on the part of human person by experience and by his reflection on his own experience.

1.4 LOVE AND THE MORAL PRECEPTS

Here we wish to bring into focus the more salient moments of our reflection on the subject bringing them to bear upon the topic at hand. To recognize human inter-relatedness as the immediate ontological foundation of the moral order and to act accordingly can be expressed in

terms of love. Love is therefore the existential basis of the moral order. This leads us already to start thinking that love is the basic moral activity.

The primary intuitively grasped demand that human person realizes himself as a human person is particularized and concretized in moral precepts. This too can be expressed in terms of love. Universal love is particularized and concretized – it is objectified – in the moral precepts. Hence as love not just one moral virtue among others but the form of all of the moral virtues, so too love is not just one moral precept among others but it is the form of all of them. It is what makes moral precepts moral precepts. Indeed it could hardly be called a precept since taken by itself in a non-objectified sense, it does not prescribe anything definite. And in the same way one can hardly call the moral realization of oneself as human as an obligation. This too taken by itself in a non-objectified sense does not oblige human person to do anything specific. And there is hardly any meaning in the saying that human person should love (love cannot be enforced) so too there is hardly any meaning in the saying that human person should fulfil himself as human.

If love is the form of the moral precepts and if love – like human moral consciousness – is a progressive affair this means that acting according to the moral precepts is acting according to love but that this awareness admits of degrees. This means that love can also be considered to be not only the beginning of the moral life but also its end. At the beginning it is present as a seed – which is more than mere potentiality but already an actuality albeit in a seminal form. The seed can develop into a fully mature and fully conscious lobe. And if it is in love that human person perfects himself as human, it is in this fully mature and fully conscious love that he/she does so.

Many factors go in this process of maturing of self-fulfilment. No matter how logically we can distinguish one human faculty (or aspect) of human person from another human person is a totality one integrated whole. As it is not the intellect which understands but human person by his intellect so too it is not with his/her heart that human person loves but human person by his heart (but heart is one's whole being). Love is an existential relation involving my whole existence.

Suffice it here to remark already that though human person can develop one or other of his/her faculties independently of the rest (or at least quasi independently) one cannot develop himself/herself as a human person without developing the core of his/her being namely his/her love and this is not achieved by mere study and reflection – although these can be very useful – but by doing. As scholastics say the operation is the perfection of being.

1.5 THE DYNAMICS OF MORALITY

Here we examine two questions which are intimately linked. In an evolutionary visions of human person to what extent can we say that morality (that is, the specification of the moral law) are universally valid for all human persons to what extent can we say that they are unchangeable? If one maintains their universal validity one is charged with absolutism with holding the opinion of a static nature of human person incompatible with present day theories about man's dynamic and evolutionary nature. If on the other hand one were to maintain a relative validity one would fall into a philosophically untenable moral relativism. Can the dilemma be overcome?

The Evolutionary nature of human person and of his human consciousness has long been recognized one way or another. Charles Darwin gave the theory of evolution a biological basis. An Evolutionary view of the world and of human person is today at the basis of a great deal of scientific philosophical and theological thinking. The thinking of such human persons as Pierre Teilhard de Chardin and of Aurobindo comes of course spontaneously to mind.

Herbert Spencer is perhaps the best known Evolutionary ethicist. He starts by observing that both human and animal conduct consists in acts adjusted to ends. The higher we proceed in the scale of Evolution the easier it becomes for us to obtain evidence of purposeful actions directed toward the good either of the individual or of the species. This purposeful activity forms part of the struggle for existence waged between individual members of the same species or between different species. But this type of conduct is according to Spencer an imperfectly evolved conduct. In a perfectly evolved conduct which is ethical conduct in the proper sense of the word this struggle for existence will yield place to cooperation and mutual help. Egoism and altruism will be both transcended. This leads Spencer to distinguish between absolute and relative ethics. Absolute ethics is an ideal code of conduct formulating the behaviour of the completely adapted human person in the completely evolved society. Relative ethics is the nearest approximation to this ideal according to the more or less perfectly evolved society in which human person happens to find him/her.

Spencer adopts the utilitarian ethical principle. In fact he takes happiness to be the ultimate end of life and measures the rightness or wrongness of actions by their conduciveness to this end. From a nascent state when this utilitarian principle was dependent on non-ethical (e.g. authoritarian) beliefs it gradually developed to become independent and as suggested by the theory of evolution, it will continue to evolve and reach an ideal limit.

Happiness however depends on the fulfilment of some conditions. And these conditions are the observances of certain principles and rules which causally determine human welfare. Spencer acknowledges the existence of moral intuitions which however are the slowly organized results of experience received by the race. In other words an induction from experience handed down from one generation to the other ends up by becoming an instinctive moral reaction. Evolution is moving towards the emergence of the highest form of life. Happiness as the supreme end of human person is the concomitant and virtue is the condition for its attainment. In the preface of the fifth and sixth parts of his the principles of ethics subsequently withdrawn Spencer confesses that the theory of Evolution has not provided as much practical guidance as he had hoped. What is peculiarly Spencer's is his interpretation of Evolution as a teleological process directed towards the establishment of a higher and higher moral order.

1.6 THE CONSTANT AND THE VARIABLE IN MORALITY

Whether or not man has evolved from sub-human beings it is not for us to decide. But we can easily accept the theory that this human consciousness itself has natured and developed. At the beginning human person was not necessarily conscious of himself/herself as human as we today are. On an individual level this progress in human consciousness is a fact of experience. The child is a human being but as it grows it becomes more and more conscious of itself as a human being. We can accept this theory even on the level of mankind as such to explain how the moral law is particularized and concretized in specific moral precepts.

Human consciousness involves one's consciousness of oneself as an individual and as a social being. Moral consciousness is an integral part of human consciousness. Primitive human (to call him so) must have been morally conscious – otherwise we are not entitled to call him/her human at all. So if moral consciousness belongs essentially to human consciousness as such – and in a univocal and not in an analogical sense – it has been a kind of constant in all the later stages of man's evolution. However, on the accepted theory that the human and therefore moral consciousness has been developing, the different stages of this development can be reasonably considered as the variable in human evolution.

If we speak of moral consciousness at all – whether of the primitive human or ours – we must speak of it in terms of the immediate data of consciousness as foundation on the human order more precisely on human inter-relatedness and these data to be in conformity to human reason and to be conducive to the self-realization of human person as human. But human moral consciousness has been evolving. This change takes different forms some of which are easily understandable and afford no real problem to ethics some are not so easily understandable and therefore afford some difficulty.

As human person becomes more and more conscious of himself as human – as an individual and as a social being – he/she becomes more conscious of his/her human inter-relatedness and of his/her rights and duties as a human person. This clearer self-consciousness is obviously concretized and particularized in specific moral precepts. Even at one given stage of human moral consciousness different people living in different human situations (situations affecting their inter-relatedness) will live a more or less different moral life. Such human situations can arise out of geographical, climatic and economic conditions.

Again since moral consciousness has been in fact intimately linked to and condition by religious consciousness, different religious beliefs have produced different moral values. And a change in religious consciousness has often wrought a corresponding change in morality. The history of religion affords us with many examples (e.g. human sacrifice, burning of witches, saturnalia, etc.). This change is primarily and directly in religious consciousness and only secondarily and indirectly in moral consciousness. It is a change in the religiously conditioned morality.

However, a change in civil law governing the mores of the people does not necessarily mean a change in morality. When a civil law declares that something is legal it does not mean to say that it is moral. Civil law as such does not pass a moral judgment. Legal means allowed as far as the state is concerned. It is not the business of the state as such to promote the moral beliefs of one section of its population as against those of another. This is important to remember today when many countries proclaim themselves to be secular – today when society is increasingly pluralistic.

The variable in morality raises the important question regarding the kind of certitude we can have in moral matters. To put it bluntly if what is believed to be morally right today can be proved to be morally wrong tomorrow and vice-versa can one be absolutely certain of what is morally right or morally wrong? In more philosophical terms if human person is conditioned by his/her existential situation and if human (and moral) consciousness is always in a process of

development and is dependent on physiological, cultural, social, psychological environmental and other factors, can he/she ever be certain of having reached objective moral truth if there is such a thing as moral truth?

At the very outset, we have to distinguish carefully between moral relativity and ethical relativism. Moral relativity is simply the view that different people especially in different civilizations and cultures have or have had different moral beliefs and what is believed to be morally right at a given time or place may be believed to be morally wrong at a different time or place. This is an undeniable empirical fact. But ethical relativism is the philosophical theory that no foundation exists, there is no universal moral norm (or basic moral principle), but what is morally right is relative to the individual or group of men in question. If such a theory can give reasons for such a position (as Sartre does), it is ethical relativism in the strict sense. If it cannot give reasons but simply admits that it is strictly impossible to say what is morally right and morally wrong it can be reasonably called ethical skepticism.

In an evolutionary view of human being, that is, on the accepted theory that human consciousness of himself/herself is increasingly developing, can we pretend to say the last word on what human person is? Obviously not. Human person's knowledge of his/her self is a progressive and dynamic knowledge, always tending towards a better and better understanding. In this sense human person's knowledge of himself/herself is relative. And if this is true his/her moral knowledge is also relative in so far as it is progressive and far from complete.

However an attentive study of the evolution of human person's self-consciousness and of moral knowledge helps one discover a certain constant progression, that is, human person is becoming more and more himself/herself. He/she is becoming more and more conscious of what he/she really is. His/her moral knowledge helps him/her to recognize himself/herself and others more and more as persons. Like in all spheres of knowledge a time of questioning debate and temporary disagreement is necessary in moral knowledge if progress is to be made. Indeed a state of incertitude on some issues is a pre-requisite and the pre-supposition of every progress. But whatever has been achieved is a definite acquisition – even if this acquisition remains still open to further advance and a deeper understanding.

Check Your Progress I

Note: Use the space provided for your answer

1) Explain Absolute Ethics and Relative Ethics.

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2) How are love and moral precepts related?

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3) How do the concepts of love and moral percepts help to build an ethical society?
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4) What is the notable difference between Aquinas and Saurez's idea of self-evident or moral principle?
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1.7 LET US SUM UP

Human person both is and is becoming; he/she is an "is-in-becoming." And this is because he/she is both essence and existence, rather he/she is and essence-in-existence. He/she is act and potency or here again he/she is act-in-potency. He/she is spirit and body, better still, spirit-in-body. In existential terms he/she is freedom and he is existentially situated, that is to say he is freedom-existentially situated.

Human person is both an end-in-himself and for others a particular human and social being. He/she can only find his self-perfection in the perfection of others. Hence the dialectical tension in human knowledge of moral law. The tension between the "is" and the "ought" between intuition and experience (or the *a-priori* and the *a-posteriori*) between the static and the dynamic the constant and the variable the absolute and the relative. We can go on like that an infinitum.

1.8 KEY WORDS

Moral Intuition: All 'deontological' theories agree that there must exist some rule or law which 'enforces' moral value and that it is natural to human person, intuitively known. There is then an element of 'intuition' in all of them – no matter how they conceive of it and the way they approach it.

Absolute Ethics: Absolute ethics is an ideal code of conduct formulating the behaviour of the completely adapted human person in the completely evolved society.

Relative Ethics: Relative ethics is the nearest approximation to this ideal according to the more or less perfectly evolved society in which human person happens to find him/her.

1.9 FURTHER READINGS AND REFERENCES

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UNIT 2 ETHICS IN GREEK PHILOSOPHY

Content

2.0. OBJECTIVES

This is an attempt to give an account of the ethical teachings of ancient Greek philosophers from Thales to Stoicism. In this unit you are guided to reflect on:

- The moral principles which have their roots in the Supreme Cause of the universe.
- Right Reason becomes the norm of ethical judgment in the affairs of human.
- Principles are designed, according to Plato, to train human soul under the supervision of intellect for the full achievement of happiness in human's life.
- Human has to be virtuous and thereby finally attain happiness through contemplation proper to one's nature.
- A perfect society is also intended in the final end of the Greek ethics.

2.1. INTRODUCTION

The aim of Greek ethics was to develop certain principles which help man to lead a good life or happy life. The most important search and quest of the human being in every human epoch is to discover the final end of his activity. Confronted with a multitude of ends, he is unable to assess and make sure of what the ultimate end would consist. Thus there are some age old questions: What is good? What is the highest good? What is the meaning of Good? Is it related to the good life of man? What is a good life? Is it happy life? What is the end and aim of life? Who is man, what is his function, what does man act for, what is the ultimate end of a man's activity and, finally, who is the supreme infallible authority to judge the good life?

2.2. PYTHAGORIAN ETHICS

Pythagoras founded an association, the purpose of which is described as ethical, religious, and political. His ideal was to develop among his followers political virtues, to teach them to act for the good of the state, to subordinate them to the whole. Here the individual should learn to control oneself, to moderate his or her passions, to harmonise his or her soul; he or she should have respect for the authority, for the authority of his or her elders, his or her teachers and the state. As a result, the view has been held that the Pythagoreans were political communities. But they were not essentially political but religious or ethical.

Purification of Soul: The chief orientation of his teaching was to the religious-ascetic ideals which centred round purification and purity. Pythagoreans saw the human soul as the life spirit which endures after the death of its first body and may take its abode subsequently in another human or animal body. This theory of metempsychosis or transmigration of souls is ethically significant since it provides for the rewarding of good action and the punishment of evil in these subsequent reincarnations. That is why they undergo purification and soul training in their life.

Right Reasoning: This is the beginning of a very important approach to ethical problems, the view that 'good' means what is rational and intelligible. Thus, in the fourth century B.C., a later Pythagorean, Archytas of Tarentum, first enunciated the principle of "right reasoning" as the key to good behaviour: "Right reckoning, when discovered, checks civil strife and increases concord...(it is) the standard and deterrent of wrong doers". It is quite possible that Aristotelian and the medieval theories of right reason (*recta ratio*) as the norm of ethical judgement are directly indebted to Pythagorean intellectualism.

2.3. HERACLITIAN ETHICS

Heraclitean fragments suggest that there is an ever-present rational pattern (logos) in this Process or 'Becoming'. Heraclitus says: "To be ethical is to live a rational life, to obey the dictates of reason, which is the same for us all, the same for the whole world." Man is entrusting himself to his senses, and he lives as if he were epileptic.

Research on Heraclitus reveals that his moral views are of primary importance in his teaching. Morality means respect for law, self-discipline, control of the passions; to be moral is to govern oneself by rational principles. The following excerpts from his writings illustrate the lofty idealism of Heraclitus' ethics: "Character is a man's guardian divinity"; "It is hard to contend with passion; for whatever it desires to get it buys at the cost of the soul". "To me one man is ten thousand if he be the best".

The word *'logos'* of Heraclitus has a decisive philosophical meaning. The *'logos'* brings the contraries into harmony or it makes possible the "coexistence of contraries". *'Logos'* reveals itself, it thinks itself and it is. It is the universal law immanent in all things and binding all things into unity and determining the constant change in accordance with universal law. Man's reason is a moment in this universal Reason. Man, therefore, has to struggle to live according to the reign of unalterable law. Man's reason and consciousness, which are the fiery element. Without pure fire body is worthless.

2.4. DEMOCRITIAN ETHICS

Democritus stressed the soul as the locus of human well-being. His concept of *eudaimonia* includes both the notion of 'good existence' (*eu-esto*) and of 'good feeling' (*eu-thumie*). Pace Gosling and Taylor think that Democritus was the first Greek philosopher to produce a systematic ethical theory. The most important step towards systematisation was the transition from the vague ethical thinking that everybody wants to be happy or cheerful, or free from troubles. Democritus argues again, "Medical science heals diseases of the body but wisdom rids soul off passions." When one is free from passion he experiences happiness. The superiority of reason is taken into consideration in the ethical life. The end of all conduct of men is well-being of society and ultimately of man. Well-being means not only the intellectual satisfaction but also the pleasure of senses. It needs a little pain, and requires repetition and moderation of pleasure. The less you desire, the less you are disappointed. All virtues are valuable only if they help to cultivate happiness. Envy, jealousy and bitterness of mind bring friction and they will destroy everybody. The sense of duty must be the basis of doing the right thing; it should not be from the fear of punishment. We have to serve the state too, because if the state is in peace, all realm of state will grow; if the governance of the state is corrupted, then there will not be any order or law but only chaos.

2.5. PROTAGORIAN ETHICS

Protagoras, a Sophist, took a relativistic position on ethical judgements. His most famous teaching is that "man is the measure of all things". This idea would closely affiliate him with the common Greek respect for the judgement of rational beings. A thing becomes right or wrong always in relation to one's need. Actually, Protagoras did advocate the practical virtue of good judgement. It is also more probable that he meant that each individual man is the sole judge of what is true or right for himself. Sextus Empiricus interprets it: "He posits only what appears to each individual, and thus he introduces relativity." That means one is more normal or natural than the other: the vision of the normal eye is more reliable than of the jaundiced eye.

2.6. THRASYMACHIAN ETHICS

Thrasymachus is said to have taught that "Might is right". In the *Republic* Plato speaks of Thrasymachus as a thinker who claims that "just or right means nothing but what is to the interest of the stronger party". Plato himself criticises, that the honourable is one thing by nature and another by law, and that the principles of justice have no existence at all in nature, but that mankind is always disputing about them and altering them. They are told by them that the highest right is might.

2.7. SOCRATIC ETHICS

His teachings on moral and religious elements are philosophical insights. These insights are the fundamental principles which brightened his life. They are mainly concerned with good and

evil, conscience, the ethical person and moral virtues. Socrates clearly did think that all the moral virtues are rooted in practical wisdom or knowledge. The central teaching of Socratic ethics is "knowledge is virtue". He who knows, what good is, will do good. By this he wanted to tell that the right insight led to the right action. For Socrates, the moral conscience is not mere sentiment but it is a responsibility before God. Human life is not tragic; one should confront it with the spirit.

Socratic ethic is teaching that human is a moral being in general. This was a revolutionary thought against the belief of the aristocratic people who thought that morals are limited only to a privileged group. He believed and taught that doing good is the moral duty of all human beings and possible for all. Socrates was teaching two moral imperatives attributed to the Delphic Oracle: "Know Thyself" (*gnôthi seauton*), and "Avoid Excess" (*meden agan*). For Socrates the ultimate evil was the "**unexamined life**". He forced upon people for the recognition of their ignorance. At the end of the *Apology* Socrates told those jurors, who voted for his acquittal, of his confidence that death will not be an evil thing for him. He advised them, "to bear in mind this one truth: that no evil comes to a good man in life or in death". Socrates believed that there is life after death, which reflects in the life itself. A virtuous life here leads to happiness in the life after death. The proof for this is his death itself. This was done according to his faith in the immortality of soul. This faith is more religious than rational certainty. His life was a faith in the soul rather than a philosophy of the spirit. For him pleasure is below to the virtue.

Check Your Progress I

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1) Explain the Purification of Soul according to Pythagoras

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2) What is the central teaching of Socratic ethics?

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2.8. PLATONIC ETHICS

Plato sees human more in the soul. He affirms that “we are souls”. He meant that Soul is human. Evil elements are not in human but in the body. The real evil for human is the body, because human is always trying to liberate oneself from the bondage of body. Only with liberation of soul from body, a person can be happy and his ethics is known as *eudaimonistic* ethics. Plato's

works on ethics are fundamentally 'eudaimonistic' i.e., about well-being or a happy life. He saw the good life for man in terms of a personal attainment of well-being. In this level man's reason would regulate and order all functions of the irrational appetites. Therefore the ethics of Plato is known as 'intellectualistic'. The wise man is the one who can do the right thing and knows the right thing. He believed that the learned and rationally developed soul is the good soul. For him therefore, wisdom is the greatest virtue.

The movement within each human toward the ideal personality is an original version of self-perfection ethics. The development of the basic virtues is a personal process, of course, and varies from one man to the next. Childress comments on this point: Platonic ethics is eudaimonistic in the sense that it is centred around the attainment of man's highest good, his true happiness, which involves the right cultivation of his soul and harmonious well-being of his life.

Human has to find happiness in intellectual exercise. Virtue does not depend upon the will, but on the practical intelligence, that understands the virtue and changes it into action. The realisation of virtue is more important than the education. If the virtue is realised only to the highly educated people then the ethical life is only for philosophers. Here the ethics of Plato becomes an ethics of aristocracy. The ordinary people get only true opinion or extrinsic knowledge through the public education of moral life. He also believed that the greatest happiness is in the contemplation of the highest 'Ideas'. Yet Plato, like most of the Greeks, was well aware of the social dimensions of human life and well-being. A good life needs association with other persons. Thus ethics grows as part of politics which treats how to deal in a state (*polis*).

Political Thought: In the book of *Republic* Plato gave the picture of an 'ideal state' which could be ruled by philosophers. The origin of state is natural. At a certain moment, a group of families can not live together and be self-sufficient. Economic needs brought division of labour and its administration. This is the functional requirement of the nature. Plato says, **"Every citizen must practise only one activity of the many regarding civil life; that activity to which his natural inclination is most disposed"**. Therefore, a sound state gets its life and its function goes well. Then there arises the need for defence and the government.

A good state depends upon the government. Here the rulers are ruling with reason in wisdom. In the fourth book of the *Republic* the citizens are divided into three classes just like the division of man. 1) The lowest class is productive and acquisitive. And its virtue is in particular temperance, but not set aside only for this class but also generally for the society as a whole because "the desire of the inferior multitude will be controlled by the desires and the wisdom of the superior few". 2) The middle class is spirited, competitive, and warlike, its distinctive virtue is courage. 3) The highest class is that of the rulers which is distinguished by its rationality and its special virtue is practical wisdom. The most capable member of the highest class will become philosophers and will be given complete political rule, since every good ruler is one who governs in virtue of knowledge of the truth. When all these three classes work well together, the city becomes virtuous and perfect. The special virtue of the highest class is justice. The goal of the state is general justice, while each of three classes follows their own virtue. In other words, we can tell that social morality or individual's morality is the purpose of the state

In Plato's 'ideal state' rulers and soldiers are not allowed family life or private property. They are suggested community life. This is a half type of communism. He confirmed that women could rule a country, because women have exactly the same powers of reasoning as men, provided that they get the same training. He said, a state that does not educate and train women is like a man who only trains his right hand. Plato had a good vision of women, considering the time he lived.

*Division of Soul:*According to Plato human's soul is divided into three parts. One part stands for the appetitive or concupiscent part of the soul (*to epithumetikon*) the second part is the spirited part (*thumos*); in fact these two parts represent two appetites in man: the desire for sensual satisfaction and aspiration for success and fame. The third part is reason (*logos, to logistikon*) the highest part of man's soul. All these three parts work together for happiness.

Virtues of the Soul: Each part of the soul has its special virtue. Practical wisdom (*phronêsis, sophia*) is the virtue of the rational part. Courage or manliness (*andreia*) perfects the spirited part. Temperance (*sôphrosunê*) is another virtue, which moderates desire. Finally,) justice (*dikaiosunê)* as a virtue of individual man is that general condition of soul in which each part performs its proper function. The just man does what is right in his external actions as a citizen of a state; he does the right because his soul is internally well-ordered. To live well, with clear understanding, one must rise to a vision of the idea of the Good.

2.9. ARISTOTLEAN ETHICS

Aristotle attempts to explain ethics as a science, which gives meaning of highest good. All acts of man have some ends in view of the acts. Every end has again another end of higher quality. If it is so, there must be some super most good, for the sake of which every other good is to be hierarchically ordered. What is the highest good? The goodness of a thing consists in the realization of its specific nature. For man it is the realization of the life of reason, not sensitive life like animal or vegetative life like plants. Therefore, man must function as a human being. The realization of human being is in happiness or 'eudaimonia'. In order to realize this goal all other parts of soul must co-operate in this direction. The virtue of the sensitive part is the moral virtue. This moral virtue must be controlled by the reason, i.e., rational part. These moral virtues are such as justice, temperance, courage, liberality.

Principle of Mean: The virtue exists in between the excess and deficiency. The mean of virtue is not to be confused with mediocrity. It is not a safe way between two extremes. The virtuous mean is the most reasonable course of action to be taken in a given situation. Aristotle does not claim the universality of the principle of mean. This principle is not applicable in the things that are bad in themselves. For example: shamelessness, envy, adultery, theft and murder. They are bad in itself, not only because of their excess or deficiency, but because they are always wrong and never right.

The mean will be relative to each individual, but it should be measured by the proper reason of the right-minded man. The virtuous man is the measure of all things. He judges everything

correctly and he acts virtuously. The good man realizes his true self when he loves and acts according to the supreme part of his self. The virtuous man does not act for his selfishness, but he acts for his friend and his countrymen. He lays down his life for the other. The nobility of his character in the function is expressed clearly all through his life. He can also love a good man as his second self. He becomes a man of justice. Justice is the crown of all virtues, because it is in relation to others. Justice consisted in giving one's due. Justice considers all in a just way, whether he is a ruler or a servant. The mean position can be judged properly only by the virtuous man.

Pleasure and Happiness: The ultimate end of man's activity is the happiness. Life of happiness includes pleasure also. Pleasure is the necessary and immediate consequences of virtuous activity, but not the end of life. Pleasure is the completion of activity. Pleasure is the concomitant of action, but pleasure is not the effect of the act of reason. Hence it will not be the highest good.

Since rational part is the highest part, its activity will be the highest activity proper to man. The contemplative life is the highest life, the most continuous, the most pleasant, most self-sufficient, most intrinsically worthy way of life. This type of life will be a step higher than virtuous life; since virtuous life belongs to the sensitive part, which is under the control of rational part.

Function Argument: Aristotle says every being has a special function according to its nature. Here the nature of a thing consists in fulfilling its special function. He is of this opinion that human function is with an "activity of soul in accordance with virtue and if there are more than one virtue, then it will be accordance with the best and most perfect virtue. He thinks with the concept of good in a specialized realm, for example, the good of a flutist or of a sculptor, consists in fulfilling a certain function. A flutist becomes a good flutist by playing the flute well, not by playing cricket. The same law should be held true of human beings in general. If human person has a function to do, its goodness consists in doing that peculiar function perfectly well. Human function is not any activity of the soul that conforms to virtue, for eating is an activity that can conform to the virtue of temperance, but it is an activity of the lowest faculty of the soul, the nutritive faculty. Like that, the sensation can not be the peculiar function of the human, because animals do the same activity. Aristotle is seeking something which is very peculiar to human alone: certain life of the part of having reason. This should be the function of the human, the activity of reason, which is characteristically the human beings engage in.

The function argument can thus be explained: 1) every species has a unique essence, which is its function. 2) The good of each species is just doing well its function. 3) The essence of the human is activity in accordance with reason. Thus the good of the human is such activities. Thereby the by-product of such activity is happiness.

Teleological Argument: Aristotle is universally praised for inventing the concept of teleology. In *Physics* Aristotle declares that "nature is among the causes which act for the sake of something". 'For the sake of something' is a thing's purpose. This is the end or goal at which a thing aims. Aristotle is of this opinion that nature does nothing purposeless. The nature is not without

purpose. The natural processes, according to Aristotle, are ordered to the good ends. Among the good ends, there must be a single supreme good; this supreme good must be God.

Aristotle believes that man's ultimate aspiration is to contemplate and imitate the highest being, God. All other material beings except human person aspire to become human person, who is the best among the material beings. Human person has the character of reason which distinguishes human person from all other beings in the cosmos. So we understand there is a hierarchical order in the process of reaching the highest good. Therefore, there is a purposeful act of actualization from lower to higher.

In Aristotelian words, one might say that everything in the universe strives to actualize its potentialities or capacities. Growth leads to maturity or fullness of things. This tendency for growth is the hidden cause within the nature of that being. This completion of hidden potencies is the good at which everything aims. This purpose or teleology, therefore, rules Aristotelian ethics, although as we shall see, deontological elements, those pointing to the duties, are not absent from it. Moral obligation is only the consequence of man's good life. Therefore in *Physics* he says that there is purpose in the things which come to be and are by nature.

Contemplation: The whole purpose of virtue is to achieve happiness, but according to Aristotle happiness is two-fold. These two kinds of happiness are proportioned to man's nature, and obtainable by means of natural capacities. These two kinds of happiness are those to which the moral and the intellectual virtues are immediately ordered. Aristotle finishes his discussion indicating that contemplation, which is the peak point of happiness, is similar to God's activity of contemplation. We understand that Aristotle puts forward by this concept of a two-fold happiness two ideals for life: theoretical life and practical life. It is not possible that everybody can lead the contemplative life; still each one has the opportunity to lead a happy life that is a virtuous political life. Here, we find the greatness of Aristotelian ethics. Those, who cannot lead the highest happy life, will not be happy as they might have been, still they can lead the best kind of life in the fullness of moral virtuous life.

The Aristotelian contemplator is a man who has already acquired wisdom; and what he is contemplating is precisely this wisdom already present in his mind. By contemplation he brings his wisdom once again to the forefront of his mind. In this way contemplation is a quasi-aesthetic appreciation of wisdom and truth. The activity of God is also contemplation. So, if man can also do the activity which resembles the activity of God, he is doing a God-like activity. That means he is experiencing the life of God.

2.10. EPICUREAN ETHICS

As all other philosophies of this age, the main thrust of Epicureanism was the acquisition of happiness. He believed that the powerful objection to happiness was fear of death instructed by religion. He wanted to root out this fear from his followers and accordingly he formulated his philosophy by explaining the nature of the universe. Our happiness depends upon ourselves in this life. Man has two types of pains: physical pain and psychological distress. According to him the end of human existence is the health of the body and tranquility. Actually he meant

when he said, pleasure is "the absence of pain in the body and of trouble in the soul." He did deliberately say that this was not the pleasure of prodigal or the pleasure of sensuality (*Letter to Menoeceus*, 131-2).

The means of pleasure are the practice of the four virtues. They are prudence, temperance, fortitude and friendship. Prudence is for the calculation of pleasures. The next two virtues are instruments for pleasures; because they control the desire and lead to the continuation of pleasures. These virtues become evil, if they do not bring pleasures. The last virtue is to enjoy the communion of the people especially in the public. For him justice is not a virtue, because it is not harming others. This is in cohabiting in the name of giving and having which reduces itself into utilitarian fact. Animals also share this reality.

Epicurus is registered as one of the members of classical Greek ethicists. We see the special role of reason in his arguments for the attainment of happiness. He believed that pleasure is not intrinsically evil in itself (Principal Doctrines, 8). But he did not recommend its pursuit. Two reasons were given. 1) Pleasures are not capable enough to attain tranquility. 2) Physical pleasures do not avoid mental anxiety. Certain sensual activities produce more pain than pleasure. Tranquility of soul was attained through philosophical study and prudence. Human persons have different desires. He classifies these desires into three groups: some are natural and necessary; some are natural but not necessary; some are neither natural nor necessary (Principal Doctrines, 29). It is good to understand that the pleasure and tranquility, that Epicurus thought, were that each one of us should seek our own pleasure and tranquility. Therefore his ethical theory is egoistic one.

2.11. STOIC ETHICS

Stoic ethics has its own originality distinguished from Platonic, Aristotelian and Epicurean. The Stoics developed a system which is based on their anthropology of the "logos", the presence of the "pneuma" in man. This is the qualified presence of the divine in man. In order to discover this divinity in man, one has to dedicate himself to the order of morals. The cosmos, for them, was a harmonious unity with a living and intelligent God. Man is the part of this universal order as a spark of divine fire. For Stoics, therefore, moral life is a discovery of "logos" and arrangement of life accordingly. There are four steps for the ethics of stoics. They are duty, virtue, good and happiness. Duty is the moral obligation that one perceives within oneself according to his nature. Mere duty is not the perfection of moral act; but right intention is also necessary. Right intention is the perfection of the morality and it is coming from the virtue. Virtuous man is better than the one who is mere duty oriented without good intention. Virtue transforms the duty to right intention. According to Stoics, virtue is the highest good and the highest happiness, because only a virtuous life can lead and experience a happy life. To live in such a way is to realize one's self; and thereby to realize the will of the universe and therefore to serve the purpose of universal reason and to remain for the universal ends. The stoic ethics stands for a universal society of rational beings with the same rights and duties, because the fundamental principle is same in all and this is the will of God.

2.12. LET US SUM UP

In *Republic* of Plato, he speaks, “Each of us should lay aside all other learning, to study only how he may discover one who can give him the knowledge enabling him to distinguish the good life from the evil”. Greek ethics is enabling one to lead a happy life all through one’s life. As we know ethics is a normative science which makes judgments on the voluntary human conduct; we are supposed to make judgment on our own life. Socrates is of this opinion that the most evil in the life of human is an unexamined life. This is a code of conduct for human to make judgment on one’s own feelings, words and activities. Each living being is born with certain good potencies. As it goes through its life, all these potencies ought to be slowly actualized into its intended end. In this ongoing process there is a control of final cause. This end is not some goal outside human’s nature, but it is compatible with well being of human person and society. For Aristotle, human’s final end is in serving and contemplating God, because this is the most beautiful act a human can do in this life. This act of contemplation is the similar act that God himself does. Here God’s act and human’s act become similar but not same.

Check Your Progress II

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1) How do you explain the *eudaimonistic* Ethics of Plato?

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2) What is Teleological argument according to Aristotle?

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2.13. KEY WORDS

Right Reasoning: This is the beginning of a very important approach to ethical problems, the view that 'good' means what is rational and intelligible. Right reasoning is the key to good behaviour. It is the standard of good action and deterrent of wrong doers. It is quite possible that Aristotelian and the medieval theories of right reason (*recta ratio*) as the norm of ethical judgement are directly indebted to Pythagorean intellectualism.

Knowledge is Virtue: The central teaching of Socrates' ethics is "knowledge is virtue". He who knows, what good is, will do well. By this he wanted to tell that the right insight led to the right

action. A man of knowledge is a virtuous man. A man who has knowledge, can do right thing and avoid vicious thing.

***Eudemonistic* Ethics:** Platonic ethics is *eudemonistic* in the sense that it is centred on the attainment of man's highest good, his true happiness, which involves the right cultivation of his soul and harmonious well-being of his life.

Principle of Mean: The virtue exists in between the excess and deficiency. The mean of virtue is not to be confused with mediocrity. It is not a safe way between two extremes. But the virtuous mean is the most reasonable course of action to be taken in a given situation. The mean will be relative to each individual, but it should be measured by the proper reason of the right-minded man.

Teleology: This is an end oriented science proposed by Aristotle. In *Physics* Aristotle declares that "nature is among the causes which act for the sake of something". 'For the sake of something' is a thing's purpose. This is the end or goal at which a thing aims.

Contemplation: Contemplation is an activity by which one's wisdom is brought once again to the forefront of his mind. The Aristotelian contemplator is a man who has already acquired wisdom; and what he is contemplating is precisely this wisdom already present in his mind. In this way contemplation is a quasi-aesthetic appreciation of wisdom and truth. Aristotle finishes his discussion indicating that contemplation, which is the peak point of happiness, is similar to God's activity of contemplation.

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2.15 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress I

1. The chief orientation of his teaching was to the religious-ascetic ideals which centred round purification and purity. Pythagoreans saw the human soul as the life spirit which endures after the death of its first body and may take its abode subsequently in another human or animal body. This theory of metempsychosis or transmigration of souls is ethically significant since it provides

for the rewarding of good action and the punishment of evil in these subsequent reincarnations. That is why they undergo purification and soul training in their life.

2. The central teaching of Socrates' ethics is "knowledge is virtue". He who knows, what good is, will do good. By this he wanted to tell that the right insight led to the right action. For Socrates, the moral conscience is not mere sentiment but it is a responsibility before God. Human life is not tragic; one should confront it with the spirit.

Answers to Check Your Progress II

1. Plato's works on ethics are fundamentally 'eudaimonistic' i.e., about well-being or a happy life. He saw the good life for man in terms of a personal attainment of well-being. In this level man's reason would regulate and order all functions of the irrational appetites. Therefore the ethics of Plato is known as 'intellectualistic'. The wise man is the one who can do the right thing and knows the right thing. He believed that the learned and rationally developed soul is the good soul. For him therefore, wisdom is the greatest virtue.

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2. Aristotle is universally praised for inventing the concept of teleology. In *Physics* Aristotle declares that "nature is among the causes which act for the sake of something". 'For the sake of something' is a thing's purpose. This is the end or goal at which a thing aims. Aristotle is of this opinion that nature does nothing purposeless. The nature is not without purpose. The natural processes, according to Aristotle, are ordered to the good ends. Among the good ends, there must be a single supreme good; this supreme good must be God.

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growth is the hidden cause within the nature of that being. This completion of hidden potencies is the good at which everything aims. This purpose or teleology, therefore, rules Aristotelian ethics, although as we shall see, deontological elements, those pointing to the duties, are not absent from it. Moral obligation is only the consequence of man's good life. Therefore in *Physics* he says that there is purpose in the things which come to be and are by nature.

UNIT 3 ENVIRONMENTAL ETHICS

Contents

3.0 OBJECTIVES

One of the main objectives of studying the Environmental Ethics is to know in depth that our existence is impossible if the nature does not exist. There is a flow of energy that seeps out from us to the environment and vice versa. This energy form a connecting link between us and the nature which is indispensable. Study of the environment and all its components is nothing but the relationship that we humans share with the nature. So I would say that by studying Environmental Ethics we establish a link, a relationship with the nature and our concern for the environment becomes stronger. Thus we are urged to do something that would stop the exploitation of the environment.

Environmental ethics has been described as having a conscience or moral that reflects one's commitment and responsibility toward the environment as well as present and future generations of people. In essence it refers to human societies living in harmony with the natural world on which they depend for survival and well being. Human beings are a part of the society and so are the other living beings. When we talk about the philosophical principle that guides our life, we often ignore the fact that even plants and animals are a part of our lives. They are an integral part of the environment and hence have a right to be considered a part of the human life.

3.1 INTRODUCTION

Adjusting the relationship between humans and nature is one of the most fundamental issues we face and must deal with today. With the increasing deterioration of ecological systems on which human beings rely and the aggravation of the environmental crisis, human beings have realized that we cannot rely on economic and judicial methods alone to solve the problems of environmental pollution and ecological imbalances; we must also appeal to human beings' limitless internal ethical resources. Only after we have adopted an appropriate attitude towards nature and have established a new ethical relationship between human beings and nature will we be able to love and respect nature automatically as well as conscientiously; and only with the guidance of such love and respect can we successfully deal with the issues of environmental pollution and ecological imbalances.

3.2 ENVIRONMENTAL ETHICS: MEANING

Environmental ethics is a new sub-discipline of philosophy that deals with the ethical problems surrounding environmental protection. It aims to provide ethical justification and moral motivation for the cause of global environmental protection. There are several distinctive features of environmental ethics that deserve our attention.

First, environmental ethics is extended. Traditional ethics mainly concerns intra-human duties, especially duties among contemporaries. Environmental ethics extends the scope of ethical concerns beyond one's community and nation to include not only all people everywhere, but also animals and the whole of nature – the biosphere – both now and beyond the imminent future to include future generations. Second, environmental ethics is interdisciplinary. There are many over lapping concerns and areas of consensus among environmental ethics, environmental politics, environmental economics, environmental sciences and environmental literature, for example. The distinctive perspectives and methodologies of these disciplines provide important inspiration for environmental ethics, and environmental ethics offers value foundations for these disciplines. They reinforce, influence and support each other.

Third, environmental ethics is plural. From the moment it was born, environmental ethics has been an area in which different ideas and perspectives compete with each other. Anthropocentrism, animal liberation/rights theory, biocentrism and ecocentrism all provide unique and, in some sense, reasonable ethical justifications for environmental protection. Their approaches are different, but their goals are by and large the same, and they have reached this consensus: it is everyone's duty to protect the environment. The basic ideas of environmental ethics also find support from, and are embodied in, various well-established cultural traditions. The pluralism of theories and multicultural perspectives is critical for environmental ethics to retain its vitality. Fourth, environmental ethics is global. Ecological crisis is a global issue. Environmental pollution does not respect national boundaries. No country can deal with this issue alone. To cope with the global environmental crisis, human beings must reach some value consensus and cooperate with each other at the personal, national, regional, multinational and global levels. Global environmental protection depends on global governance. An environmental ethic is, therefore, typically a global ethic with a global perspective.

Fifth, environmental ethics is revolutionary. At the level of ideas, environmental ethics challenges the dominant and deep-rooted anthropocentrism of modern mainstream ethics and extends the object of our duty to future generations and non-human beings. At the practical level, environmental ethics forcefully critiques the materialism, hedonism and consumerism accompanying modern capitalism, and calls instead for a 'green lifestyle' that is harmonious with nature. It searches for an economic arrangement that is sensitive to Earth's limits and to concerns for quality of life. In the political arena, it advocates a more equitable international economic and political order that is based on the principles of democracy, global justice and universal human rights. It argues for pacifism and against an arms race. In short, as the theoretical representation of a newly emerging moral idea and value orientation, environmental ethics is the fullest extension of human ethics. It calls on us to think and act locally as well as globally. It calls for a new, deeper moral consciousness.

3.3 THE MODERN CONSTRUCTION OF ENVIRONMENTAL ETHICS

We are cutting down forests for making our homes. We are continuing with an excessive consumption of natural resources. Their excessive use is resulting in their depletion, risking the life of our future generations. Is this ethical? This is the issue that environmental ethics takes up. Scientists like Rachel Carson and the environmentalists who led philosophers to consider the philosophical aspect of environmental problems, pioneered in the development of environmental ethics as a branch of environmental philosophy.

The Earth Day celebration of 1970 was also one of the factors, which led to the development of environmental ethics as a separate field of study. Today, environmental ethics is one of the major concerns of mankind. When industrial processes lead to destruction of resources, is it not the industry's responsibility to restore the depleted resources? Moreover, can a restored environment make up for the originally natural one? Mining processes hamper the ecology of certain areas; they may result in the disruption of plant and animal life in those areas. Slash and burn techniques are used for clearing the land for agriculture.

Most of the human activities lead to environmental pollution. The overly increasing human population is increasing the human demand for resources like food and shelter. As the population is exceeding the carrying capacity of our planet, natural environments are being used for human inhabitation. Thus human beings are disturbing the balance in the nature. The harm we, as human beings, are causing to the nature, is coming back to us by resulting in a polluted environment. The depletion of natural resources is endangering our future generations. The imbalance in nature that we have caused is going to disrupt our life as well. But environmental ethics brings about the fact that all the life forms on Earth have a right to live. By destroying the nature, we are depriving these life forms of their right to live. We are going against the true ethical and moral values by disturbing the balance in nature. We are being unethical in treating the plant and animal life forms, which co-exist in society.

Human beings have certain duties towards their fellow beings. On similar lines, we have a set of duties towards our environment. Environmental ethics says that we should base our behavior on a set of ethical values that guide our approach towards the other living beings in nature. Environmental ethics is about including the rights of non-human animals in our ethical and moral values. Even if the human race is considered the primary concern of society, animals and plants are in no way less important. They have a right to get their fair share of existence. We, the human beings, along with the other forms of life make up our society. We all are a part of the food chain and thus closely associated with each other. We, together form our environment. The environment is not the property of the humans alone. Humans exist because of all other non-living elements of the environment. Therefore conservation of natural resources is not only the need of the day or time but also our prime duty.

Does the Earth exist for the benefit of humanity alone? Do humans have any ethical obligations with respect to the natural world? Have we the right to take all the Earth's resources for our own use? Do we have a responsibility to be good stewards over the Earth? Do other species have an intrinsic right to exist? Do trees have legal standing? What do various religions have to say about humanity's relationship to the rest of the living world? These are some of the questions addressed in the study of environmental ethics.

Check Your Progress I

Note: Use the space provided for your answer

1.What is Environmental Ethics?

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2.What are the distinctive features of environmental ethics?

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3. What is green life style?

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3.4 ENVIRONMENTAL ETHICS AND SUSTAINABLE DEVELOPMENT

Although there is disagreement over the meaning of sustainable development, most countries have accepted sustainable development as their basic policy. The overlapping areas of consensus between sustainable development and environmental ethics are obvious: the need for environmental justice among the present generation (especially to eliminate absolute poverty), the need to care for future generations and the need to live harmoniously with nature. Only once human society gets on track with regard to achieving sustainable development can we deal successfully with the challenges of global warming, diminishing biodiversity and world hunger.

3.5 ENVIRONMENTALISM AND PACIFISM

The last thing human beings should do is expend huge amounts of resources on studying and making weapons of mass destruction. Environmental security, does not come from hegemonic militant power, but from a just and peaceful international order. As war is a massive violation of humans' right to life, and causes massive destruction of the environment, avoidance of war should be the primary concern of environmental ethics. Democratic countries should apply their domestic political principles to relations with other countries and allow themselves to be subject to the authority of the UN. The policy that might is right, which prevailed in colonial times, must be condemned and abandoned. The UN and its Member States must aim to construct and strengthen the international legal and judicial system and to arbitrate any disputes among its Member States through this system to avoid military conflict. Only a peaceful international order can foster co-operation among countries in dealing with the global environmental crisis. The close connection between environmental protection and peace must be recognized. All countries have a responsibility to spend more money on environmental programmes rather than on military programmes.

3.6 ECOSYSTEMS: THE LAND ETHIC

Aldo Leopold, a forester-ecologist, wildlife manager, professor, conservationist, author, and prophet of environmental ethics, claimed, famously: *A* thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.' 'That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics' (Leopold 1969: 224-5, viii-ix). In a holistic ethic, this eco-systemic level in which all organisms are embedded also counts morally-in some respects more than any of the component organisms, because the systemic processes have generated, continue to support, and integrate tens of thousands of member organisms. The appropriate unit for moral concern is the fundamental unit of development and survival. That, we were just saying, is species lines. But a species is what it is where it is, encircled by an ecology.

A land ethic might seem a naturalistic ethic, but people are living on this land, and so nature and culture soon mix. Trying to map the human environments, we are valuing three main territories: the urban, the rural and the wild - all three of which are necessary if we are to be three-dimensional persons. Nature is much present in the hybrid habitats of rural landscapes; we need an ethic for agro-ecosystems. Wildlife can extensively remain on landscapes put to multiple use; and so we need an ethic of wildlife management. We need an ethic for forests and farmlands, for the countryside. Nature is present in, and a support of, our cities as well. A land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow members, and also respect for the community as such". Nature means everything in our environment - the soil, the climate, and all living things.

Is Christianity to blame for the destruction of the natural environment? How do different religions approach our relationship with the natural world? The world was not created solely for man's use, but exists apart from humans, complete in its own right. "A numerous class of men are painfully astonished whenever they find anything, living or dead, in all God's universe, which they cannot eat or render in some way what they call useful to themselves".

Environmental ethics is also concerned with the issue of responsible personal conduct with respect to natural landscapes, resources, species, and non-human organisms. Conduct with respect to persons is, of course, the direct concern of moral philosophy as such. "Moral responsibility" normally implies knowledge, capacity, choice, and value significance. That is to say, if a person is morally responsible to do something, then he (a) knows of this requirement, (b) is capable of performing it, (c) can freely choose whether or not to do it, and (d) the performance thereof affects the welfare and/or liberty of other beings. Because one's response to these requirements reflects upon his value as a person, we say that this response has "moral significance. We know that we can cause massive and permanent damage to natural landscapes, resources and ecosystems. Not only do we know that we can cause these insults, we also know how we can cause them, and how we can prevent or remedy them. Knowing all this exacts a moral obligation to act with care, foresight and, at times, with forbearance and constraint. In our dealings with the natural environment, we are, in short, called upon to reflect, act, or perhaps to refrain from acting, in a manner which testifies to our worth as persons and as a culture -- in a word, to respond morally. One of the most serious problems with the environmental movement today is that its moral position is badly articulated and defended -- it is more "felt" than thought through.

Check Your Progress II

Note: Use the space provided for your answer

1. What is sustainable development?

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2. How do we foster pacifism?

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3. Explain Land ethics.

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3.7 ENVIRONMENTAL ETHICS: DESCRIPTIVE, NORMATIVE AND CRITICAL

Moral philosophers have found it useful to distinguish three "levels" of study in their discipline. The first "level," "descriptive ethics," consists of accounts of what people and/or their cultures do, in fact, value. Imagine, for example, a hypothetical public opinion survey reporting that 55% of Californians favor extraordinary and costly measures to protect and preserve their northern forests, that 30% oppose such measures, and that 15% are undecided. Since the survey reports the moral opinions of the sample population without offering a moral judgment of these beliefs, the poll is an exercise in descriptive ethics. Similarly, an anthropological report that such and such a tribe values head hunting describes the values of that tribe. Descriptive ethics, then, can be regarded as a specialized type of social science.

The second level, normative ethics (also called "prescriptive ethics") deals with moral issues in the conventional sense of that term -- that is, with questions of right or wrong, duties and rights, justice and injustice, virtue and wickedness, and so forth. On this level of ethical discourse, judgments are made and defended concerning the moral value of acts, motives and policies, or of the persons or communities responsible for these acts, motives or policies. Also, in particular cases, recommendations are made as to the morally "best" course of action or conduct. Thus a normative response to the hypothetical poll on the Northland forests might be "how dreadful that our fellow citizens should care so little about their biotic legacy." Or, on the other hand, "I am glad to see that our citizens are at last coming to their moral senses and recognizing that human

beings are more important than a bunch of trees." Similarly, one might normatively condemn the practice of head hunting accurately described by the anthropologist.

The philosopher, accustomed as he is to "ask the next question," is not content simply to hear a normative opinion. He insists upon a clear and precise statement of the meanings of the concepts employed in the opinion. When the philosopher seeks to clarify the meaning of normative terms or to examine the structure, grounds and justification of normative arguments, he is engaging in the activity of critical ethics, or "metaethics." He is thus, in a sense, an intellectual spectator of the normative judgment. It is the task of the critical moral philosopher to take account of the logic, language and methodology of normative discourse and argument. Thus, if a moralist condemns capital punishment as "unjust" or head hunting as "barbaric," the meta- ethical philosopher will ask the meaning of "justice" and "barbarism" in these contexts. He will also inquire as to the nature and soundness of the arguments offered in defense of these normative (i.e, moral) claims.

A failure to discriminate among these levels of ethical inquiry can lead to considerable confusion and error. For instance, a failure to distinguish between descriptive and normative ethics can draw one into a naive cultural relativism or even a subjective relativism. Failure to distinguish normative ethics from critical ethics can lead to hasty moral conclusions. For example, if we affirm (metaethically) that future generations can meaningfully be said to "have rights," it does not follow that they (normatively) have a right to share the company of snail darters or to find the Boundary Waters Canoe Area in a natural state. Furthermore, if someone (normatively) argues that dumping nuclear wastes in the ocean is "inherently unjust," we should neither accept nor reject his claim until we have (metaethically) determined what he means by "inherently unjust" and have examined the structure of his argument and the premises and point of view from which it is argued.

Let us now apply these three levels of ethical inquiry to environmental ethics. First, descriptive environmental ethics is not a significant problem in environmental ethics for the simple reason that, strictly speaking, "descriptive ethics" isn't really a part of moral philosophy at all. Rather, because it is "descriptive," it is really a type of social science. If we ask "what do 'the American people' think of their national parks? Do they believe the parks to be 'valuable'? Worth the cost of their preservation?" If we judge the environmental values of most Americans to be "deplorable" (a normative judgment) and thus feel moved to "do something about it," we might attempt to change these attitudes. And so we would enter the fields of environmental education and moral education. And what teaching methods most effectively produce the attitude we approve of?

Normative ethics deals directly with the "nerve" of morality; namely, the question "what should we do?" or example, such issues as: What is the optimum use of this canyon, or forest, or desert? How should we treat this natural area? Use it up? Protect it? Preserve it intact? What "good" is a "useless" endangered species? How much effort and cost should we devote to protecting it? What damage to the environment and what risk to future generations is acceptable in return for the development of synthetic fuels and nuclear power?

Critical ethics ("metaethics") is concerned with the meanings of ethical concepts and with the justification of normative claims. Thus environmental metaethics brings to policy and legislative debate such questions as these: Upon what unstated moral assumptions are these contending positions based (e.g., the positions of the "developer" and the "preservationist")? We are now prepared to clarify a crucial distinction: "Environmental Ethics" is to be identified in this Introduction, as a metaethical term designating any ethical position that expresses a viewpoint concerning man's responsibility to nature. "Ecological morality," on the other hand, identifies the particular normative environmental ethics of such writers as Aldo Leopold, who view man as a part of the natural community with duties of respect and forbearance toward that community.

3.8 ENVIRONMENTAL ETHICS: WHY AND WHY NOW?

Why? Because we can't sit this one out. "Not to decide" about issues of environmental ethics is "to decide" -- in favor of the status quo, and in favor of "business as usual." But our poor, battered, plundered and polluted planet can not long endure a continuation of "business as usual." We have, in the past couple of centuries, achieved a cleverness that has far overshot our wisdom. The explosive growth of scientific knowledge, followed shortly by a parallel growth in technical ingenuity, has created an "explosive growth" in moral problems -- some unprecedented in human history.

Ethics is a very ancient human preoccupation (older, perhaps, than philosophy itself). And yet, environmental ethics is very new. In view of the recent dramatic growth in knowledge and technology, it is not difficult to see why this is so. Ethics deals with the realm of imaginable human conduct that falls between the impossible and the inevitable -- that is, within the area of human capacity and choice. And now, even within our own lifetime (and ever more so with each year), we have acquired capabilities and thus face choices that have never been faced before in the course of human history -- indeed, we now face many capabilities and choices never contemplated or even imagined before. These include choices of birth, life, and death for our species and others; choices that are rapidly changing the living landscape forever.

When the ecosystem was not understood, or even recognized or appreciated as a system; when the earth and its wilderness were believed to be too vast to be damaged by voluntary human choice; at such a time, there was no environmental ethics. But in our own time we have revalidated the myth of Genesis, for in our own time, with knowledge has come power, and with both knowledge and power, we have lost our innocence. This knowledge and this power are due, of course, to the scientific revolution. And therein resides a puzzle and a paradox: The scientists, steadfastly and correctly, claim that their content and methodology are "value neutral." In the narrow sense, they are right. As methodology, science is properly value-free and should be value-free (an evaluative reflection, you will notice). But this "properly value-free" methodology has opened up a bewildering array of capacities and choices to us evaluating creatures. And we are not equipped with the ethical insights and the moral restraints that are necessary to deal wisely and appropriately with these choices. Yet the choices are before us and we can not evade them. "Not to decide is to decide."

The issues of environmental ethics are momentous, live and forced (to borrow William James' terms); that is to say, these issues involve moral choices of enormous importance that we can make and, even more, that we must make. Our moral responsibility to nature and to the future is

of unprecedented significance and urgency, and it is a responsibility that we can not escape. In our heretofore careless and capricious hands lies the fate of our natural environment, our brother species, and the generations that will succeed us. Therein lies our inalienable, dreadful challenge --- and our awesome responsibility.

Check Your Progress III

Note: Use the space provided for your answer.

1. Distinguish three "levels of environmental ethics.

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2. What is "Ecological morality"?

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3. Why has environmental ethics become an important issue of human concern?

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3.9 LET US SUM UP

Environmental ethics is theory and practice about appropriate concern for, values in, and duties regarding the natural world. By classical accounts, ethics is people relating to people in justice and love. Environmental ethics starts with human concerns for a quality environment, and some think this shapes the ethic from start to finish. Others hold that, beyond inter-human concerns, values are at stake when humans relate to animals, plants, species and ecosystems.

Humans deliberately and extensively rebuild the spontaneous natural environment and make the rural and urban environments in which they reside. We care about the quality of life in these hybrids of nature and culture. Ethics arises to protect various goods within our cultures: this, historically, has been its principal arena. As philosophers frequently model this, ethics is a feature of the human social contract. People arrange a society where they and the others with whom they live do not (or ought not) lie, steal, kill. This is right, and one reason it is right is that

people must co-operate to survive; and the more they reliably co-operate the more they flourish. One way of envisioning this is the so-called original position, where one enters into contract, figuring out what is best for a person on average, oblivious to the specific circumstances of one's time and place. This is where a sense of universality, or at least pan-culturalism, in morality has a plausible rational basis.

The four most critical issues that humans currently face are peace, population, development and environment. All are interrelated. Human desires for maximum development drive population increases, escalate exploitation of the environment and fuel the forces of war. Those who exploit persons will typically exploit nature as readily -animals, plants, species, ecosystems and the Earth itself. Eco-feminists have found this to be especially true where both women and nature are together exploited. The interests of environmental ethics done from perspectives of political ecology, sustainable development, bioregionalism, ecojustice, from an ethics of stewardship, or human virtues in caring, or a sense of place -all these tend to be humanistic and to recognize that nature and culture have entwined destinies.

3.10 KEY WORDS

Environmental Ethics **:** new sub-discipline of philosophy that deals with the ethical problems surrounding environmental protection. It aims to provide ethical justification and moral motivation for the cause of global environmental protection.

Pacifism **:** Peaceful international order to foster cooperation among countries in dealing with the global environmental crisis.

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UNIT 1 NATURE AND SCOPE OF ETHICS

Contents

1.0 OBJECTIVES

This unit aims at introducing the students to the philosophical need for Ethics starting from a brief discussion of Moral law and how the human person in his or her process of growth intuits the ethical principles. Discussions pertaining to the dynamics of morality is undertaken to show how on the one hand new situations call for new responses from moral point of view and on the other hand certain fundamentals of ethics remain the same in so far as there is something of a common human nature adequately understood.

1.1 INTRODUCTION

Let us begin our study of Nature and Scope of Ethics by understanding what we mean by moral law. But two things need to be clarified before we raise the question with which we are concerned here. First, the moral law is called 'law' only metaphorically, or if one prefers, analogically. The primary meaning of law is "a rule of action, promulgated by him/her who is in charge of a community in view of the common good". This is called positive law. If the legislator is considered to be God, it is divine positive law; if the legislator is human person, and it is human positive law. Human positive law can further be subdivided according to what the common good aimed at. (e.g. civil law, criminal law, commercial law, etc.) In a case, a positive law lays down rules to be observed by human persons. It is prescription. Then there is another sense of 'law' which is quite different. In this sense it is a formula expressing a constant of behaviour of things and of persons. So we have physical law (including laws studied in physics, chemistry, biology, etc.), psychological law, sociological law, etc. (Since the constant of behaviour among human persons is less fixed and foreseeable than that among things it is more of a statistical constant). As distinct from positive law, this kind of law is called 'natural law'. It is descriptive. It can also be called prescriptive to the extent if it is considered as willed by God and includes the divine positive law, and descriptive to the extent that this divine will is the ultimate cause of the constant of behaviour in things and human persons. However, moral law corresponds exactly neither to the positive law nor to the natural law. On the contrary, the sense of the 'absolute should' is an immediate datum of the moral consciousness itself.

Secondly, in the language of Moral philosophers, moral law includes not only general and abstract rules of action (e.g. "do good and avoid evil"), or, in our language, the sense of the absolute should, but also particular and concrete precepts (e.g. help the poor, obey legitimate

authority, be truthful, do not kill the innocent, adultery is wrong, etc.). These particular and concrete precepts, we are here calling the specifications of the moral law.

Hence our question: How are the general data of the moral consciousness particularized and concretized in specific precepts and what is the cause of this difference among men? In terms of moral value, we can raise this question as follows. If the moral value par excellence is human person's self-realization as human how can this moral value determine specific moral values? And why is there disagreement as to whether such and such an action is a 'good' (moral value) or not?

1.2 MORAL INTUITIONISM

All 'deontological' theories agree that there must exist some rule or law which 'enforces' moral value and that it is natural to human person, intuitively known. There is then an element of 'intuition' in all of them – no matter how they conceive of it and the way they approach it, whether as 'conscience' (Ockham), 'Logos' (Stoics), 'moral sense' (Shaftesbury), the 'a-priori categorical imperative' (Kant), 'right reason' (Thomas Aquinas and Suarez). This element of moral 'intuition' is also found in the 'teleological' theories whether implicitly or even explicitly. It is implicitly found in the concept of '*autarxia*' (Epicurus), in that of '*eudemonia*' (Aristotle), and explicitly in the concept of 'right reason' (Hobbes), in the 'conscientious feelings of mankind' (Mill).

And in fact the more the idea of moral obligation is prominent in an ethical theory, the more explicit becomes the recourse to this element of 'intuition' (or 'direct perception'). This element of 'intuition' is strongly emphasized by meta-ethicists who maintain that moral language is 'objective' and therefore 'informative'. But here again, they differ as to what the 'object' of this moral intuition is. This difference is explainable by the difference in their meta-ethical theories regarding the meaning of moral 'good.' Hence for some, this object is the 'rightness of specific acts' (Carritt, Prichard) for others it is a kind of moral property, simple and indefinable in non-moral terms (Moore), for others, it is a general principle (e.g. the 'the principle of utility' itself – Sidgwick) or a set of principles (e.g. the 'Prima facie' duties of fidelity, reparation, gratitude, justice, beneficence, self-improvement and non-maleficence – Ross). In ethics the philosophy which insists on the necessity of moral intuition is called Ethical Intuitionism.

But even the most insistent of all moral philosophers on this element of intuition in the moral consciousness, namely Kant, not only does not deny, but, on the contrary, explicitly states that the moral judgment includes elements derived from experience (which are therefore '*a-posteriori*' as opposed to the '*a-priori*' element). Kant denies the possibility of deriving particular and concrete moral precepts from the concept of practical reason alone. For this the study of human nature is necessary.

Similarly, Thomas Aquinas distinguishes between the 'first principles' of the *synderesis* which are 'self-evident', intuitively known by all, and which cannot be deleted from the human heart, and the 'secondary and more specific principles' which are derived from the former 'as if by way of conclusion from premises' what is implied here is that this secondary principles require reflection. Thomas speaks of the difficulty involved in applying general principles to concrete cases. Even though principles whether theoretical or practical can be evident in themselves, they

may not be so evident to us. And this is due, according to Thomas, to wrong persuasions on the part of human person.

Saurez is perhaps even more explicit in his doctrine that even the secondary principles – which like the primary are self-evident in themselves – require a certain amount of thought and experience. This is truer of the tertiary principles which require study and discursive thought. But all moral principles can be derived from self-evident principles. One notable difference between Thomas and Saurez is that the former derives the concrete principles in a way corresponding to 'human person's natural inclinations,' the latter derives them in a way corresponding to a legal system. For Saurez these precepts have their immediate norm the 'good' of human nature. The need of experience and reflection is similarly – indeed even more insisted upon by contemporary ethicists. Why this greater insistence?

1.3 HUMAN PERSON IN SEARCH OF HIMSELF/HERSELF

What we are dealing with here is to see whether a general principle such as 'serious promises should not be lightly broken' is 'self-evident' and therefore be counted among the 'first principles' intuitively known by everybody. If yes, how is it derived from the very first self-evident principle that 'good is to be done, evil to be avoided?' Is it merely by a kind of logical deduction? And if it is 'self-evident' in itself but not known by all, is it because of some accidental reason such as ignorance or bad habit? Finally, if it is not 'self-evident' how is it that human person has today come to agree that such a general principle is correct (that it is amoral value)?

To speak more specifically of thinkers like Thomas Aquinas, Suarez and Ross are we to say that the examples they give of first principles (or of *pirma facie* duties) are meant to serve merely as examples or are we to say that they are meant to be included among the first principles themselves? In the first case we could perhaps disagree that the examples they give are good examples but still agree with their doctrine that there exist first principles intuitively known by every man. The question would be then which are these fist principles. In the second case to question the aptness of the examples would be to question their doctrine itself. Irrespective of what such thinkers actually mean we have got to study the problem in itself.

If there is any principle that cannot be denied, it is the immediate data of moral consciousness. If these data cannot be denied they are self-evident. They are self-evident not as principles, that is, as formulae but as data whether they are thematically formulated or not. The immediate ontological foundation of the moral obligation is human inter-relatedness and that the norm for moral good (as distinct from the moral right) is human person as a social being. We have also reflected how the only moral precept which is immediately given that is self-evident and cannot be justified on a mere moral level is that human person should be human (as an individual and social being). Hence all other precepts (what we are here calling specifications of the moral law) must somehow or other flow from this fundamental precept that a person should realize himself/herself as human.

Human consciousness is in a process of becoming. Human person is becoming moral and more himself and in the process his awareness of himself develops. He/she has been continuously asking himself the question what he is. Human person is in a never-ending search of

himself/herself. The more he/she grows the more he/she becomes conscious of himself/herself as human person the more he/she is himself/herself. Moral consciousness is a part or an aspect of human consciousness. The more human person becomes himself/herself the more he/she becomes conscious of what he/she should be. This leads to the emergence of moral precepts specifying evermore clearly the conduct of human person.

Hence the moral precepts (moral values) flow from the first fundamental moral precept that human person should be himself/herself (the moral value par excellence not by way of mere logical deduction or of mere mediate inference. The former are related to the latter not simply as logical conclusions or as implicitly correlated to their premises. Logic has got to do with ideas, with mere ideas. It cannot be denied that this relation of the explicit to the implicit of the clear to the unclear to the unclear of the concrete to the abstract is here present. But it is present in the sense that a continuously developing human consciousness is related to its stages past and future of its development. Existence is more than logic.

If what we are saying about the progressive development of human consciousness, and therefore of moral consciousness is true one can easily understand the development of morals from the cave-man to modern human person from ancient slavery to the Universal Declaration of Human Rights which was approved without a dissenting voice in the United Nations General Assembly in 1948.

Ignorance of the moral precepts is therefore not necessarily the result of perverse customs as if this result were accidental. It is a fact of experience that perverse customs not only weaken the will to pursue the moral good but darkens the mind to recognize what the moral good is. But this is more easily possible on an individual level. Here we are placing ourselves on the level of mankind and its historical progress. This ignorance and the variety of morals can be explained by human historicity itself, that is, by the historical progressive development of his human moral consciousness.

However, we must not easily take it for granted that this development has always and everywhere been a linear progress. It may have suffered setbacks, reverses and regress. We need not go into that. What is more pertinent here to ask is whether we should reasonably suppose that human person has now attained the some of his/her self-consciousness and of his/her moral consciousness. What is reasonable to suppose according to us is that he/she has not. Apart from the fact that one cannot predict the future, contemporary moral problem of the morality of abortion hinges to a great extent on whether one should consider the human foetus a human person. The so-called women's liberation movement indicates no matter what its merits and demerits are that women have not been treated as full human persons everywhere in the world. One could think of many other indications. If progress is still possible it can only be done by the passage of time and on the part of human person by experience and by his reflection on his own experience.

1.4 LOVE AND THE MORAL PRECEPTS

Here we wish to bring into focus the more salient moments of our reflection on the subject bringing them to bear upon the topic at hand. To recognize human inter-relatedness as the immediate ontological foundation of the moral order and to act accordingly can be expressed in

terms of love. Love is therefore the existential basis of the moral order. This leads us already to start thinking that love is the basic moral activity.

The primary intuitively grasped demand that human person realizes himself as a human person is particularized and concretized in moral precepts. This too can be expressed in terms of love. Universal love is particularized and concretized – it is objectified – in the moral precepts. Hence as love not just one moral virtue among others but the form of all of the moral virtues, so too love is not just one moral precept among others but it is the form of all of them. It is what makes moral precepts moral precepts. Indeed it could hardly be called a precept since taken by itself in a non-objectified sense, it does not prescribe anything definite. And in the same way one can hardly call the moral realization of oneself as human as an obligation. This too taken by itself in a non-objectified sense does not oblige human person to do anything specific. And there is hardly any meaning in the saying that human person should love (love cannot be enforced) so too there is hardly any meaning in the saying that human person should fulfil himself as human.

If love is the form of the moral precepts and if love – like human moral consciousness – is a progressive affair this means that acting according to the moral precepts is acting according to love but that this awareness admits of degrees. This means that love can also be considered to be not only the beginning of the moral life but also its end. At the beginning it is present as a seed – which is more than mere potentiality but already an actuality albeit in a seminal form. The seed can develop into a fully mature and fully conscious lobe. And if it is in love that human person perfects himself as human, it is in this fully mature and fully conscious love that he/she does so.

Many factors go in this process of maturing of self-fulfilment. No matter how logically we can distinguish one human faculty (or aspect) of human person from another human person is a totality one integrated whole. As it is not the intellect which understands but human person by his intellect so too it is not with his/her heart that human person loves but human person by his heart (but heart is one's whole being). Love is an existential relation involving my whole existence.

Suffice it here to remark already that though human person can develop one or other of his/her faculties independently of the rest (or at least quasi independently) one cannot develop himself/herself as a human person without developing the core of his/her being namely his/her love and this is not achieved by mere study and reflection – although these can be very useful – but by doing. As scholastics say the operation is the perfection of being.

1.5 THE DYNAMICS OF MORALITY

Here we examine two questions which are intimately linked. In an evolutionary visions of human person to what extent can we say that morality (that is, the specification of the moral law) are universally valid for all human persons to what extent can we say that they are unchangeable? If one maintains their universal validity one is charged with absolutism with holding the opinion of a static nature of human person incompatible with present day theories about man's dynamic and evolutionary nature. If on the other hand one were to maintain a relative validity one would fall into a philosophically untenable moral relativism. Can the dilemma be overcome?

The Evolutionary nature of human person and of his human consciousness has long been recognized one way or another. Charles Darwin gave the theory of evolution a biological basis. An Evolutionary view of the world and of human person is today at the basis of a great deal of scientific philosophical and theological thinking. The thinking of such human persons as Pierre Teilhard de Chardin and of Aurobindo comes of course spontaneously to mind.

Herbert Spencer is perhaps the best known Evolutionary ethicist. He starts by observing that both human and animal conduct consists in acts adjusted to ends. The higher we proceed in the scale of Evolution the easier it becomes for us to obtain evidence of purposeful actions directed toward the good either of the individual or of the species. This purposeful activity forms part of the struggle for existence waged between individual members of the same species or between different species. But this type of conduct is according to Spencer an imperfectly evolved conduct. In a perfectly evolved conduct which is ethical conduct in the proper sense of the word this struggle for existence will yield place to cooperation and mutual help. Egoism and altruism will be both transcended. This leads Spencer to distinguish between absolute and relative ethics. Absolute ethics is an ideal code of conduct formulating the behaviour of the completely adapted human person in the completely evolved society. Relative ethics is the nearest approximation to this ideal according to the more or less perfectly evolved society in which human person happens to find him/her.

Spencer adopts the utilitarian ethical principle. In fact he takes happiness to be the ultimate end of life and measures the rightness or wrongness of actions by their conduciveness to this end. From a nascent state when this utilitarian principle was dependent on non-ethical (e.g. authoritarian) beliefs it gradually developed to become independent and as suggested by the theory of evolution, it will continue to evolve and reach an ideal limit.

Happiness however depends on the fulfilment of some conditions. And these conditions are the observances of certain principles and rules which causally determine human welfare. Spencer acknowledges the existence of moral intuitions which however are the slowly organized results of experience received by the race. In other words an induction from experience handed down from one generation to the other ends up by becoming an instinctive moral reaction. Evolution is moving towards the emergence of the highest form of life. Happiness as the supreme end of human person is the concomitant and virtue is the condition for its attainment. In the preface of the fifth and sixth parts of his the principles of ethics subsequently withdrawn Spencer confesses that the theory of Evolution has not provided as much practical guidance as he had hoped. What is peculiarly Spencer's is his interpretation of Evolution as a teleological process directed towards the establishment of a higher and higher moral order.

1.6 THE CONSTANT AND THE VARIABLE IN MORALITY

Whether or not man has evolved from sub-human beings it is not for us to decide. But we can easily accept the theory that this human consciousness itself has natured and developed. At the beginning human person was not necessarily conscious of himself/herself as human as we today are. On an individual level this progress in human consciousness is a fact of experience. The child is a human being but as it grows it becomes more and more conscious of itself as a human being. We can accept this theory even on the level of mankind as such to explain how the moral law is particularized and concretized in specific moral precepts.

Human consciousness involves one's consciousness of oneself as an individual and as a social being. Moral consciousness is an integral part of human consciousness. Primitive human (to call him so) must have been morally conscious – otherwise we are not entitled to call him/her human at all. So if moral consciousness belongs essentially to human consciousness as such – and in a univocal and not in an analogical sense – it has been a kind of constant in all the later stages of man's evolution. However, on the accepted theory that the human and therefore moral consciousness has been developing, the different stages of this development can be reasonably considered as the variable in human evolution.

If we speak of moral consciousness at all – whether of the primitive human or ours – we must speak of it in terms of the immediate data of consciousness as foundation on the human order more precisely on human inter-relatedness and these data to be in conformity to human reason and to be conducive to the self-realization of human person as human. But human moral consciousness has been evolving. This change takes different forms some of which are easily understandable and afford no real problem to ethics some are not so easily understandable and therefore afford some difficulty.

As human person becomes more and more conscious of himself as human – as an individual and as a social being – he/she becomes more conscious of his/her human inter-relatedness and of his/her rights and duties as a human person. This clearer self-consciousness is obviously concretized and particularized in specific moral precepts. Even at one given stage of human moral consciousness different people living in different human situations (situations affecting their inter-relatedness) will live a more or less different moral life. Such human situations can arise out of geographical, climatic and economic conditions.

Again since moral consciousness has been in fact intimately linked to and condition by religious consciousness, different religious beliefs have produced different moral values. And a change in religious consciousness has often wrought a corresponding change in morality. The history of religion affords us with many examples (e.g. human sacrifice, burning of witches, saturnalia, etc.). This change is primarily and directly in religious consciousness and only secondarily and indirectly in moral consciousness. It is a change in the religiously conditioned morality.

However, a change in civil law governing the mores of the people does not necessarily mean a change in morality. When a civil law declares that something is legal it does not mean to say that it is moral. Civil law as such does not pass a moral judgment. Legal means allowed as far as the state is concerned. It is not the business of the state as such to promote the moral beliefs of one section of its population as against those of another. This is important to remember today when many countries proclaim themselves to be secular – today when society is increasingly pluralistic.

The variable in morality raises the important question regarding the kind of certitude we can have in moral matters. To put it bluntly if what is believed to be morally right today can be proved to be morally wrong tomorrow and vice-versa can one be absolutely certain of what is morally right or morally wrong? In more philosophical terms if human person is conditioned by his/her existential situation and if human (and moral) consciousness is always in a process of

development and is dependent on physiological, cultural, social, psychological environmental and other factors, can he/she ever be certain of having reached objective moral truth if there is such a thing as moral truth?

At the very outset, we have to distinguish carefully between moral relativity and ethical relativism. Moral relativity is simply the view that different people especially in different civilizations and cultures have or have had different moral beliefs and what is believed to be morally right at a given time or place may be believed to be morally wrong at a different time or place. This is an undeniable empirical fact. But ethical relativism is the philosophical theory that no foundation exists, there is no universal moral norm (or basic moral principle), but what is morally right is relative to the individual or group of men in question. If such a theory can give reasons for such a position (as Sartre does), it is ethical relativism in the strict sense. If it cannot give reasons but simply admits that it is strictly impossible to say what is morally right and morally wrong it can be reasonably called ethical skepticism.

In an evolutionary view of human being, that is, on the accepted theory that human consciousness of himself/herself is increasingly developing, can we pretend to say the last word on what human person is? Obviously not. Human person's knowledge of his/her self is a progressive and dynamic knowledge, always tending towards a better and better understanding. In this sense human person's knowledge of himself/herself is relative. And if this is true his/her moral knowledge is also relative in so far as it is progressive and far from complete.

However an attentive study of the evolution of human person's self-consciousness and of moral knowledge helps one discover a certain constant progression, that is, human person is becoming more and more himself/herself. He/she is becoming more and more conscious of what he/she really is. His/her moral knowledge helps him/her to recognize himself/herself and others more and more as persons. Like in all spheres of knowledge a time of questioning debate and temporary disagreement is necessary in moral knowledge if progress is to be made. Indeed a state of incertitude on some issues is a pre-requisite and the pre-supposition of every progress. But whatever has been achieved is a definite acquisition – even if this acquisition remains still open to further advance and a deeper understanding.

Check Your Progress I

Note: Use the space provided for your answer

1) Explain Absolute Ethics and Relative Ethics.

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2) How are love and moral precepts related?

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3) How do the concepts of love and moral percepts help to build an ethical society?
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4) What is the notable difference between Aquinas and Saurez's idea of self-evident or moral principle?
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1.7 LET US SUM UP

Human person both is and is becoming; he/she is an "is-in-becoming." And this is because he/she is both essence and existence, rather he/she is and essence-in-existence. He/she is act and potency or here again he/she is act-in-potency. He/she is spirit and body, better still, spirit-in-body. In existential terms he/she is freedom and he is existentially situated, that is to say he is freedom-existentially situated.

Human person is both an end-in-himself and for others a particular human and social being. He/she can only find his self-perfection in the perfection of others. Hence the dialectical tension in human knowledge of moral law. The tension between the "is" and the "ought" between intuition and experience (or the *a-priori* and the *a-posteriori*) between the static and the dynamic the constant and the variable the absolute and the relative. We can go on like that an infinitum.

1.8 KEY WORDS

Moral Intuition: All 'deontological' theories agree that there must exist some rule or law which 'enforces' moral value and that it is natural to human person, intuitively known. There is then an element of 'intuition' in all of them – no matter how they conceive of it and the way they approach it.

Absolute Ethics: Absolute ethics is an ideal code of conduct formulating the behaviour of the completely adapted human person in the completely evolved society.

Relative Ethics: Relative ethics is the nearest approximation to this ideal according to the more or less perfectly evolved society in which human person happens to find him/her.

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UNIT 5 ETHICS IN CONTEMPORARY PHILOSOPHY

Contents

5.0. OBJECTIVES

An overview of history of western ethics (which is a branch of philosophy), called "Moral Philosophy" as well, gives us an idea that there are at least five important epochs in the philosophical enterprise regarding moral matters. "Contemporary Western Ethics" is the fifth epoch; the objective of this paper is:

- to bring out the characteristic features of contemporary ethics

5.1. INTRODUCTION

First, there is early and rich *Greek Ethics* marked by Pre- Socratic, Socratic, Platonic, Aristotelian and Sophistic original thinking and writings. Furthered by some equally influential writings of some Hellenistic and Roman ethicists, the Cynic and the Cyrenaics and the Stoics in the main. And then after Epicurus' Cyrenaicism, Plotinus was responsible for what we now call, "Neo-Platonism." Contemporary ethics owes much to these early and rich ethical reflections, about which we shall come to know later on in the discussion.

Nothings less do we owe to the *Medical Moral* philosophy, especially to the ethical thinking and writings of some remarkably eloquent Christian ethicists like Augustine, Aquinas, Duns Scotus and William of Ockham. This paved way to what we may call, the third epoch, the Early Modern ethical epoch, growing particularly during the sixteenth and seventeenth centuries influenced by religious Reformation, and the scientific revolution of Copernicus and Galileo, Francis Bacon, Erasmus, Luther and Calvin, However the real modern turn came with the radical writings of Thomas Hobbes (1588 – 1679) and the Cambridge Platonists like, Cudworth, Cumberland, Malebranche. No less forceful were the views of Spinoza (1632 – 1677), Locke (1632 – 1704). Huge impact was made by the moral sense theories of Shaftesbury (1671 – 1713), Hume (1711 – 1776), Reid (1710 – 1796) and Richard Price (1723 – 1791). Then we reach the *Enlightenment* era in ethical thought, with the French and the German enlightenment, contributed tremendously

by Voltaire, Rousseau and Immanuel Kant. It was with Kant (1724 – 1804) that the signs of a *Modern Ethics* were visible, which is more or less the fourth epoch. The Nineteenth century ethics grew mainly owing to the works of the utilitarian, Bentham and Mill. Though another idealistic turn was marked by the writings of Fichte, Hegel and the radical ethicists like, Marx, and Nietzsche. However, idealists Schopenhauer and theistic existentialist Kierkegaard were no less souls. Gradually as times' tide progressed closer to the twentieth century with a new idealist and intuitionist call of some British ethicists like T.H. Green, Bernard Bosanquet, F. H. Bradley and Henry Sidgwick, do we really come to what we call The basic question is then, what are the distinctive features that mark "Contemporary Western Ethics"? We can enlist the following problems which were raised particularly after Sidgwick, i.e. after 1900:
What exactly should be done in moral philosophy?
What if any is the need for ethical monolithic norms?
Why should logico – linguistic concerns take precedence in moral philosophy?
Why should we not revive Aristotelian tradition of virtues and values?
Why should we show any practical interest in ethics?

5.2. DEFINITION

Contemporary ethical enterprise is an attempt to justify *de novo* that ethics as a branch of philosophy should have at least four important tasks, namely, the normative, the meta-ethical, the virtue ethical and the practical tasks.

5.3. NORMATIVE ETHICS: A NEW LOOK

Contemporary western ethics takes a fresh look at normative ethics because at the outset, a number of challenges in our times in ethics are against the old and repetitive normative ethics. It is old in the sense of its much abused style of inquiries and repetitive in the sense of moving in a circle of monolithic thinking, not really giving us anything new. For instance, the entire story of moral philosophy from the Greek to the modern times, has been the story of either teleological or deontological norms, each trying its best to show that one norm is *necessary and sufficient* basis for moral evaluation of human and institutional decisions and actions that are voluntary. Either we need to abide by a definite "purpose" or "teleos" while deciding and acting, that is, taking it as the one end of life or the only moral ideal; or, we need to abide by what is stated to be our "duty", and not purpose, which is merely accidental and external to what we decide and do. In this sense, the calls are: either our actions have external worth or they have an intrinsic worth. If our actions were extrinsically valuable, the deontologists (the latter view), argues that they are bereft of moral worth because only worthwhile thing is what is our "purpose". On the other hand, we need to respect what we do for its own sake or for its intrinsic worth. The teleologists (the former view), argues that bereft of purpose, all our intended actions are morally lackadaisical because doing our drab duties for their sake is to forget that calling 'duty" its own purpose is circular and vague. It is in these ways we moved through the ages, sometime inventing one norm as superior to other, for instance, we were either stuck to egoism, egotism, altruism, consequentialism, welfarism eudemonism, and later to pragmatism, existentialism, and so on. Or we were stuck to Kantian deontology or later to its various revisions, the act and the rule forms of deontology proposed by Carritt, Ross and others. Hence, the era preceding contemporary

normative ethics, is monolithic, the main line of justification being, and there is one norm or a *summum bonum* of our moral life.

There were immediate sceptical questions in contemporary ethics (as expressed above), because we gradually came to know that though teleological and deontological norms have half-truths, they were not needed as monolithic life goals or as exclusive standards for a wide range moral evaluations. The scepticism followed two ways: One way was more radical than the other. Some sceptics called for *normative relativism* and rejected any practical application of a norm or more norms in our real life. The other milder sceptics called for the same 'relativism' though not rejecting normative application if it followed an acceptable methodology for application. The first view was a contemporary attempt at establishing "normative ethical relativism", the main tone of which is to do away with "one norm" theories of the old ethics, though obliquely recognized the fragmented values of normative theories provided one keeps in mind that relative worth of these norms depend on several factors, social, economic, cultural, political and so on, and if one does not forget the truism that with time, our mindset changes. Interestingly, a number of contemporary ethicists of the Vienna Circle, such as R Carnap, A. J. Ayer, M. Schlik and Wittgenstein, called for "normative neutralism" and "pluralism" was unanimous about rejecting "normative application". These sceptical thinkers of the *logical positivist gharana,* toeing the positivist line of the sciences thought that philosophers *gua* philosophers should remain "normatively neutral" in so far as their task to the heart is language clarification of ethics, for the same reason philosophers should not apply ethical norms.

With this extreme non-normative stance in contemporary ethics, some other contributors in this field felt that though relativity of norms is a proven thesis, it is too hard to accept that philosophers as philosophers we need only to take logico-linguistic interest, and that normative interest along its application are non-philosophical. A numbers of contemporary writers taking logico-linguistic concern in ethics seriously thought that it is meaningful to inquire into the relative value of norms because it needed logic for their relative worth. Ethicist like W. K. Frankena and R. B. Brandt, for instance, despite deep logico-linguistic interests, inquired respectively into the possibility of a fresh set of norms is like *Beneficence* and *Political and Institutional norms*, which was reminder to a fresh look at breaking the barrier of thought raised owing to fact-value dichotomy. With this, in contemporary ethics, a number of norms, social, political, metaphysical were advocated, and their relative values assessed given the logic that were available to their supporters. This is also a reminder of breaking of ice that crystallized owing to our fateful fact-value debate. Needless to say that despite such interest meta-ethical interest of justification of norms was not sacrificed. Another interesting, turn to be noticed is that ethical application was not an unphilosophical affair for most of these thinkers. They were not neutral to application possibilities of norms in question in our real life. This brings ethics closer to life or a serious inquiry into the ways in which what should be done in life. Many conscious thinkers revived a type of "casuistic" method made famous in medieval Christian ethics. We shall come to it later on.

Check Your Progress I

Note: a) Use the space provided for your answer
b) Check your answer with those provided at the end of the unit:

1. What is the contemporary approach to normative monism?

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2. What is normative scepticism?

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3. What is contemporary normative relativism?

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5.4. META-ETHICS OR SECOND ORDER ETHICS

We have noticed that despite a long history of normative or first order ethics, contemporary ethics felt an urgency to lay more stress on meta-ethics or second order ethics. The “first order ethics” is so called for it was not only historically prior inquiry, rather it inquired into what was thought primary in ethics, that is, assessment of moral worth of our intended actions. The second order ethics is then, not secondary, rather, considered what lay beyond the first order of inquiry. And what lay beyond the first order inquiry is the whole gamut of “ethical language”, most evidently normative or evaluative in character, though, language containing elements of values, virtues and institutional decisions and actions were equally important. However, in contemporary ethics there have been animated debates whether a number of utterances to be found in the ethical parlance are truly "ethical" in nature. "Good", for instance, is an umbrella term, covering descriptive (factual) as well as evaluative (moral) functions and meanings, which needs to be clearly demarcated. "My car is good" and "Honesty is good" do not bear the same evaluative tone because the former is evaluation of an object based on its descriptions of mechanical properties, which could be observed and experimented, whereas the latter evaluates a virtue of humans, which cannot be observed and experimentally proved or disproved, and for that matter, does not need such justification at all. So the justification in favour of calling “car” a “good” is different from calling “honesty” a “good”. Hence, moral utterances need to be differentiated for a proper logico-linguistic analysis of truth and meaning from factual utterances, which is expected of meta-ethics.” However, as said before, there is a lot of debate regarding this is/ought question. One conclusion with which it is not difficult to agree is that *logically speaking*, that is, based on strict logical or formal rules; it is difficult to derive a fact from a value statement without an intervening factual statement, as well as to derive a value statement from a factual statement without an intervening value statement. Moreover, it is difficult to derive a fact from value or vice versa based on an assumed truth or predilection or blank presupposition.

But the stiffer debate is how to identify “a factual statement purely so called” and “a value statement purely so called”. There are evidences of statements appearing to be purely factual but

in essence, 'value-laden". Hence, a number of so called facts related assertions are found to blur the boundary of fact value. This is why socio-political and legal assertions are value-laden, and many positivistic assertions are carriers of value. This is why there is little hesitation in imagining political ideals and ideologies as bases for moral judgments. And this is why normative pluralism transcends the old theories. Interestingly, contemporary ethics does not hesitate to evaluate the moral worth of the corporate and the government decisions and functions though they are not an individual's intention and action. We have moved from the thought that moral judgment is true of a human being on earth. Group morality is equally important. Hence, the private and the public, the individual and the collective intentions, decisions and actions are our objects of moral judgement.

However, the Is/Ought duality debate appears at another point for meta-ethical inquiry, again related to normative inquiry. As was said before, norms beg justification for they are not our predilections. However, we justify a moral norm logically based on facts; there is a fallacy of deducing a value from a fact. In the similar fashion, meta-ethicists of contemporary times like G.E. Moore, argued that if clarification of meaning of moral language is so important, one cannot without a blatant "naturalistic fallacy" *logically define* moral terms like "good", "bad", "right", "wrong" and many more. The reason is that any logical definition falls back on defining by equivalent natural or factual or metaphysical terms, which cannot be the case. How can an ethical term which is a simple, non-natural, indefinable concept be equivalent in import to complex, natural, definable concept? Any confusion like this is again confusing a value for a fact. This, Moore learnt from Plato (also Socrates), that "justice" is naturalistically indefinable (cf. *The Republic*). Hence, neither can we logically define moral terms, nor can we logically justify moral premise based on factual premise.

Although contemporary ethicists started a logical inquiry into ethical language and justification in this way, they were quickly challenged. This is the liberal spirit of contemporary ethics, which moved miles away from the feudal, obstinate and orthodox linear thinking of the old medieval and even modern ethics. Thinkers like W. K. Frankena, R. C. Cross and A. D. Woozley argued that "naturalistic fallacy" as a *definist fallacy* if a moral term has been "logically defined". However, in a number of normative and value related discussions, moral terms are not logically defined at all because no one has ruled out the possibility of their *non-logical definitions* or *explanations* for clarification of meaning. Hence, there are hardly noticeable naturalistic fallacies in ethics; the fallacy is nevertheless, a reminder to minds tending to move to this fallacy. Similarly, proving and justifications are different. If we cannot logically prove several ethical conclusions or a majority of moral theories, no one has really prevented us from justifying them *non-logically*, such as "persuasively" and "heuristically".

Further, meta-ethicists consider moral language as such for their truth and meaning. In contemporary ethics we care for clear criteria for truth and meaning of moral assertions. This was by far not systematically dealt in earlier ethics, though no way it has suddenly popped up owing to fertile imagination of some contemporary genius like Ayer or Moore or Wittgenstein. Contemporary ethicists followed two major lines with regards to justification and meaning of ethical language, where 'ethical language" has been more or less taken as the language pertaining to ethics or the one that clearly deals with moral values and value judgments. The cognitivists including the *naturalists*, *non – naturalists* and *metaphysical moralists* justify the

truth of moral assertions based on the "cognition" of what has been asserted by means of either sense experience (*naturalists*) or intuitive experience (*non–naturalists*) or by means of spiritual/metaphysical experience (*metaphysical moralists*). The cognitivists are divided partly because they debated over the basis of justification. The naturalists for justification translate all ethical assertions to factual assertions without any distortion in meaning, and hold that like all factual assertions, ethical statements are to be justified based on observation and experiment of facts. Hence, "X is good" is true because "good" is translatable to what one 'desires", "wishes", "likes", "approves" and so on, thus *describing* the speaker's psychological state of affairs or *describing* one's feeling and emotions about "X", which is evidently true as a matter of fact. This theory is a "descriptive theory of meaning" supported by Hume, Westermarck, utilitarians, Russell, Perry and other naturalists in contemporary ethics.

We can now consider the 'metaphysical" position. The only difference with the naturalists is that unlike naturalists, metaphysical moralists translate moral assertions to "metaphysical/spiritual assertions" for justification and meaning. This is another "descriptive" theory, though the description offered in not in nature, and therefore, not sense experienced. Nevertheless, the justification owes to our queer spiritual disposition to know distinctly and clearly the truth of moral assertions as we know all religious assertion to be true. In this sense, "X is good" amounts to "X is what is loved by God", which is true in so far as we have this unique experience not really intuitively but through our "spiritual experiential disposition". In our times Barth, Brunner, Muirhead are among important ethicists who take this line.

G. E. Moore on the other hand criticizes both views in *Principia Ethica* because the naturalistic theory confuses ethical statements as descriptive statements. On the other hand, the ethical statements are *non–natural* statements because they do not describe any object or state of affairs whether natural or metaphysical. Hence, ethical assertions can be justified for truth and meaning based on direct cognition enabled by our intuitive disposition. They are thus "intuitive assertions", not really describing anything. Rather, they reveal what comes to us as distinct ideas. But what this queer "faculty" really is, one is not sure. Is it a rational faculty or a non-rational faculty? And what is the source for the universality of the established truth?

Looking at the several problems that both the naturalists and the intuitionists face, the *non-cognitivists* in the contemporary times pointed out a major truth which we were unaware of. The point is when we find ethical assertions, they are not combination of letters, and they are spoken and/or written words used meaningfully by a speaker to a hearer. If we miss this speaker– hearer situation in moral language, we miss the functional aspect of the said language and any language for that mater is not inert, it is dynamic, it serves human purpose. If this be true, it is useless to harp on what language describes or how we can intuit truth. It is more important to know what purpose moral or any language serves. Coming to this, contemporary emotivists like A.J. Ayer said that moral assertions do not have a truth value as factual statements have because they are pseudo-statement or rather, pseudo – factual assertions. Moral statements are neither about the world nor about describing our feelings and emotions, nor are they intuitive non-natural truths. Moral assertions are "expressive", that is, they *express our emotions*. Moral statements are thus emotively meaningful, and that truth is a plain matter of finding display of our emotions in real life moral discourses. However, Ayer said that such emotive statements are not about real moral agreements or disagreements because emotions do not beg for logical or rational justifications.

This was opposed by C. L. Stevenson, a later emotivist, who thought that moral assertions are real life agreements and disagreements about matters pertaining to moral intentions and actions, and we can, and should provide some justifications or arguments at least in the favour of what is expressed. Though, emotive expressions are not subject of rational arguments. But we can provide *psychological arguments* or *persuasive arguments* to justify what has been assisted. This is so because moral assertions are in the main *emotive* exhortations, and *descriptive* of the properties of something about which emotions are expressed. Moreover, we need to persuade the disagreeing person to see the truth that for the evident properties or worth, such and such thing is of moral worth.

This was further rejected by R. M. Hare on three major counts: First, he said that moral assertions far from being emotive exhortations and non-rational, are *prescriptive assertions* for they "prescribe" what we "ought" to do or what should be a moral course in life. Hence, "X is good" is not a mere emotive outburst; it is prescription to someone to follow a moral course in life. Second, Hare is of the opinion that moral assertions are *universalizable*, and therefore, not isolated relative truths depending on one's state of mind or what one expresses. Finally, such moral assertions demand *rational justification* and not persuasion or any psychological justification. Nevertheless, in contemporary times meta-ethics progressed further with a number of thinkers like P. H. Nowell- Smith and the adherents of Ryle – Wittgenstein – Austin tradition in linguistic philosophy. Hare was particularly charged for coming so close and forget what the "use theory" and the other "functionalist" theories advocated about meaning and justification of moral language. In fact, the use of moral words in moral contexts that gives us a gamut of moral statement is not one, there is no fixity as the theory goes – it is rather multifunctional or "janus headed" (Nowell- Smith). This rules out any monistic tendency, whether emotivist or prescriptivist in finding out its meaning. Though this approach finds a number of supporters in metaethics, we have in contemporary times *the good- reasons approach* of S. Toulmin, Kurt Baier, Kai Nielson and many others, who thought that the best representation of the later Wittgenstein theory was to find out "good reasons" in favour of ethical assertions, and to do so is to be reminded of the description, connotative, performative, and other uses of ethical utterances. Without trying to bridge the gap of the moral and the non-moral assertions (because they are so evidently distinct), these thinkers banked on the several performances moral language is capable of to unravel its meaning. But the point is, whether normative and/or meta-ethical inquiries were sufficient for a moral philosophy. This takes us to questions regarding ethical values and virtues, and practical application of ethics.

Check Your Progress II

Note: a) Use the space provided for your answer

b) Check your answer with those provided at the end of the unit:

1. What is the position of the ethical naturalists?

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2. What do the emotivists argue?

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3. What are contemporary post- emotivist positions in meta- ethics?

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5.5. VIRTUE ETHICS: THE ARISTOTELIAN REVIVAL

In a seminal essay Ms. G. E. M. Anscombe inquired whether modern moral philosophy needs a shake up for being too overloaded with theoretical churning. Put in another way, some contemporary thinkers worried of theory-ladenness of ethics and wanted to get rid of it to inquire whether ethics was all good to read and no good to live a virtuous life. Is it not out of way to imagine that moral philosophy, if it pertains to moral matters, be engrossed in language analysis and not in the values and virtues that humans should possess so that a good life is lived on earth? This is exactly the most troubling question for an ethicist called Aristotle, whose revival was badly needed in moral philosophy, thought Anscombe. Thus the Aristotelian revival came with "virtue or value based ethics", or simply, "virtue ethics". This was looked upon by many as "anti-theoreticism" and 'anti-normativism" or moving away from theory to consider, "being good". What exactly are the dispositions cultivating which amounts to "being good"? There may be many, most importantly, the *traits of character* and the *traits of duty*. "Deontic traits" and "aretaic traits or virtues'' are most important for "being good". Such moral men if infested our world will cause moral cleansing of the already burdened world of vices due to human follies. Hence, it is needless asking what ideals or rules should we follow. It is more important to find out what values should we cultivate. In contemporary ethics, there are other classifications of virtue ethics, the most important ones are: *Agent focussed, Agent based, Agent prior* virtue ethics. The first concentrates on a moral agent and asks for the inculcation of *virtues most needed*, whether deontic or aretaic or both (cf. Swanton). The second concentrates more on *human beings as such* and inquires about the core of life which demands inculcation of virtues that are essential to it (cf. James Martineau). Whereas the last one concentrates more on the inculcation of such virtues which are most needed for humans for their holistic well being (cf. Rosalind Hursthouse). However in our times there is a debate whether virtue ethics can be sensible without theoretical concerns (both normative and meta-ethical). First, we must know the meaning of "virtue" and "value" and their types. Second, anti-theoretic stance itself needs a logical justification (which is a meta-ethical problem). Then we need to know that calling virtue by a name, demands on what basis we call it by that name. If I call "honesty" a virtue, we need to ask: On what basis is "honesty" a virtue? Thus we speak of a norm for calling "honesty" a virtue. Now, if we say that "self-fulfilment" is basic to call "honesty" a virtue, and then we need to ask, without being honest first of all, how self-fulfilment is realizable? This takes us to the

contemporary debate to conceive of a virtue ethics with normative and meta-ethical theoreticism — it is thus "return to theory".

Check Your Progress III

Note: a) Use the space provided for your answer

b) Check your answer with those provided at the end of the unit:

1. Why is virtue ethics referred to Aristotelian revival?

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2. What are the contemporary classifications of virtue?

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3. What is contemporary reply to anti-theoreticism?

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5.6. PRACTICAL ETHICS: FORGOTTEN PAST UNEARTHED

It is strange thinks many contemporary ethicists to try and discover what is right below our nose. If it is true that virtues are extremely important in ethical discussion, can application of ethics be far behind? The point has been already raised by us when Anscombe asked obliquely whether ethics is so glorious without doing something worthwhile. The simple answer should be in the negative, think many ethicists, who do not support application of ethics or practice of ethics. The problems are, what should be applied in ethics and how? The remarkable feature of contemporary ethics is not that if stresses on ethical application but answers what is applied and how. Again this is a revival of Greek ethics of the Aristotelian trend in particular but much different from the methodology of "golden mean" or Socratic dialogue or the sophist mechanics. It is different from the casuistry of the medieval Christian fathers. The first point is that either standard *ethical theories* (deontology and teleology) should be *applied by ethicists,* or, *ethical experience and knowledge* of sane, grown up individuals need to be applied wherein professional philosophers take a lead or any other competent party, does so in a *theory neutral* way. The first model for ethical application, a mistaken one, it is relatively older among contemporary application models. It is nothing but relic of old mechanics, sophistry and casuistry. We can call it a 'theory guided" and "Chauvinistic" model for ethical application, which has to give up its cause for a number of mistakes noted by Caplan, James Brown, David Callahan and others. They call it "Sophistic", "artificial", "casuistic and chauvinist" because ethicists assume the role of all powerful ethical angels by virtue of ethical wisdom that they have (much like Plato's Philosopher Kings), to consider value-laden practical problems of urgency and work in isolation as experts pulling out right tools for mending mechanical defects, and then prescribing moral

dictates or do's and don'ts, which problem ridden ethics-less ordinary people should follow. This is what Sophists did (sophistry) or what casuists did (Casuistry) in isolation, and what in our times Bradley, Sidgwick, and many others nourished. Even anti-practical ethicists like the positivists and later Wittgenstein thought that practical ethics is an ethical abuse just because it is sophistry and/or casuistry.

Contemporary ethicists, a number of them, argue against such "mechanics of duty" of artificiality in ethical application, which is "chauvinistic" because ethics bosses apply norms from the top. Rather, there is a "bottom down" approach or a model for application that rightly answers what needs to be applied, and how. It is argued that for ethical application we need moral debates amounting to a moral closure leading to formulation of relatively valuable set of decision making cues regarding value-laden practical problems of social urgency. The moral debates should be initiated and moderated by any interested party who is well versed in the practical problem in consideration and its aspects of value. Ethicists, whether professional philosophers or others who are trained in this field, are a better choice for some reasons: First, they can select moral debates fairly well; second, they can construct people friendly non-structuralist questions for debate; third, they can remain theoretically non-bossing while debates go on, and finally, they are best placed to analyse moral debates, find out the closure points and contribute academically to let us know which moral theory of theories were in interplay in debates and which gained prominence in a closure. This is a non-theory laden approach, which nevertheless, is not blind to academic interest of post-corroboration analysis of moral debates. The model is best referred to as "intersubjective corroboration". The theory/anti-theory debate is taken care of as practical ethics is not application of moral theories, rather application of "common moral experience and knowledge" for moral resolutions. Nevertheless, post–corroboration analysis of dialogues reveals normative dynamics, which is a return to theory.

In contemporary western ethics application of the moral experiences of professionals of different fields for moral crises resolution has gained prominence, which is called "professional ethics". It covers a broad field, ecological, biological, medical, educational, economic, business, management, administration, as well as social, political and legal fields. It covers mass media, communication and many other fields like sports. The reason is that in different professional fields, with the passage of time, a number of value–crises crops up. The professionals are worried to settle them following a moral methodology. We thus have environmental ethics, bioethics and much such ethical discussion in our times.

Check Your Progress IV

Note: a) Use the space provided for your answer
b) Check your answer with those provided at the end of the unit:

1. What practical ethics is not?

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2. What is intersubjective corroboration?

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3. What is professional ethics?

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5.7. LET US SUM UP

It is encouraging to note that contemporary ethics possesses dynamicity, it does not cling any more to one or two standard functions. Since 1900 ethics has been changing. We now discuss about the use of "empirical ethics" as well, which is partly empirical field work based study of moral opinions followed up by empirical data, which are further analysed for several moral conclusions. Further, there is a feminist turn in ethics and ethics of care. Ethics in contemporary epoch in thus coming closer to social scientific vocation and is set to be the most rapidly growing interdisciplinary aspect of philosophy. Ethics is no more the same cafeteria philosophy of norms and the language churning by intellectual.

5.8. KEY WORDS

Normative or First order ethics: Deals with one or more standard or standards for the evaluation of the moral worth of intended human as well as institutional actions. Also evaluates individual and collective dispositions, virtues and values. First order is indicative of both historical priority of the discourse as well as the primacy of the same.

Meta-ethics or second order ethics: Deals with one or more justification or justifications which might be strictly logical as well as non- logical in nature in favour of normative theories. It also deals the truth and meaning of ethical terms such as good, right, just and many more. It is second order with regard to the follow up analysis of first order inquiry though completely transcending it in terms of linguistic and logical inquiries.

Virtue ethics: The ancient Greek and particularly Aristotle's interest in basic human virtues that is expected of man qua man or by virtue of being a human. In contemporary ethics, its revival is a thorough analysis of meaning, nature, kinds and importance of virtues in humans, and ways they might be inculcated.

Practical ethics: The nature of practical ethics depends on what is practiced in ethics and how. In contemporary ethics it is a bottom down method to resolve value-laden practical problems in the world we live in. The method is intersubjective corroboration in which problems are resolved through collective moral debates followed by moral consensus, decision making rules and post-corroboration analysis of moral debates to unravel the role and relative value of normative theories.

5.9. FURTHER READINGS AND REFERENCES

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5.10. ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress I

1. Normative ethical monism support verity of a particular ethical norm like deontology or teleology while rejecting the usefulness of a number of norms.
2. Normative ethical scepticism does not support the verity of any absolute ethical norm either because normative standards are never eternal, they depend on many changing circumstance or because ethicist have nothing to do with norms, they should take analytic task more seriously.
3. Normative ethical relativism justifies that any ethical norm is not sacred as the value of each of these norm are dependent on several circumstances such as social, economic, political and so on. Hence, there is no objectively valuable standard of morality; morality is relative in our societies.

Answers to Check Your Progress II

1. Ethical naturalism holds that ethical assertions for their meaning and truth should be translated to natural assertions such as the psychological description of our feelings, emotions because only in that way we come to know empirically what has been really meant by the asserter.
2. Ethical emotivism argues that ethical assertions do not describe anything, and are meaningful; they are rather, expressions of the favourable and unfavourable emotions of the asserter.
3. Ethical prescriptivism and the good reasons approach are the major post- emotive theories. Prescriptivists argue that ethical assertions are prescriptions about a way of moral life. The good reasons approach argues that for understanding the meaning and truth of moral assertions, we should look at the several good reasons that we have for their meaningful use in moral contexts. Hence, the multiple perfomatives of ethical assertions clarify their meaning.

Answers to Check Your Progress III

1. Virtue ethics is referred to as “Aristotelian revival” because this ethical trend made a strong come back after it was discovered that basic human virtues were essential for following a moral goal, which was stressed by Aristotle and his predecessors. However, it was Aristotle who considered at length a number of cardinal and other virtues for inculcation in humans.

2. Contemporary ethicists classify virtue ethics in terms of primacy of virtues, whether that is aretaic or deontic. Further, keeping moral agents in mind, we have agent focussed, agent based and agent prior virtue ethics.

3. Some contemporary critics of virtue ethics hold that it is illogical to call virtue ethics anti-normative or anti- theoretic because without reference to a particular norm it is impossible to call something a virtue. Similarly, it is useless to have norms without having a basic virtue to pursue them.

Answers to Check Your Progress IV

1. Practical ethics is not artificial application of one or more normative theories as absolutely true by the ethicists, and others are merely left to follow them. It is also not casuistic application of theistic ethics by the moralists. Hence, it is not "from the up'' or chauvinism of ethicists and moralists.

2. Inter-subjective corroboration is a 'bottom down' model for the application of ethics which speaks of resolution of ethical problems by collective application of our moral experience and moral knowledge through moral dialogues and subsequent corroboration of our views.

3. Professional ethics is consideration of several theoretical problems of justification, conceptual analysis and methodological issues in the resolution of a number of value- laden moral problems that professionals face in social life.

GE3752-TOTAL QUALITY MANAGEMENT

UNIT – I

PART – A

1. Define quality.

Quality is the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.

2. List the dimensions of quality.

1. Performance,	2. Features	3. Conformance
4. Reliability	5. Durability	6. Service
7. Response	8. Aesthetics,	9. Reputation

3. What do you mean by quality planning?

It is a strategic planning process in which quality is embedded in each and every step.

4. Where we use the quality planning road map?

The quality planning road map can be applied at the following levels :

a) Supervisory and worker level
b) Functional level
c) Multifunctional systems, and
d) Major programmes

5. Define quality costs.

Quality costs are defined as those costs associated with the non-achievement of product / service quality as defined by the requirements established by the organization and its contracts with customers and society.

6. List the categories of quality costs.

1. Cost of prevention
2. Cost of appraisal

3. Cost of internal failures, and
4. Cost of external failures

7. What is meant by cost of prevention?

Prevention costs are the costs that are incurred on preventing a quality problem from arising.

8. List the elements of cost of prevention.

Cost of prevention includes: (i) cost of quality planning, (ii) cost of documenting; (iii) process control cost; (iv) cost of training; (v) costs associated with preventing recurring defects, etc.

9. What is cost of appraisal?

Appraisal costs are the costs that are incurred in assessing that the products / services conform to the requirements.

10. What are the costs of appraisal?

Cost of appraisal includes : 1. Cost of receiving test and equipment; 2. Cost of laboratory acceptance testing ; 3. Cost of installation testing ; 4. Cost of installation and commissioning ; 5. Cost of maintenance and calibration of testing and inspecting equipments.

11. What is meant by cost of internal failures?

The costs associated with defective products, components and materials that fail to meet quality requirements and result in manufacturing losses are called as costs of internal failures. These costs are linked to correcting mistakes before delivery of the product.

12. List the components of cost of internal failures.

Cost of internal failures include : 1. Cost associated with scrap and rejects ; 2. Cost of repair and rework; 3. Cost of design changes; 4. Cost of trouble shooting; 5. Cost of reinspection and retesting ; etc.

13. What is meant by cost of external failures?

It consists of the costs which are generated because of defective products being shipped to customers. These costs are associated with the adjustments of malfunctions after delivery of the

product.

14. What are the elements of cost of external failure?

Cost of external failures include : 1. Cost of processing complaints from customers ; 2. Cost of commissioning failures; Cost of servicing or replacing the defective items; 4. Cost of guarantee and warranty claims; 5. Cost of lost goodwill of customers; etc.

15. What are the techniques commonly used for analyzing the quality costs?

The techniques used for analyzing the quality costs are:

a) Trend analysis, and
b) Pareto analysis.

16. Differentiate between inspection and quality control.

Parameters	Inspection	Quality control
1. Scope	Inspection is a part of quality control	Quality control is a broad term. It involves inspection at particular stages, but mere inspection does not mean quality control.
2. Definition	Inspection is an act of checking materials, parts, components or products at various stages in manufacturing and sorting out the faulty or defective items from good items.	Quality control is an effective system for integrating quality development, quality maintenance and quality improvement efforts of various groups in an organization to enable the production to be carried out at most economical level and to achieve satisfaction of customers.
3. Responsibility	Inspectors are mainly responsible for inspection.	Everybody working in an organization is responsible for quality of products produced.

17. Define TQM.

Total Quality Management is the management approach of an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society.

18. What are the six basic concepts that a successful TQM programme require?

a) Top management commitment
b) Focus on the customer

c) Effective employee involvement
d) Continuous improvement
e) Treating suppliers as partners, and
f) Establishing performance measures.

19. What are the elements of TQM?

Three elements of TQM include :

a) **The philosophical element:** It includes leadership, continuous improvement, employee participation and development, design quality and prevention, partnership development, etc.
b) **The generic tools :** This include SPC tools, QFD, new seven management tools, and FMEA.
c) **QC department:** It consists of SQC methods, benchmarking, Taguchi methods, and TPM.

20. What are the pillars of TQM?

The four pillars of TQM are:

a) Problem solving discipline
b) Interpersonal skills
c) Teamwork; and
d) Quality improvement process

21. List out any four barriers to TQM implementation.

a) Lack of management commitment
b) Lack of employees commitment
c) Lack of effective communication
d) Lack of continuous training and education.

22. Tabulate the tangible and intangible benefits of TQM.

Tangible Benefits	Intangible Benefits
a) Improved product quality	a) Improved employee participation
b) Improved productivity	b) Improved teamwork.
c) Reduced quality costs	c) Improved working relationships
d) Increased market and customers	d) Improved customer satisfaction
e) Increased profitability	e) Improved communication
f) Reduced employee grievances	f) Enhancement of job interest
	g) Enhanced problem-solving capacity

h) Better company image

23. What do you mean by the term leadership?

Leadership is the process of influencing the activities of an individual or a group towards the achievement of a goal in a given situation.

24. List out the different leadership roles required for effective teamwork.

The eight leadership roles are:

1. Producer role	2. Director role
3. Coordinator role	4. Checker role
5. Stimulator role	6. Mentor role
7. Innovator roles, &	8. Negotiator role

25. What is a quality council? Who are all the members in the quality council?

a) **A quality council** is a team to provide overall direction for achieving the total quality culture.
b) **The members of quality council** are: (i) the chief executive officer 9CEO), (ii) the senior managers of the different functional areas, and (iii) a coordinator or consultant.

26. What is vision statement?

The vision statement is a short declaration of what an organization aspires to be tomorrow.

27. What is mission statement?

It is a broad organizational goal, based on planning premises, which justifies an organization's existence.

28. What is quality policy statement?

The quality policy is a guide for everyone in the organization as to how they should provide products and service to the customers.

29. What is strategic planning?

Strategic planning sets the long-term direction of the organization in which it wants to

proceed in future.

30. What are the steps involved in strategic planning process?

The strategic planning process involves seven basic steps. They are :

1. Customer needs
2. Customer positioning
3. Predict the future
4. Gap analysis
5. Closing the gap
6. Alignment, and
7. Implementation

31. Define Quality in a mathematical way?

a) Quality can be quantified as follows:

$$Q = \frac{P}{E}$$

Where Q = Quality,
P = Performance, and
E = Expectations.

If Q is greater than 1.0, then the customer has a good feeling about the product or service. The determination of P and E will most likely be based on perception with the organization determining performance and the customer determining expectations.

32. Define Quality Control.

Quality Control may be defined as

a) Evaluate actual operating performance
b) Compare actual performance to goals
c) Act on difference.

33. Define Quality assurance.

It is defined as that all planned and systematic activities implemented within the quality system and demonstrated as needed to provide adequate confidence that an entity will fulfill the requirements for quality.

34. Define Hidden costs.

There are many costs which cannot be identified easily. These are termed as hidden costs. These includes customer – incurred costs, lost reputation costs and customer dissatisfaction costs.

Hidden costs can be eliminated only by eliminating external failures.

35. Mention the stakeholders for any organization?

The stakeholders for any organization are

a) Customers
b) Employees
c) Suppliers
d) Owners
e) Society

36. Expand TQM in a simple manner?

Total	-	Made up as a whole
Quality	-	Degree of Excellence
Management	-	Act, art or manner of handling, controlling, directing, etc.

37. State the Characteristics of TQM.

a) TQM is customer oriented
b) TQM is a teamwork
c) TQM requires a long term
d) TQM requires the leadership

38. State the four pillars of TQM.

a) Problem solving discipline
b) Interpersonal skills
c) Teamwork
d) Quality improvement process

39. State any two principles of TQM.

a) Regular communication with staff at all levels is must.
b) Every job must add value.
c) It should focus on teamwork.

40. State any two barriers to TQM.

a) Lack of management commitment

b) Improper planning.

41. State the responsibility of the Quality Council Coordinator.

a) To empower the team
b) To share council expectations with the team
c) To brief the council on the team progress.

42. Mention the levels where the quality planning can be applied.

a) Supervisory and worker level
b) Functional level
c) Multifunctional level
d) Major programmes

43. Define trend graph.

It is a planning tool that provides information for long – range planning.

44. Define pareto analysis.

It is a method of classifying items, events or activities according to their relative importance.

45. Define Quality Council.

It is a team to provide overall direction for achieving the total quality culture (TQC).

PART – B

1. Mention the Dimensions of Quality in detail.

DIMENSIONS OF QUALITY

Quality has many dimensions. The dimensions of quality are nothing, but the various features of a product or service. We will discuss some of them briefly:

Product Quality

1. Functionality: Functionality refers to the core features and characteristics of a product. The definition of functionality is stated as "A set of attributes that bear on the existence of a set of functions and their specified properties. The functions are those that satisfy stated or implied needs".

For instance, a car has to have a seating capacity for five persons; a steering wheel, an accelerator a break, a clutch, head lights, gears, four wheels, etc. The functionality of a car represents each one of the functions mentioned above and many others not listed above. Thus, functionality refers to those functions that will satisfy a customer.

2. Reliability: A car should not breakdown often. This is the reliability attribute to quality. Reliability is measured by mean (average) time between failures (MTBF). Reliability is an indicator of durability of products. For instance, the MTBF of a car can be specified as 1000 hours of running or 10000 kilometers.

3. Usability : A product should be easily usable. The customer should be able to use the product easily without the help of experts. For instance, repairing a car may need the help of a mechanic, but the car can be driven by the owner himself, it he is trained accordingly. Thus, each product should be made so that a person can use it with minimum training. Usability can also be measured by the time taken for training an operator for error-free operation of a system.

4. Maintainability: Maintainability refers to the ease with which a product can be maintained in the original condition. Products may become defective while in use or in transit. It should be repairable so as to retain the original quality of the product at the lowest cost at the earliest possible time. This applies to software, automobiles, household items such as refrigerator, air conditioners, personal computer, etc. For instance, when we use a Walkman we may need to change the batteries periodically. For software, maintainability is defined as "A set of attributes that bear on the effort needed to make specified modifications".
Maintainability is measured as Mean Time To Repair (MTTR). For instance, the MTTR of a street

light controller is 15 minutes.

5. Efficiency: This is applicable to most products. Efficiency is the ratio of output to input. If a car gives a mileage of 20 kms per liter of gasoline and another car with identical features given 15 kms per liter, then the former is more efficient than the latter. Another example is the brightness of a lamp at a given input voltage.

6. Portability: This is more important in the context of software. Portability is defined as a set of attributes that bear on the ability of software to be transferred from one environment to another. The environment may be organizational, hardware or software environment. Any program purchased, such as accounting software, should be usable in many different machines without any problem. This is portability. This feature is applicable even to consumer goods such as bulbs, razors, etc.

Service Quality

Unlike products, every service is made to order. Therefore, the service quality has additional features. In availing a service, the customer interacts more with the service provider. The quality of service depends to an large extent on understanding the correct requirements of the customer through such interactions. Each service has to be designed specifically for the customer. Hence, quality of service design is an important feature. Service delivery is another feature of service quality. Thus, the additional features of service quality are :

a) Quality of customer service
b) Quality of service design
c) Quality of service delivery

Each one of the above may have further dimensions. For instance, quality of service delivery includes timeliness of service and the number of defects on delivery.

1. ***Quality of Customer Service:*** Customer service is important in every business. In a service industry meeting customers and finding out their implied requirements is more challenging. Therefore, ability to satisfy customer depends on the quality of customer service. This includes but is not limited to:

a) How well the customer is received?
b) How well the implied requirements are elucidated?
c) How well the customer is treated/handled/satisfied?

2. ***Quality of Service Design:*** Since services are usually made to order, it is important that the service is designed as per the requirements of the specific customer. For instance, a software product developed for a specific bank takes into account the unique requirements of the bank.

Quality of service design in turn depends on the quality of customer service.
3. *Quality of Delivery:* Quality of delivery is important in any sector, but more crucial in case of services. Defects on delivery should be zero to satisfy the customers.

Additional attributes of quality, which are applicable to both products and services, are given below:

1. *Timeliness:* Delivery on schedule as per requirements of the customer is a must both in the product sector as well as in service sector. No customer likes waiting. Any anticipated delay in schedule should be communicated to customer well in advance. Timeliness is critical for many products and services. Delay in arrival of aircrafts or trains are instances of poor quality of the services encountered in day-to-day life.
2. *Aesthetics:* A product or service should not only perform well but also appear attractive. Therefore, aesthetics is an important element of quality. Aesthetics may include, but not limited to the appearance of the product, the finish, colour, etc. Customers will buy only those refrigerators or TV receivers or music systems, which look good.
3. *Regulatory Requirements:* Regulatory requirements as stipulated by the local and federal governments should be fulfilled by the product or service. For instance, an automobile has to meet Euro II Standards in respect of emission to minimize environmental pollution. Similarly, there are regulatory requirements in respect of safety of electro-medical products.
4. *Requirements of Society:* The products should fulfill both the stated and implied requirements imposed by society. The customer requirement should not violate society or regulatory requirements. Thus to satisfy a customer, a product cannot be built in such a way as to violate the requirements of society of a safe and healthy product. For instance, providing belts for persons sitting in the front seat in a car is a requirement of the society. Hence, the car manufacturers should provide belts for the passengers traveling in the front seat.
5. *Conformance to Standards:* Product or service should conform to the stated and implied requirements of customers. Where applicable, they should conform to applicable standards such as national standards, international standards and industry standards. For instance, Electro-Magnetic Interference (EMI) from a PC should be within the limits prescribed by the corresponding standard.

2. Explain the concept of Quality Planning in detail.

QUALITY PLANNING:-

Quality planning attempts to meet the quality needs of the customers. In order to meet these customer needs a **quality planning road map** can be prepared, as shown in Fig.

a) The road map consists of structured and sequential steps.

b) Output of each preceding activity or step becomes the input for the next step and so on.
c) This quality planning road map is applicable to all industries in both the manufacturing and service sectors. It is applicable at all levels in an organization, such as corporate, division, department, job and in all functional areas such as marketing, finance, production / operations and human resources.

The quality planning road map can be applied at the following levels:

i) Supervisory and worker level
ii) Functional level
iii) Multifunctional systems, and
iv) Major programmes.

Supervisory and Worker Levels

Each employee is assigned a job. Large number of jobs require quality planning as well as replanning as the job may be dynamic. In some cases the employees themselves are given training to plan their jobs.

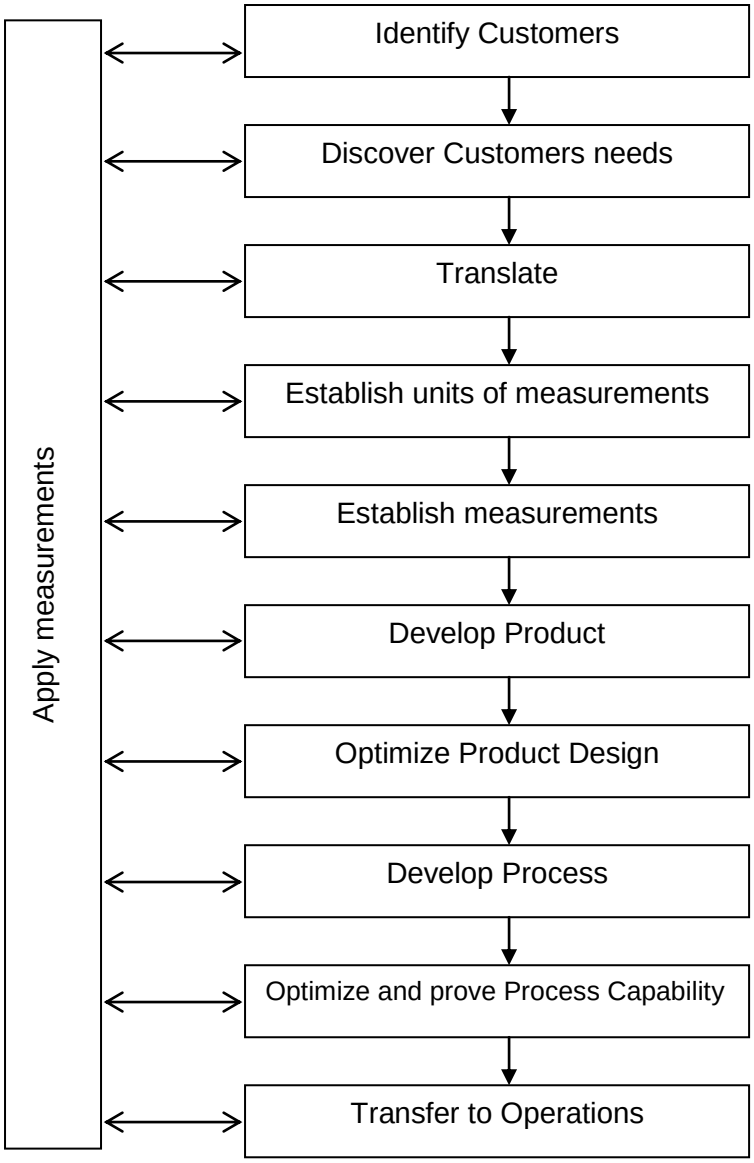
The concepts and tools which are used for quality planning at this stage are:

i) Self-control concept, and (b) Triple role concept

(a) Self-control concept:

The self-control concept emphasizes that the person should have full control as well as mastery over the attainment of planned results for the assigned job. In order to achieve self-control, a person should be provided with:

a) Knowledge of what he is supposed to do.
b) Knowledge of what others are doing, and
c) Means for regulating either of the above two, if the failure to meet the objective results.

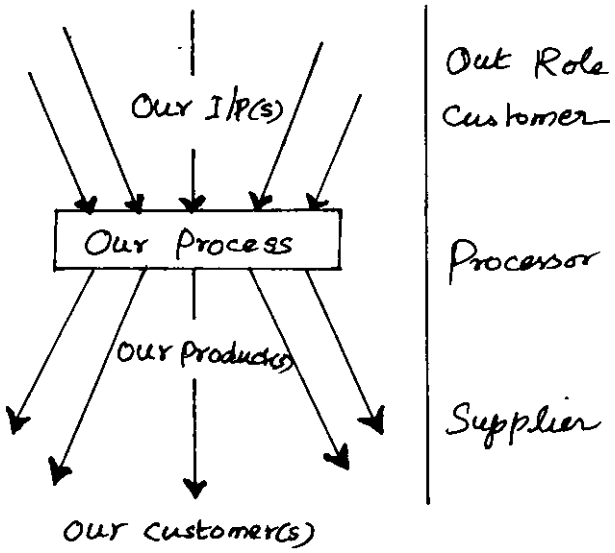


(b) The triple role concept:

The triple role concept stresses that each employee holding a job should be able to carry out the following three roles:

a) As a customer
b) As a processor
c) As a supplier

This concept is illustrated in Fig.



Using this concept natural progression of quality planning can be achieved.

Functional Level

a) Functional managers in charge of different areas undertake quality planning to manage their performance in a better way.
b) For example, planning for the marketing function places major emphasis on the defined role of quality planning in marketing department.
c) For untrained professionals, training may be given in the field of skills and tools of planning for quality.

Multifunctional Systems

- Systems such as Management Information Systems (MIS). Human Resource and New Product Development Systems have spread their functional areas as they receive inputs from all major functional areas. So inadequate quality planning may severely harm the working of the systems.
- Central quality planning is high useful in achieving coordination among all the functional areas involved.
- The central quality planning can be achieved through any one of the following teams / departments.
    - A team (or committee) of functional managers.
    - A team (or committee) of functional managers, with the assistance of quality

specialists.
- A project management department.
- A quality assurance department.

Major Programmes

Major programmes is otherwise termed as costly projects such as nuclear power plants, development of a new weapon system, launching a satellite into space, etc. These projects are complex and unique. So they require specific quality planning.

In these types of projects / programmes, it is common for clients to specify the quality plans and also the product / project performance specifications. For meeting these specifications, the organization requires central quality planning system.

3. Describe the concept and elements involved in Quality costs.

CONCEPT AND DEFINITION OF QUALITY COSTS

- **Concept:** Quality-related costs are costs incurred by an organization to ensure that the products / services it provides conform to customer requirements. In other words, quality costs are the sum of money spent on ensuring that customer requires are met and also the costs wasted through failing to achieve the desired level of quality. Thus quality cost is the cost of not meeting the customer's requirement. i.e., the cost of doing things wrong.
- The cost of quality is the difference between the actual cost of making and selling products / services and the cost of no failure.
- **Definition :** Quality costs are defined as those costs associated with the non-achievement of product / service quality as defined by the requirements established by the organization and its contracts with customer and society.
- In simple word, quality cost is the cost of poor products or services.

ELEMENTS OF QUALITY COSTS

The cost of quality (COQ) can be classified into the following four categories.

- Cost of prevention
- Cost of appraisal
- Cost of internal failures, and
- Cost of external failures.

Cost of Prevention

- ***Prevention costs*** are the costs that are incurred on preventing a quality problem from arising.
- Prevention costs relate to efforts to prevent failures.

- ***Cost of prevention includes:***
- ***Cost of quality planning :*** It includes the costs associated with creating an overall quality plan, the cost of market research and product development, inspection plan, reliability plan, etc.

- ***Cost of documenting:*** It includes cost of preparation of required documents such as manuals, procedures, policies, etc.

- ***Process control cost:*** It is the cost associated with implementing the quality plans and procedures to achieve the stated purpose.

- ***Cost of training:*** It includes the costs of conducting training programmes.

- ***Costs associated with preventing recurring defects:*** It is the engineering, technical and supervisory costs for preventing the reoccurring defects.

- Costs of investigation, analysis and correction of causes of defects by quality control and engineering departments.

- Cost of quality awareness programme.

Cost of Approval

a) Appraisal costs are the costs that are incurred in assessing that the products / services conform to the requirements.

b) Appraisal costs relate to testing, execution, and examination to assess whether specified quality is being maintained.

c) ***Cost of appraisal includes :***

   a. Cost of receiving test and inspection.
   b. Cost of laboratory acceptance testing.

c. Cost of installation testing.
d. Cost of installation and commissioning.
e. Cost of maintenance and calibration of testing and inspecting equipments.
f. Cost of test equipment depreciation.
g. Cost of analysis of reporting of tests and inspection results.
h. Cost of line quality engineering.
i. Cost of vendor rejects,

Cost of Internal Failures

- ***Internal failure costs*** arise due to internal failures.
- These costs are linked to correcting mistakes before delivery of the product, such as : scrap, rejects, adjustments, downtime of equipment, labour sitting idle while waiting for repairs, and sales discounts for inferior products.

- ***Cost of internal failure includes:***

1. Cost associated with scrap and rejects.
2. Cost of repair and rework.
3. Cost of design changes.
4. Cost of trouble-shooting or defect failure analysis.
5. Cost of reinspection and retesting.
6. Cost of sales discounts for inferior products.
7. Cost of downgrading.
8. Cost of downtime.

Cost of External Failures

1. ***External failure costs*** arise from the rejection of the products / services by the customers due to poor quality.
2. These costs are associated with the adjustments of malfunctions after delivery of the product, such as : repair costs, travel and lodging expenses, replacement costs, stock spare parts, lost goodwill of customer, guarantee and warranty costs, and dispatchment costs.

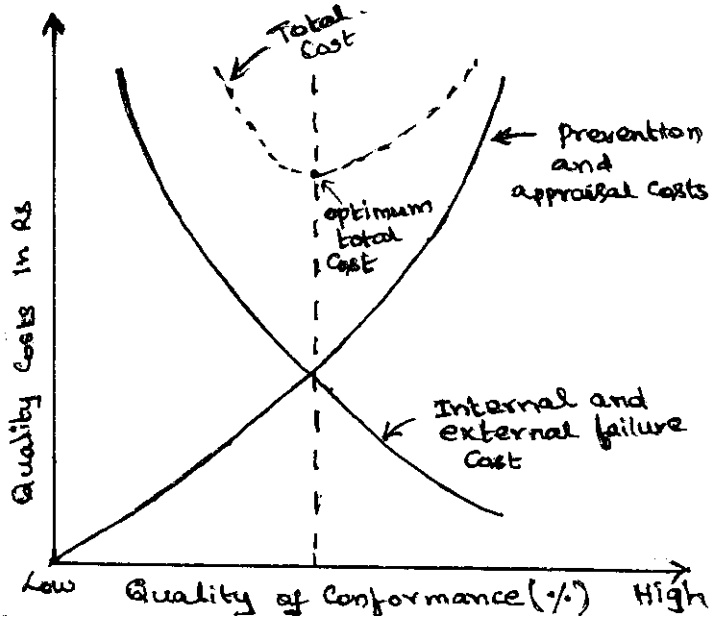
3. ***Cost of external failures include :***

1. Cost of processing complaints from customers.
2. Cost of commissioning failure.
3. Cost of servicing or replacing the defective items.
4. Cost of guarantee and warranty claims.

5. Cost of lost goodwill of customer.
6. Cost of product reliability compensation (voluntary or legal).
7. Cost of loss of sales.
8. Cost of concessions offered to customers (due to substandard products being accepted by customers).

OPTIMUM COST OF PERFORMANCE

The relationship between various cost categories is depicted in Figure. It is understood that the sum of the prevention and appraisal costs rises from zero to infinity as perfection is approached. Thus the optimum total cost point lie between two infinities, as shown in figure.



From the figure, it is clear that to achieve a reduction in failure costs, it is necessary to increase prevention and appraisal costs.

4. Discuss the various Analysis techniques involved for Quality Costs.

ANALYSIS OF COQ FOR IMPROVEMENT

Management should use the COQ data to identify and prioritize improvement opportunities. The first priority is to eliminate external failures and then internal failures. Thereafter inspection can be reduced gradually. By spending more money on prevention all these can be achieved. A typical case study is given in Table.

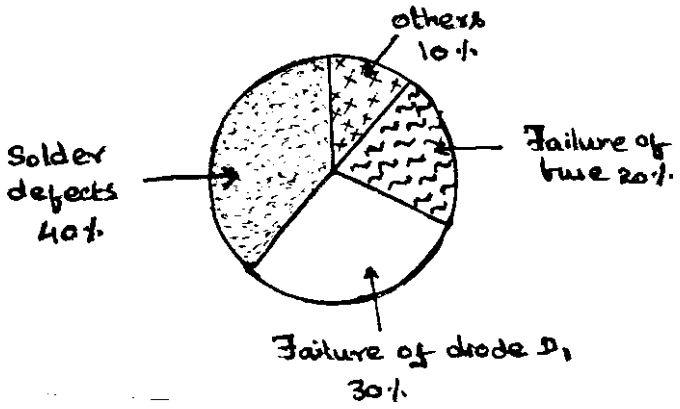
Cost of Quality as a Percentage of Total Manufacturing Cost

Year	External	Internal	Appraisal	Prevention	Total COQ
1995	3	1.5	1	0.5	6
1997	1.5	2.5	1.5	0.5	6
1999	0.5	1	1.5	1	4
2001	0.1	0.2	0.5	1.2	2

During 1997, increasing appraisal without increasing prevention increased internal failures but reduced external failures. However, the total COQ did not change. This is certainly an improvement because external failures affect business very badly. During 1997, the organization decided to get into ISO 9000 and focus on prevention. During 1999 when prevention was stepped up, keeping the same level of inspection, the failures and overall COQ came down. In 1999, the CEO decided to adopt TQM. Vigorous efforts were made to improve quality further and do things right, the first time and every time. Hence in the year 2001, appraisal could be brought down drastically. However, the result is much better as the table indicates. Now both the internal failures and external failures are quite low. Efforts should be made in the same direction so that overall COQ reduces further. Thus, TWM is aimed at enabling the lowest cost of quality.

ANALYSIS OF EXTERNAL, FAILURE COST

Similarly an analysis of external failures was made by the organization. The pie chart below indicates the distribution of causes of external failure.



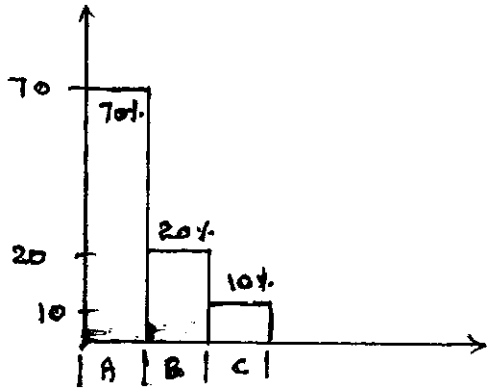
The above pie chart gives the priorities for action to be taken as given below:

1. Improve quality of soldering
2. Eliminate the cause of failure of diode D_1.
3. Estimate the correct rating of fuse and analyze the causes of failure of fuse.

If all the above failures can be eliminated then the failure cost will reduce to about 10 per cent.

ANALYSIS OF INTERNAL FAILURE COSTS

From the data available, the causes for the internal failure costs were analyzed and plotted as a Pareto Diagram.



1. Wrong component placed
2. Soldering failure
3. Other causes.

A major cause of internal failure was insertion of wrong components in the PCB. The process was studied and found that the lighting in assembly line needed improvement and the operators needed training. This analysis and the external failure analysis pointed to problems in the soldering process. A thorough study was required to reduce the defects caused by poor soldering.

Thus, it is very important to analyze the data more closely to derive benefits to the organization.

The COQ analysis gives the following benefits to the organization.

1. Brings out the magnitude of the quality problem in the organization. It further leads to establishing goals for the organization to improve quality.
2. Enables cost reduction owing to steps taken for improvement based on analysis.
3. Enables taking steps to improve customer satisfaction.
4. Displaying the results motivates employees to improve further.

5. Mention the characteristics, basic concepts and elements of TQM in detail.

CHARACTERISTICS OF TQM

The above definitions revealed the following characteristics of TQM :

1. TQM is a customer oriented.

2. TQM required a long term commitment for continuous improvement of all processes.
3. TQM is a teamwork.
4. TQM requires the leadership of top management and continuous involvement.
5. TQM is a strategy for continuous improving performance at all levels and in all areas of responsibility.

BASIC CONCEPTS OF TQM

A successful TQM programme requires the following six basic concepts.

1. Top Management Commitment: Top management should participate and completely involve in the total quality programme. They should ensure their complete commitment to the approach through management meetings, company magazines or newsletters. Also, top management should make sure that everybody within the organization from top to bottom is communicated about the TQM programme.

2. Focus on the customer : Achieving customer satisfaction is the heart of TQM. Customers include both internal and external customers. So focus on the customer is the key for any TQM programme.

3. Effective involvement and utilization of the entire work force: This concept is sometimes referred as 'principle of employees involvement' or 'respect for people'. TQM is a team work. Total quality recognizes that each person is responsible for the quality of his work and for the work of the group. All persons must be trained in TQM, Statistical Process Control (SPC), and other appropriate quality improvement skills so that they can effectively participate on quality teams.

4. Continuous improvement:: TQM is based on the quest for progress and improvement. TQM believes that there is always a better way of doing things, way to make better use of the company's total quality resources, a way to be more productive. For this purpose various quality tools and techniques may be used.

5. Treating suppliers as partners: Since the suppliers influence the company's quality, therefore a partnering relationship should be developed between the management and the suppliers.

6. ***Establishing performance measures for the processes:*** As we know, quantitative data are necessary to measure the continuous quality improvement activity. Therefore performance measures such as uptime, productivity, sales turnover, absenteeism, percent non- conforming, customer satisfaction, etc., should be determined for each functional area. These results can be used for further improvement activities.

ELEMENTS OF TQM

A framework summarizing the important elements of TQM discussed in this text.

Three elements of TQM include

1. The philosophical elements of TQM stress the operation of the company using quality as the integrating element.

2. The generic tools consist of various statistical process control (SPC) methods that are used for problem solving and continuous improvement by quality teams. Quality function deployment is typically used by managers to drive the voice of the customer into the organization.

3. Tools of the QC department consists of statistical quality control (SQC) methods such as sampling plans, process capability and Taguchi methods.

6. Describe the historical review of quality management in detail.

Historical review of quality management

Time	Events
Until the 1960s	
Prior to the 20th century	Quality is an art. Demands overcome potential production. An era of workmanship.
F. Taylor	The scientific approach to management resulting in rationalization of work
1900s	and its break down leads to greater need for standardization, inspection and supervision.
Shewart 1930s	Statistical beginnings and study of quality control. In parallel, studies by R.A. Fisher on experimental design; the beginning of control charts at Western Electric in U.S.A.
Late 1930s	Quality standards and approaches are introduced in France (Darmois) and Japan. Beginning of SQC, reliability and maintenance engineering.
1942	Seminal work by Deming at the Ministry of War in U.S.A. on quality control and sampling. Working group setup by Juran and Dodge on SQC in U.S. Army. Concepts of acceptance sampling devised.
1944	Dodge and Deming carried out seminal research on Acceptance Sampling.
1945	Founding of the Japan Standard Association.
1946	Founding of the ASQC (American Society for Quality Control)
1950	Visit of Deming in Japan at the invitation of K. Ishikawa.

1951	Quality Assurance increasingly accepted.
1954	TQC in Japan (Feigenbaun and Juran); book published 1956.
1957	Founding of European organization for the control of quality. (France – AFCIQ, Germany, Italy, Holland, England)
After the 1960s	
1961	The Martin (Marietta) Co. in U.S.A. introduces the zero-defects 'approach' while developing and producing Pershing Missiles (Crosby). Quality motivation is starting in the U.S. and integrated programmes begun.
1962	Quality Circles and started in Japan.
1964	Ishikawa publishes book on Quality Management.
1970	Ishikawa publishes the book on the basics of Quality Circles and the concept of Total Quality is affirmed and devised in Japanese Industries.
1970 to 1980	Just-In-Time and Quality become crucial for competitiveness. A large number of U.S. and European Corporations are beginning to appreciate the advance of Japan's industries. Taguchi popularizes the use of environmental design to design robust systems and products.
1980 +	Facing the rising sun challenge in quality management. Development and introduction of FMSs and greater dependence on supplier contracts. Growth of economic based on quality control, information software packages.
1990 +	The Management of Quality has become a necessity that is recognized at all levels of management. Increasing importance is given to off-line quality management for the Design of Robust Manufacturing processes and products. The growth of process optimization.

7. Discuss the Principles of TQM.

PRINCIPLES OF TQM

The important underlying principles of TQM are as follows:

1. Customers' requirements must be met the first time, every time.

2. There must be agreed requirements, for both internal and external customers.

3. Everybody must be involved, from all levels and across all functions.

4. Regular communication (both formally and informally) with staff at all levels is must. Two way communication at all levels must be promoted.

5. Identifying training needs and relating them with individual capabilities and requirements

is must.

6. Top management's participation and commitment is must.
7. A culture of continuous improvement must be established.
8. Emphasis should be placed on purchasing and supplier management.
9. Every job must add value.
10. Quality improvement must eliminate wastes and reduce total cost.
11. There must be a focus on the prevention of problems.
12. A culture of promoting creativity must be established.
13. Performance measures is a must at organization, department and individual levels. It helps to assess and meet objectives of quality.
14. There should be focus on team work.

8. Discuss the Barriers to TQM Implementation.

BARRIERS TO TQM IMPLEMENTATION

(IMPEDIMENTS OR OBSTACLES TO TQM IMPLEMENTATION)

The various roadblocks in implementing TQM are:

- ❖ Lack of management commitment.
- ❖ Lack of faith in and support to TQM activities among management personnel.
- ❖ Failure to appreciate TQM as a cultural revolution. In other words, inability to change organizational culture.
- ❖ Misunderstanding about the concept of TQM.
- ❖ Improper planning.
- ❖ Lack of employees commitment.

- ❖ Lack of effective communication.
- ❖ Lack of continuous training and education.
- ❖ Lack of interest or incompetence of leaders.
- ❖ Ineffective measurement techniques and lack of access to data and results.
- ❖ Non-application of proper tools and techniques.
- ❖ Inadequate use of empowerment and team work.
- ❖ Inadequate attention to internal and external customers.
- ❖ Delay or non-implementation of quality improvement team's recommendations.

9. Discuss the behaviour of Quality leaders and their role in an organization.

LEADERSHIP

INTRODUCTION

The success of quality management is to a greater extent is influenced by the quality of the leadership. Peter Drucker, the eminent management thinker and writer quotes: "Leadership is lifting of man's visions to higher sights, the raising of man's performance to a higher standard, the building of man's personality beyond its normal limitations".

Leadership is the process of influencing others towards the accomplishment of goals. Leader triggers the will to do, show the direction and guide the group members towards the accomplishment of the company's goal.

CHARACTERISTICS OR BEHAVIOURS OF QUALITY LEADERS

Successful quality leaders tend to demonstrate the 12 characteristics or behaviours. They are :

1. The customers first : Quality leaders give primary importance to both internal and external customers and their needs. Leaders should listen to customers; actively seek their opinion on the value of the products / services ; develop a close link with customers ; seek joint improvement activity; and lead the handling of complaints.

2. Value people : Quality leaders take care of the development of people's skill and capabilities. They enable people to be responsible for the result of their work. They monitor, appraise and

recognize people's performance.

3. Build supplier partnership: Quality leaders clarify quality to suppliers; audit their capabilities; give feedback; discuss improvements; and support them where needed. They recognize quality improvements made by suppliers and encourage joint improvement action.

4. Empower people : Quality leaders train and coach the people, rather than directing and supervising them.

5. Demonstrate involvement / commitment : Quality leaders continually demonstrate their commitment to quality.

6. Strive for excellence : Quality leaders emphasize continuous improvement rather than maintenance. They strictly believe the statement 'There is always room for improvement'.

7. Explain and deploy policy : Quality leaders explain the quality policy to all involved. They set stretching targets and deploy these to business processes, to the functions within the organization, and to suppliers.

8. Improve communication : Quality leaders continually improve communications. They establish channels of communication, which are reliable and accessible to everyone in the organization.

9. Promote teamwork: Quality leaders promote multidisciplinary teamwork ; create involvement; and active participation of everyone.

10. Benchmark continuously : Quality leaders learn from problems. They continuously do benchmarking and create new learning effects through innovation.

11. Establish system : Quality leaders establish organizational systems to support the quality effort.

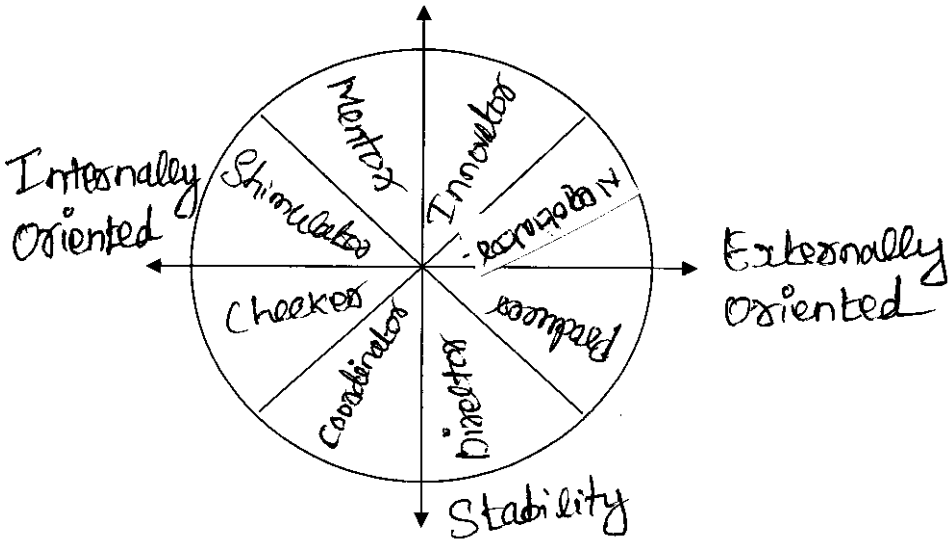
12. Encourage collaboration : Quality leaders encourage collaboration rather than competition. They emphasize the importance of collaboration among and within functional areas, departments or work centres.

LEADERSHIP ROLES

Effective teamwork requires effective leaders. Effective leaders are people who can perform different roles. Quinn lists the following eight leadership roles:

1. Producer role ; 2. Director role ;

3. Coordinator role ; 4. Checker role ;
5. Stimulator role ; 6. Mentor role ;
7. Innovator role; and 8. Negotiator role



10. Briefly discuss the role of senior management in an organization.

ROLE OF SENIOR MANAGEMENT

1. In practice, the TQM effort has been led by members of senior management. They provide the vision of where the company is heading with its quality effort. They lead in creating a cultural change within the company.

2. ***The responsibilities of senior management are:***

- ❖ To study and investigate the TQM concepts and issues.
- ❖ To set clear quality policies and provide challenging tasks.
- ❖ To establish 'priority of quality' and 'customer satisfaction' as the basic policy and determine the long term goals.
- ❖ To bring a cultural charge required for the TQM effort.
- ❖ To establish the TQM vision for the future and communicate to all involved.
- ❖ To become coaches and cheer leaders for encouraging and supporting the managers

during the transition phase of the transformation change,

- ❖ To stimulate employee to be involved.
- ❖ To teach employees to realize that the company's interest and their interest are geared into one another.
- ❖ To uphold norms and values, and let it be known.
- ❖ To attend TQM training programmes.
- ❖ To create coordination and harmony among and within departments.
- ❖ To monitor whether quality improvement programs are conducted as planned.
- ❖ To create a basic of trust, respect and open communication, which ensures individual participation and continuous improvement.

11. Define Quality Council. Explain its duties, responsibilities, involved in detail.

QUALITY COUNCIL

What is it?

1. ***A quality council*** is a team to provide overall direction for achieving the total quality culture (TQC).
2. ***The quality council is composed of :***

    a. The chief executive officer (CEO);
    b. The senior managers of the functional areas, such as design, marketing, finance, production, and quality; and
    c. A coordinator or consultant.

Duties of the Quality Council

The duties of the quality council are :

1. To establish the core values and quality statements. Quality statements include vision statement, mission statement, and quality policy statement.
2. To establish the strategic long-term plan with goals and the annual quality improvement program with objectives.

3. To plan the training and education programmes.
4. To determine and monitor the cost of poor quality.
5. To perform and monitor the performance measures for each functional areas of the organization.
6. To establish multifunctional project and departmental teams and monitor their progress.
7. To establish / revise the recognition and reward system periodically.

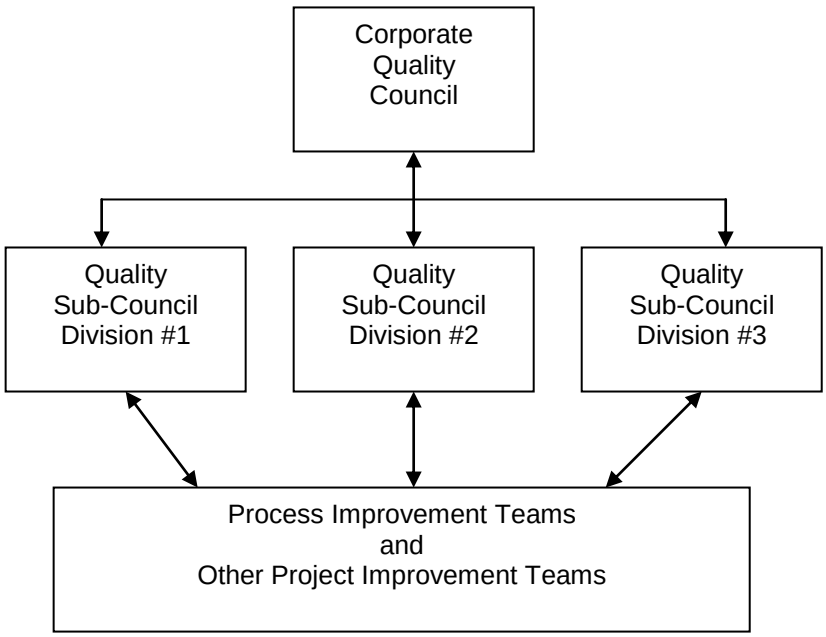
Responsibilities of the Quality Council Coordinator are

1. To develop two-way trust ;
2. To propose team requirements to the council;
3. To share council expectations with the team;
4. To empower the team; and
5. To brief the council on team progress.

Thus quality councils are the instruments for creating the idea of never-ending quality improvement. In other words, it is the driver for the TQM engine.

Quality Structure

Figure shows a typical quality structure involving different levels of cross-functional participation by managers.



12. Discuss the various elements involved in quality statements.

QUALITY STATEMENTS

Three elements of quality statements are :

a. Vision statement,
b. Mission statement, and
c. Quality policy statement

What is Vision Statement?

1. ***The vision statement*** is a short declaration of what on organization aspires to be tomorrow.
2. It is the ideal state that might never be reached; but on which one will work hard continuously to achieve. Successful visions provide a brief guideline for decision making.
3. The vision statement should be coined in such a way that the leaders and the employees working in the organization should work towards the achievements of the vision statement.
4. ***An example of a simple vision statement is :***
   "To continuously enrich knowledge base of practitioners in mobility industry and institutions in the service of humanity". – Society of Automotive Engineers (SAE)

What is Mission Statement?

1. The mission statement, describes the function of the organization. It provides a clear statement of purpose for employees, customers, and suppliers.
2. ***The mission statement*** answers the following questions : who we are?; who are our customers? ; what we do?; and how we do it?
3. ***An example of a simple mission statement is :***
   "Concern for the ultimate customers – millions of customers
   Concern for the intermediate customers – the trade
   Concern for the suppliers – the sources of raw materials and ancillaries
   Concern for the employees – the most valued asset
   Concern for the competitors – wishing them well as healthy competition ultimately benefits the customers.
   Concern for the shareholders – the investing public
   Concern for the national aspiration – India's future!"
   - ITC Limited

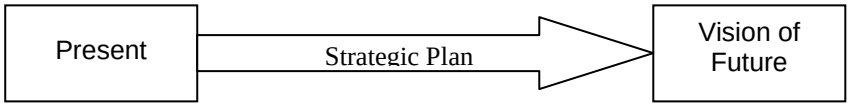
What is Quality Policy Statement?

- ***The quality policy*** is a guide for everyone in the organization as to how they provide products and service to the customers.
- It should be written by the CEO with feedback from the workforce and be approved by the quality council.

- A quality policy is a important requirement of ISO 9000 quality systems.
- ***An example of a simple quality policy statement is***:
  "Xerox is a quality company. Quality is the basic business principle for Xerox. Quality means providing our external and internal customers with innovative products and services that fully satisfy their requirements. Quality is the job of every employee".

  - Xerox Corporation

13. Define strategic planning? Discuss the steps involved in it.



- ***Strategic planning*** sets the long-term direction of the organization in which it wants to proceed in future. This is depicted in Figure.
- ***Definition :*** Strategic planning can be defined as the process of deciding on objectives of the organization, on changes on these objective, on the resource used to attain these objectives and on the policies that are to govern the acquisition, use and disposition of these resources".
- ***Examples of strategic planning*** in an organization may be : planned growth rate in sales, diversification of business into new lines, type of products to be offered, and so on.

STRATEGIC PLANNING PROCESS
(SEVEN STEPS TO STRATEGIC PLANNING)

In order to integrate quality with the strategic planning process, a systematic and sequential procedure has to be adopted. There are seven basic steps to strategic process planning. They are

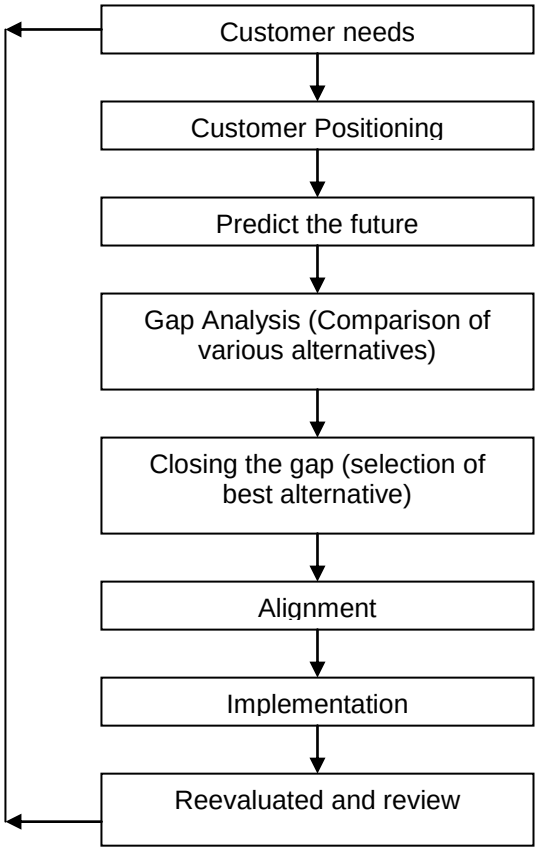
Step 1. Customer Needs

The basic step is the identification of customers and their wants and needs. An organization must seek its customers' requirements, expectations and assess future trends before developing a

strategic plan.

Step 2. Customer Position

The second step requires the planners to determine its positioning with regards to its customers. Various alternatives such as whether the organization should give up, maintain or expand market position should be considered. In order to become successful, the organization should concentrate and consolidate its position in its areas of excellence.



Step 3. Predict the Future

Next, the planners must predict future conditions that will affect their product or service: To help predicting the future, the tools such as demographics, economic forecasts, and technical assessments or projections may be used.

Step 4. Gap Analysis

In this step, the planners must identify the gaps between the current state and the future state of the organization. This concept is also known as ***value stream mapping.*** For identifying the gaps, an analysis of the core values and concepts and other techniques may be used.

Step 5. Closing the Gaps

Now the planners should develop a specific plan to close the gaps. This process is also termed as ***Process improvement***. By assessing the relative importance and relative difficulty of each gap, planners can close the gaps.

Step 6. Alignment

Now the revised plan should be aligned with the mission, vision, and core values and concepts of the organization. Organization should embrace quality as an essential ingredient in their vision, mission, and objectives.

Step 7. Implementation

In order to implement the action plan, resources must be allocated to collecting data, designing changes, and overcoming resistance to change. Also the planners should monitor and assess the result of the strategic plan.

Since quality is a continuous improvement process, one has to reassess and renew the strategic plans periodically. So it is a cyclic process. Figure summarizes the strategic planning cycle.

14. Discuss the 14 points involved in Deming Philosophy.

Deming defines quality in terms of quality of design, quality of conformance and quality of the sales and service functions. Table summarizes his 14 principles on route to quality.

Deming's 14 points on route to quality

1. *Create constancy of purpose toward improvement of product and service,* **with the aim to become competitive and to stay in business, and to provide jobs.**
2. *Adopt the new philosophy.* **We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.**
3. *Cease dependence on inspection to achieve quality.* **Eliminate the need for inspection on a mass basis by building quality into the product in the first place.**
4. *End the practice of awarding business on the basis of price tag.* **Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.**
5. *Improve constantly and forever the system of production and service,* **to improve quality and productivity, and thus constantly decrease costs.**
6. *Institute training* **on the job.**

7. *Institute leadership.* **The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.**
8. *Drive out fear,* **so that everyone may work effectively for the company.**
9. *Break down barriers between departments.* **People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.**
10. *Eliminate slogans, exhortations, and targets for the work force* **which ask for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, since the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the workforce.**
11. *Eliminate work standards (quotas) on the factory floor.* **Substitute leadership.** *Eliminate management by objectives.* **Eliminate management by numbers, numerical goals, substitute leadership.**
12. *Remove barriers to pride of workmanship.* **The responsibility of supervisors must be changed from sheer numbers to quality. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, for example, abolishment of annual or merit rating and of management by objectives.**
13. *Institute a vigorous program of education and self-improvement.*
14. **Put everybody in the company to work to** *accomplish the transformation.* **The transformation is everyone's job.**

15. Write short notes on

(i) Different views of Quality

(ii) Dimensions of quality with examples.

Different Views of Quality

1. ***From the user's point of view,*** quality is an expression of the products / services usefulness in meeting the needs and expectations and its reliability, safety, durability and so on.
2. ***From the production point of view,*** the quality of a product is measured by the quality of its performance which depends on the quality of design and the quality of conformance.

DIMENSIONS OF QUALITY

Quality has nine different dimensions. Table shows these nine dimensions of quality with their meanings and explanations in terms of a cell phone.

Dimensions of quality

S.No.	Dimension	Meaning and Example
1.	Performance	Primary operating characteristics of a product, such as signal coverage, audio quality, display quality, etc.
2.	Features	Secondary characteristics, added features, such as calculators, and alarm clock

features.

3.	Conformance	Meeting specifications or industry standards, workmanship (or) the degree to which a product's design or operating characteristics match pre-established standards.
4.	Reliability	The probability of a product's failing within a specified period of time.
5.	Durability	It is a measure of product's life having both economic and technical dimensions.
6.	Service	Resolution of problem and complaints, ease of repair.
7.	Response	Human to human interface, such as the courtesy of the dealer.
8.	Aesthetics	Sensory characteristics, such as exterior finish.
9.	Reputation	Past performance and other intangibles, such as being ranked first.

16. Write short notes on

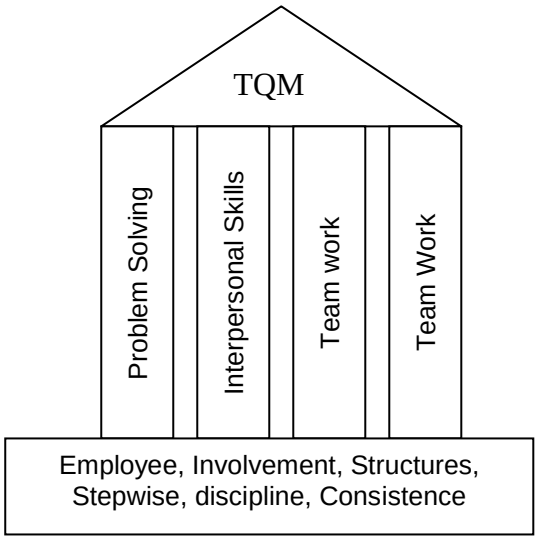
(i) Pillars of TQM

(ii) Potential Benefits of TQM

(iii) Evolution of TQM (Structure)

PILLARS OF TQM

Figure depicts the four pillars of the TQM-house.



The four pillars of TQM are :

1. Problem solving discipline,
2. Interpersonal skills,
3. Teamwork, and
4. Quality improvement process.

TQM is used to improve the whole organization stepwise, structured and systematically according to hard work, discipline, intensive training, and consistent implementation of techniques and resources. These quality principles form the ***foundation*** of TQM, as shown in Figure.

POTENTIAL BENEFITS OF TQM

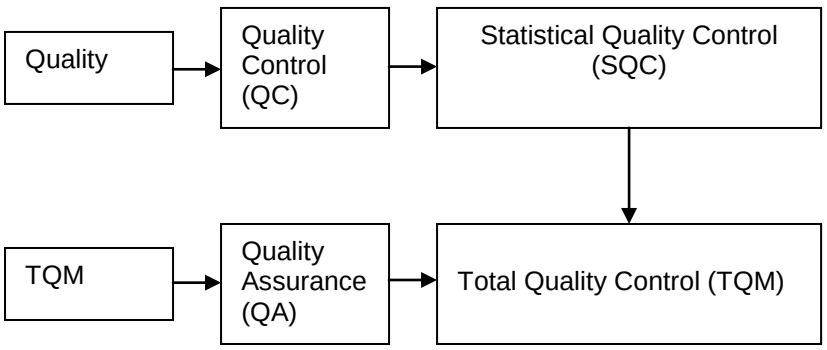
Table presents the tangible and intangible benefits of TQM.

Table – Benefits of TQM

Tangible Benefits	Intangible Benefits
1. Improved product quality	2. Improved employee participation
3. Improved productivity	4. Improved teamwork
5. Reduced quality costs	6. Improved working relationships
7. Increased market and customers	8. Improved customer satisfaction
9. Increased profitability	10. Improved communication
11. Reduced employee grievances	12. Enhancement of job interest.
	13. Enhanced problem-solving capacity.
	14. Better company image

EVOLUTION OF TQM

The TQM philosophy has evolved from quality in the sequence, as shown in figure.



UNIT – II

TQM PRINCIPLES

PART – A

1. Who are internal and external customers?

The customers inside the company are called internal customers, whereas the customers outside the company are called external customers.

2. What are the customer's perception on quality?

The six important customer's perceptions are :

1. Performance, 2. Features,
3. Service, 4. Warranty,
5. Price, and 6. Reputation.

3. List the various tools used for collecting customer complaints.

The various tools used are :

1. Comment Card; 2. Customer questionnaire;
3. Focus groups; 4. Toll-free telephone numbers;
5. Report cards; 6. The internet and computer, etc.

4. What is meant by customer retention?

Customer retention is the process of retaining the existing customers.

5. What is motivation?

Motivation means a process of stimulating people to accomplish desired goals.

6. What are the Maslow's basic needs?

Maslow's basic needs are: 1. Physiological, 2. Safety 3. Social, 4. Esteem and 5. Self-

actualization needs.

7. What are physiological needs?

Physiological needs are the biological needs required to preserve human life. These needs include needs for food, clothing and shelter.

8. List the Herzberg's motivators and dissatisfiers.

Motivator factors	Dissatisfier or hygiene factors
• **Achievement**	• Supervisors
• **Recognition**	• Working conditions
• **The work itself**	• Interpersonal relationships
• **Responsibility**	• Pay and security
• **Advancement and growth**	• Company policy and administration

9. Define empowerment.

Empowerment is an environment in which people have the ability, the confidence, and the commitment to take the responsibility and ownership to improve the process and initiate the necessary steps to satisfy customer requirements within well-defined boundaries in order to achieve organizational values and goals.

10. What are the conditions necessary for empowerment?

The conditions required are :

1. Everyone must understand the need for change.
2. The system needs to change to the new paradigm.
3. The organization must provide information, education, and still to its employees.

11. Define team and team work.

a. A team can be defined as a group of people working together to achieve common objectives or goals.
b. Teamwork is the cumulative actions of the team during which each member of the team subordinates his individual interests and opinions to fulfill the objectives or goals of the group.

12. List the different types of teams.

a. Process improvement team
b. Cross-functional team
c. Natural work team, and
d. Self-directed work team

13. Name different members in a team.

1. Team leader
2. Facilitator
3. Recorder
4. Timekeeper, and
5. Members

14. What are the stages of team development?

The six stages of team development are :

1. Forming stage,
2. Storming stage
3. Norming state,
4. Performing stage
5. Maintenance stage, and
6. Evaluating stage.

15. What is meant by recognition in an organization?

Recognition is a process whereby management shows acknowledgement of an employee's outstanding performance.

16. Classify rewards.

1. ***Intrinsic rewards :*** These are related to feelings of accomplishment or self-worth.
2. ***Extrinsic rewards:*** These are related to pay or compensation issues.

17. What is performance appraisal?

Performance appraisal is a systematic and objective assessment or evaluation of performance and contribution of an individual.

18. List four common barriers to team progress.

1. Insufficient training
2. Incompatible rewards and compensation
3. Lack of planning, and
4. Lack of management support.

19. List various techniques to sustain continuous improvement.

1. Juran trilogy
2. PDSA cycle
3. 5S concept, and
4. Kaizen

20. What are the three elements of Juran trilogy?

1. Quality planning,
2. Quality control, and
3. Quality improvement

21. What is PDSA cycle?

The PDSA stands for Plan, Do, Study, and Act. It is a model for testing ideas that you think may create improvement.

22. What is '5W2H' method?

The 5w2H stands for what, why, where, when, who, how, and how much. It is also a continuous improvement tool.

23. What is 5S practice?

The 5S practice is a housekeeping technique used to establish and maintain productive and quality environment in an organization. 5S stands for SEIRI, SEITON, SEISO, SEIKETSU, and SHITSUKE.

24. Differentiate SEIRI and SEITON.

1. **SEIRI** denotes action to identify and sort out all items into necessary and unnecessary items and discard all necessary items.
2. **SEITON** means to arrange everything in proper order so that it can be easily picked up for use.

25. What does SEIKETSU mean?

SEIKETSU means maintaining a high standards of workplace organization and house keeping at all times.

26. What is Kaizen?

Kaizen is a Japanese word which means continuous improvement or improvement over improvement. It is the process of continuous improvements in small increments that make the process more efficient, effective, controllable, and adequate.

27. Define Recognition.

It is a process whereby management shows acknowledgement of an employee's outstanding performance.

28. Different Kaizen and Kairyo.

Kaizen	Kairyo (Innovation)
1. It is achieved through conventional know-how and PDCA.	2. It is obtained by technological or organizational breakthrough.
3. It is employee oriented	4. It is technology oriented.
5. It requires little investment but great effort to maintain.	6. It requires large investment but little effort to maintain.
7. It involves everybody in the company.	8. It involves a selected few experts and researchers.
9. It requires recognition of effort before results.	10. It is motivated by expected results.

29. What does the term 'Muda' refer?

Muda refers to the seven classes of wastes. They are over-production, delay, transportation, processing, inventory, wasted motion, and defective parts.

30. Define partnering.

Partnering is defined as a continuing relationship, between a buying firm and supplying firm, involving a commitment over as extended time period, an exchange of information and acknowledgement of the risks and rewards of the relationship.

31. List the various elements to achieve partnering.

1. Long-term commitment
2. Trust, and

3. Shared visions.

32. What are the types of sourcing?

1. Sole sourcing 2. Multiple sourcing, and 3. Single sourcing.

33. Differentiate between sole sourcing and single sourcing.

Sole sourcing is the use of only one supplier for the organization, whereas single sourcing is the use of one supplier for an item when several sources are available.

34. What are the various stages in supplier selection and evaluation?

The four stages in supplier selection and evaluation are :

1. Survey stage,
2. Enquiry stage,
3. Negotiation and selection stage, and
4. Experience stage.

35. What is supplier rating?

A supplier rating system, also referred as a scorecard system, is used to obtain an overall rating of supplier performance.

36. Why does customer rate supplier?

The customer rates supplier in order to :

1. obtain an overall rating of supplier performance;
2. ensure complete communication with supplier;
3. provide each supplier about the details of problems for corrective action; and
4. maintain and improve the partnering relationship.

37. What does the term relationship development refer?

The relationship development refers to maintaining and improving the growth of the customer-supplier relationship.

38. What are the techniques commonly used for performance measures presentation?

1. Time series trend graph 2. Control charts

3. Capability index 4. Taguchi's loss function
5. Cost of poor quality, & 6. Quality awards

39. What is Malcom Balridge National Quality Award (MBNQA)?

The MBNQA is an annual award given to recognize U.S. organizations for performance excellence. This award is used to measure TQM efforts on an annual basis.

40. Why is Customer Feedback / Customer Complaint Necessary?

Customer feedback or customer complaint is required:

- to discover customer dissatisfaction,
- to identify customer's needs

41. Mention the types of rewards.

TYPES OF REWARDS

Broadly, one can classify the rewarding systems into two groups. They are :

a. ***Intrinsic rewards :*** These are related to feelings of accomplishment or self-worth.
b. ***Extrinsic rewards:*** These are related to pay or compensation issues.

42. State the objectives of performance measures.

OBJECTIVES OF PERFORMANCE MEASURES

Performance measures indicates the measurement of success in an organization. Ray F. Boedecker has identified and listed seven objectives of performance measures.

The seven objectives are :

a. To establish baseline measures and reveal trends.
b. To determine which processes need to be improved.
c. To indicate process gains and losses.
d. To compare goals with actual performance.
e. To provide information for individual and team evaluation.
f. To provide information to make informed decisions.
g. To determine the overall performance of the organization.

43. Compare Intrinsic Rewards & Extrinsic rewards.

Table – Intrinsic Vs Extrinsic rewards

Intrinsic Rewards	Extrinsic Rewards
a. Non-monetary forms of recognition to acknowledge achievement of quality improvement goals.	a. Profit sharing
b. Celebrations to acknowledge achievement of quality improvement goals.	b. Gain sharing
c. Regular expressions of appreciation by mangers and leaders to employees to acknowledge achievement of quality improvement goals.	c. Employment security
d. 360° performance appraisals – feedback from co-workers (other than the immediate supervisor), subordinates or customers is incorporated into performance appraisals.	d. Compensation time e. Individual based performance systems f. Quality based performance appraisals.

44. Mention the objectives of 5S.

Objective of '5S'

The objectives of '5S' are :

1. To create a neat and clean work place.
2. To systemize day to day working.
3. To improve work efficiency.
4. To standardize work practices.
5. To improve work discipline.
6. To improve the quality of work and products.

45. Why should one recognize the employees?

The employees effort towards the improvement should be recognized for many reasons. Recognition is essential to :

1. Improve employees morale.
2. How the company's appreciation for better performance.
3. Create satisfied workplace.
4. Create highly motivated workplace.

5. Reinforce behavioural patterns
6. Stimulate creative efforts.

PART – B

1. What is customer satisfaction? Who are the customers and mention its types?

As emphasized so far, in today's buyers market 'the customer is the king'. Even the definition of quality, 'quality is what customer wants', emphasizes on the customer requirements. In other words, quality is a measure of customer satisfaction. It is obvious that business cannot survive without satisfied customers. Therefore TQM's purpose is meeting or exceeding customer expectations, so that the customers are delighted.

It is understood that the customer satisfaction must be the primary goal of any organization. Therefore it is essential that every employee in the organization understands the importance of the customer.

Customer Satisfaction Model

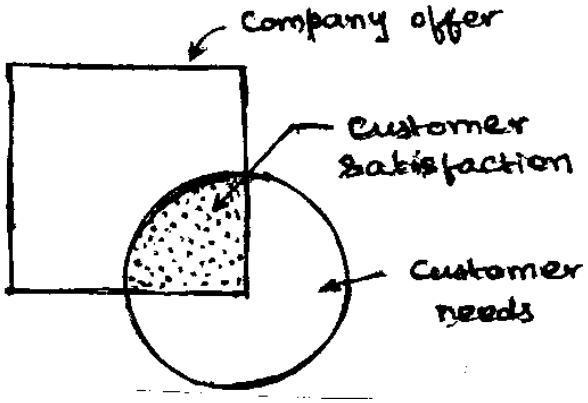


Figure shows the Teboul's model of customer satisfaction. In figure, the customers' needs are represented by the circle, and the square represents the product or service offered by the company. The intersection portion, shown with dots, is perceived as the customer satisfaction. So it is understood that the company should strive for increasing the intersection portion i.e. customer satisfaction.

WHO ARE THE CUSTOMERS?

The customers are :

1. The most important people in the business.

2. Not dependent on the organization. The organization depends on them.
3. Not an interruption to work but are the purpose of it.
4. Doing a favour when they seek business and not vice-versa.
5. A part of business, not outsiders.
6. Life blood of the business.
7. People who come with their needs and jobs.
8. Deserve the most courteous and attentive treatment.

Types of Customers

Customers are two types. They are :

1. Internal customers, and 2. External customers.

1. ***Internal Customers***

1. The customers inside the company are called internal customers.
2. As there is a flow of work, product and service in the organization, each department is dependent on the other. In this, each department or each quality management unit is considered as a customer by the previous department and as a supplier for the next department. Similarly every person in a process is considered as a customer of the preceding operation. This explains the concept of internal customer.

2. External Customers

- The customers outside the company are called external customers.
- In other words, an external customer is the one:
- who uses the product or service ;
- who purchases the product or service; or
- who influences the sale of the product or service.

Customer – Supplier Chain

In order to achieve the total customer orientation, TQM requires the better customer – supplier relationship. Figure shows the model of customer – supplier chain.

All processes require inputs, which are provided by the internal or external suppliers. Similarly all processes delivers outputs, which are used by internal or external customers. Each unit is considered as a customer by the previous unit and as a supplier for the next unit.

2. In detail explain the customer perception of quality.

CUSTOMER PERCEPTION OF QUALITY

Quality is what customer perceives it to be. However, as the customers go on changing their needs, the quality level needs are to be improved continuously to meet the customers demand. That's why the basic concept of TQM philosophy is continuous process improvement.

An American Society for Quality (ASQ) survey ranked the customer perceptions in the following order :

1. Performance
2. Features
3. Service
4. Warranty
5. Price, and
6. Reputation.

1. Performance

1. Performance involves "fitness for use". It indicates that the product and service is ready for the customers' use at the time of sale.
2. ***Other considerations include:***
    a. ***Availability :*** It is the probability that a product will operate when needed,
    b. ***Reliability :*** It is freedom from failure over time, and
    c. ***Maintainability:*** It is the ease of keeping the product operable.

2. Features

(a) Features are secondary characteristics of the product or service.
(b) For example, the primary function of a cell phone is for communication, whereas other facilities such as calculator and alarm are features of the cell phone.

3. Service

(a) Customer service is an intangible in nature. Intangible characteristics are those traits that are not quantifiable, but it contributes greatly to customer satisfaction.
(b) Organizations objective is to provide good quality of the product to the customer at the right time, even though the customers are not complaining about their service.

4.Warranty

(a) The product warranty represents an organization's public promise of a quality product.

In other words, it represents a public commitment to guarantee a level of service sufficient to satisfy the customer.

(b) A warranty forces the organization to focus on the customer's definition of product and service quality. It also forces the organization to develop a corrective action system.

(c) In present scenario, the warranty attracts and builds the market. It encourages customers to buy a service by reducing the risk of the purchase decision. Hence it generates more sales from existing customers by enhancing loyalty.

5. Price

1. Nowadays customer is willing to pay a higher price to obtain value. Also customers expect high quality products at the lower price.
2. Customers are preferring the organizations who are providing the greatest value for their money. For this purpose, customers are constantly evaluating all the organizations.
3. In our highly competitive environment, each customer's concept of value is continually changing. In order to overcome this challenge, the organizations should identify, verify and update each customer's perception of value in relation to each product and service regularly.

6. Reputation

1. It is obvious that customers are willing to buy products or service from a known, trusted and reputed organization. The total customer satisfaction is based on, not only with the product, the entire experience with the organization.

2. Thus reputation of a firm brings the market to them. So organization should strive for customers for life.

3. Describe the customers feedback (or) Describe the customer complain in detail.

Feedback

Customer feedback must be continually solicited and monitored. Customers continually change. They change their minds, their expectations, and their suppliers. Customer feedback is not a one-time effort; it is an ongoing and active probing of the customers' mind. Feedback enables the organization to:

Discover customer dissatisfaction.
Discover relative priorities of quality
Compare performance with the competition.
Identify customers' needs.

Determine opportunities for improvement.

Even in service industries, such as insurance and banking, customer feedback has become so important that it drives new product development. There are programs to identify and analyze errors, take corrective action, and make ongoing enhancements. All these efforts are justified when the consumers' expectation levels are very high. Effective organizations take the time to listen to the voice of the customer and feed that information back to the idea stage. For instance, listening to the voice of the customer changed how the Internal Revenue Service does business. Previously, IRS thought that good customer service was mailing tax forms out right after New Year's Day. Then, the IRS asked its customers what good customer service was. The IRS found out that the customers wanted fast refunds and very little contact with the IRS. Now, about 20 million taxpayers can forget using the 1040EZ form and file on their touch-tone phone. There is no contact with the IRS, it takes about six minutes, and the phone system does the math. Refunds are received within 21 days.

Listening to the voice of the customer can be accomplished by numerous information-collecting tools. The principal ones are comment cards, questionnaires, focus groups, toll-free telephone lines, customer visits, report cards, the Internet, employee feedback, mass customization and the American Customer Satisfaction Index.

Comment Card

A low-cost method of obtaining feedback from customers involves a comment card, which can be attached to the warranty card and included with the product at the time of purchase. The intent of the card is to get simple information, such as name, address, age, occupation, and what influenced the customer's decision to buy the product. However, there is very little incentive for buyers to respond to this type of card, and the quality of the response may not provide a true measure of customers' feelings. Generally, people respond only if something very good or very bad has happened. Comment cards are also used in the hospitality industry. Restaurants and hotels provide them at the ends of tables and in hotel rooms. They can even be found on the bottom of restaurant sales receipts. Often, free meals or hotel stays are provided to rectify a poor experience noted on a comment card. Free means and hotel stays can generate significant customer loyalty provided the organization also fixes the problem.

Customer Questionnaire

A customer questionnaire is a popular tool for obtaining opinions and perceptions about an organization and its products and services. However, they can be costly and time-consuming. Surveys may be administered by mail or telephone. In the form of questionnaires, the customer is asked to furnish answers relating to the quality of products and services. Most surveys ask the customer to grade the question on a one-to-five scale or a one-to-ten scale, where the highest number typically has a description like "highly satisfied". One of the reasons the one-to-five or

one-to-ten scale is used is because it easily produces a metric. For example, the Spouse Satisfaction Survey.

Although the "1 to 5" scale is a typical approach to surveys, it probably is not entirely effective. It does not tell the surveyor how important trash removal is relative to other Customer focus groups are a popular way to obtain feedback, but they too can be very expensive. These groups are very effective for gathering information on customer expectations and requirements.

	Highly Satisfied		**Neutral**		**Highly Dissatisfied**
1. Trash removal	5	4	3	2	1
2. Personal hygiene	5	4	3	2	1
3. Lawn maintenance	5	4	3	2	1
4. Romance	5	4	3	2	1
5. Thoughtfulness	5	4	3	2	1
6. Listening skills	5	4	3	2	1
7. Faithfulness	5	4	3	2	1

Surveying a focus groups is a research method used to find out what customers are really thinking. A group of customers is assembled in a meeting room to answer a series of questions. These carefully structured questions are asked by a skilled moderator, who probes into the participants' thoughts, ideas, perceptions, or comments. The moderator has a clear understanding of the type of information wanted and a plan for obtaining it. Meetings are designed to focus on current, proposed, and future products and services. The people selected to participate have the same profile as the customers that the organization is trying to attract. As an incentive to participate, these people are reimbursed for their time. Focus groups are sometimes used with an organization's employees to examine internal issues.

Toll-Free Telephone Numbers

Toll-free (800/888) telephone numbers are an effective technique for receiving complaint feedback. Organizations can respond faster and more cheaply to the complaint. Such a number does not, however, reach those who decided not to buy the product or those who discovered some liable feature on a competitor's product. Toll-free numbers are in use by at least 50% of all organizations with sales of at least $10 million.

Implementation of toll-free telephone numbers has grown tremendously – in six years, the Cadillac division of General Motors added 24 toll-free numbers. In response to what customers said, Cadillac eliminated deductibles on warranties and pioneered 24-hour roadside service.

Customer Visits

Visits to a customer's place of business provide another way to gather information. An organization can proactively monitor its product's performance while it is in use and thereby identify any specific or recurring problems. Senior managers should be involved in these visits and not delegate them to someone else. However, it is a good idea to take along operating personnel so they can see firsthand how the product is performing. One site visit L-S Electro Galvanizing Company made to its customer, General Motors, produced a surprisingly simple idea. An arrow was needed on the finished 25-ton rolls of steel to show which way the steel unrolled. Previously, GM employees had to guess and often times had to resummon a crane to turn the roll around, which wasted 30 minutes. [14] Another example of a productive customer visit is when U.S. Steel sent an hourly worker, who applied anti-corrosion coating, to the Ford auto plant that used their steel. The worker found flaking zinc and knew there was too much zinc buildup on the edges of the steel. The rods that trimmed the steel were not properly aligned. U.S. Steel also discovered that Ford was wasting steel and money by scraping the bottom sheet of each pile of steel. Ford mistook the harmless white residue on the bottom sheets for rust, when in fact the residue was caused by tremendous pressure from the heavy pile and could easily be wiped off.

The organization should also continually keep informed about new developments in the customer's industry by reading their journals and attending their conferences. Brain-storming sessions with the customers about future products and services should be held at least annually.

Report Card

Another very effective information-gathering tool is the report card. Figure shows a typical one. It is usually sent to each customer on a quarterly basis.

QUARTERLY REPORT CARD

To our Customers:

We are continually striving to improve. To assist us in this endeavor, we need your feedback. Would you please grade our performance in each category? The grading scale is

A	=	Excellent
B	=	Very Good
C	=	Average
D	=	Poor
E	=	Failing

I. PRODUCT QUALITY Grade _____
Comments: _____

II. ON-TIME DELIVERY Grade _____
Comments: _____

III. SERVICE Grade _____
Comments: _____

IV. OVERALL Grade _____
Comments: _____

Signed _____ Date _____

Title _____Organization _____

The Internet and Computers

Some managers are beginning to monitor discussions that take place on the Internet to find out what customers are saying about their products. Internet users frequently seek advice regarding their everyday activities or activities related to specific interests, hobbies, or sports. Newsgroups, electronic bulletin boards, and mailing lists can be scanned using keyword searches if one knows that a company's product is of interest to participants in certain activities, hobbies, or professions. Ideally, messages that compare a company's products with those of its competitors can be uncovered. In the newsgroups it is best to read the views and discussions of others and not intervene in the discussion with the organization's perspective on the product or service. Intervening will most likely end the discussion. Monitoring Internet conversations is timely, the cost is minimal, and it can be a source of creative ideas. One of the drawbacks of monitoring Internet conversations, however, is that the conversations can be unfocused.

There are even Internet sites that take consumer complaints and compliments about businesses and gives organizations grades based on their ratio of complaints to compliments. Planetfeedback.com also sends letters to companies on behalf of consumers. The organization's web page also provides an easy way for customers to e-mail the company with their thoughts on the organization's products and services.

Computers can be used to detect patterns in seemingly chaotic data. For instance, the sales data from a convenience store chain showed that the peak hours for selling diapers and for selling

beer were the same. The diapers were put next to the beer and sales increased for both. [18]

Employee Feedback

Employees are often an untapped source of information. Companies are listening more to the external customer but still are not listening to employees. Employees can offer insight into conditions that inhibit service quality in the organization. Employee groups can brainstorm ideas to come up with solutions to problems that customers have identified.

Although customer research reveals what is happening, employee research reveals why it is happening. Employee feedback should be proactively solicited, instead of checking the wooden suggestion box once a year. For instance, Chrysler regularly surveys employees for issues, because employee surveys are timely compared to customer surveys. When staff members cannot get what they need or have low morale, then they cannot provide good service. Chrysler requires that management share the survey results with employees and uses the findings to make substantial changes.

4. Describe the concept of service quality or customer service.

SERVICE QUALITY OR CUSTOMER SERVICE

a. Customer service is the set of activities an organization uses to satisfy the customers and their needs.
b. The service can be provided at : (i) before the sale of the product; (ii) during the sale of the product; and (iii) after the sale of the product.
c. Though the terms 'service quality' and 'customer service' are used invariably, the term 'service quality' may be misleading sometimes. Because many authors use the term 'service quality' to represent the quality efforts in service sectors / industries. However, our text focuses more on customer service.

Elements of Customer Service

Jacques Horovitz and Chan Cudennec-poon have listed the 25 elements of customer service. They are:

I. Organization

a. Identify each market segment
b. Write down the requirements
c. Communicate the requirements

d. Organize processes
e. Organize physical spaces

II. Customer Care

a. Meet the customer's expectations.
b. Get the customer's point of view.
c. Deliver what is promised
d. Make the customer feel valued.
e. Respond to all complaints.
f. Over-respond to the customer.
g. Provide a clean and comfortable customer reception area.

III. Communication

a. Optimize the trade-off between time and personal attention.
b. Minimize the number of contact points.
c. Provide pleasant, knowledgeable and enthusiastic employees.
d. Write documents in customer friendly language.

IV. Front-line People

a. Hire people who like people
b. Challenge them to develop better methods.
c. Given them the authority to solve problems.
d. Serve them as internal customers.
e. Be sure they are adequately trained.
f. Recognize and reward performance.

V. Leadership

a. Lead by example.
b. Listen to the front-line people.
c. Strive for continuous process improvement.

5. Write short notes on customer retention.

CUSTOMER RETENTION

a. ***Customer retention*** is the process of retaining the existing customers. It is obvious that customer retention is more powerful and effective than customer satisfaction.
b. ***Customer care*** can be defined as every activity which occurs within an organization that ensures that a customer is not only satisfied but also retained.

c. The following research findings will enable us to understand the real significance of customer retention. The important research findings are:

a. Over 60% of an organization's future revenue will come from existing customers.
b. A 2% increase in customer retention has an equivalent impact upon profitability as a 10% reduction in operating costs.
c. Upto 96% of unhappy customers do not infact complain. But they are three times more likely to communicate a bad experience to other custome5rs than a good one.
d. 91% of the unhappy customers will never purchase goods and services from you again.
e. If you make an effort to remedy customers' complaints, 82 to 95% of them will stay on with you.
f. It costs 5 times as much to attract a new customer as it costs to keep an old one.

Thus the customer retention is more essential than attracting new customers.

a. Customer retention represents the activities that produce the necessary customer satisfaction that creates customer loyalty.
b. Customer retention can be improved by obtaining customer feedback and by measuring customer satisfaction.
c. Customer feedback is obtained from customer satisfaction surveys, focus groups, interviews, and observations. Customer satisfaction should be measured by using the hard measures of cash register receipts, market share, the level of customer retention, and the number of referrals from customers.
d. Customer retention really moves the customer satisfaction to the next level called customer delight.

6. Explain the concept of Employee motivation? Its importance and theories involved in it.

EMPLOYEE MOTIVATION

CONCEPT OF MOTIVATION

a. Scott defines, "Motivation means a process of stimulating people to accomplish desired goals."
b. Edwin B. Flippo defines, "Motivation is the process of attempting to influence others to do your will through the possibility of reward."
c. In simple words, motivation is the process of inducing people inner drives and action towards certain goals and committing his energies to achieve these goals.

IMPORTANCE OF MOTIVATION

a. Motivation improves employee involvement.
b. Motivation promotes job satisfaction and thus reduces absenteeism and turnover.
c. Motivation helps in securing a high level of performance and hence enhances efficiency and productivity.
d. Motivation creates a congenial working atmosphere in the organization and thus promotes interpersonal cooperation.

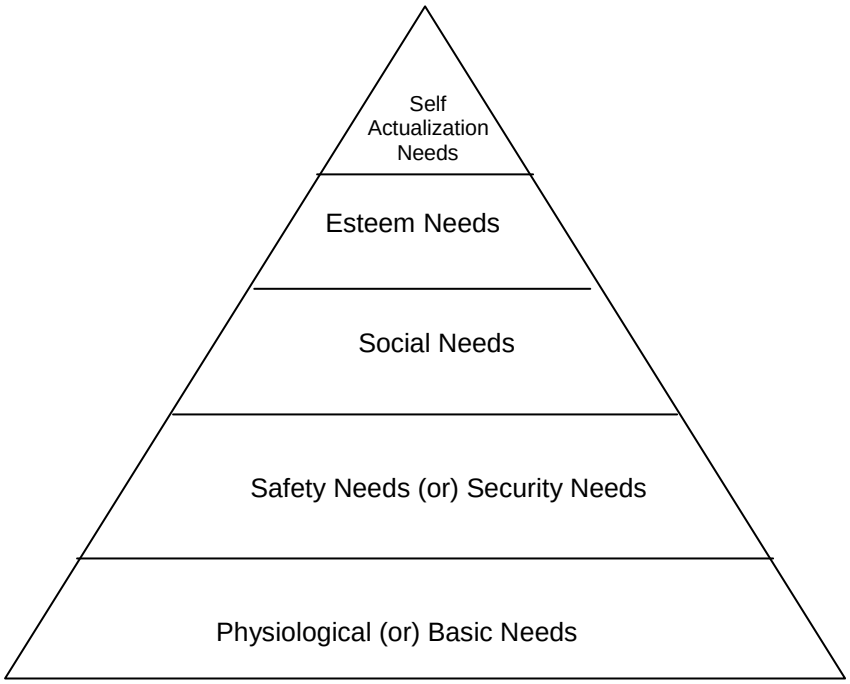
THEORIES OF MOTIVATION

Though there are many theories of motivation, the Maslow's hierarchy of needs theory and Herzberg's two factor theory are more important from our subject of view.

Maslow's Hierarchy of Needs

According to Maslow human motivation is a hierarchy of five needs, as shown in Figure. The five basic needs are: (1) Physiological; (ii) Safety; (iii) Social; (iv) Esteem; and (iv) Self-actualization. These needs form a hierarchy or ladder and each need becomes active only when the next lower need is reasonably satisfied.

Maslow's hierarchy of needs



1. Physiological or Survival Needs

Physiological needs are the biological needs required to preserve human life. These needs

include needs for food, clothing and shelter. These needs must be met first before higher level needs emerge.

2. Safety Needs

When the physiological needs are reasonably satisfied, then the safety needs become activated. These needs include: (i) Protection from physiological dangers (fire, accident); (ii) Economic security (fringe benefits, health, insurance); (iii) Desire for an orderly and predictable environment; and (iv) Desire to know the limits of acceptable behaviour. These safety needs are really provisions against deprivation in the future. It also involves a sense of protection against danger and threats.

3. Social Needs

After the needs of the body and security are satisfied then a sense of belonging and acceptance becomes predominant in motivating behaviour. These needs are for love, friendship, exchange of feelings and grievances, recognition, conversation, belongingness, companionship, etc.

4. Esteem Needs

There are two types of esteem needs: Self-esteem and esteem of others. Self-esteem needs include those for self-confidence, achievement, competence, self-respect, knowledge and for independence and freedom. The second group of esteem needs is those that related to one's reputation needs for status, for recognition, for appreciation and the deserved respect of one's fellows.

5. Self-Actualization Needs

This is the ultimate need which dominates a person's behaviour when all lower needs are satisfied. Self-actualisation, also called self-realisation needs, refers to the desire to become everything that one is capable of becoming.

The first three needs, also known as lower level needs, can be satisfied by monetary and non-monetary compensations. But the last two needs, also known as higher level needs, can be satisfied through participation in decision-making process, delegation of authority and responsibility, more freedom, self-development, etc.

Herzberg's Two Factor Theory

This theory is also called ***motivation-hygiene theory***. This theory is based on two factors: 1.

Motivation factors or satisfiers, and 2. Hygiene factors or dissatisfiers. Various motivation and hygiene factors are listed in Table.

Motivation and hygiene factors

Motivation Factors	Hygiene Factors
• **Achievement**	• Supervisors
• **Recognition**	• Working conditions
• **The work itself**	• Interpersonal relationships
• **Responsibility**	• Pay and security
• **Advancement and growth**	• Company policy and administration

According to Herzberg, maintenance or hygiene factors are necessary to maintain a reasonable level of satisfaction among employees. These factors do not provide satisfaction to the employees but their absence will dissatisfy them. Therefore these factors are called dissatisfiers.

On the other hand, motivational factors creates satisfaction to the workers at the time of presence but their absence does not cause dissatisfaction. It can be noted that Herzberg's dissatisfiers are roughly equivalent to Maslow's lower levels, and the motivators are similar to the Maslow's upper levels.

Thus the knowledge of motivation is required for any organization to understand the utilization of employee involvement.

7. Explain the concept of Empowerment? Also state the general principles for empowering employees.

EMPLOYEE EMPOWERMENT

CONCEPT OF EMPOWERMENT

Empowerment is the opposite of helplessness or dependency. An empowered person does not feel incapable of doing the things that he considers important for the well-being of his organization. There are no constraints that he perceives to be externally imposed. In other words, being empowered implies that the person acts from a state of autonomy, doing what he knows is the right thing to do under a given set of circumstances.

It is understood that empowerment is dependent upon two factors:

(i) An individual's personal choices; and
(ii) The organization climate, that can either encourage dependency or foster autonomy.

EMPOWERMENT DEFINED

1. According to Webster's Dictionary, the verb ***empower*** means 'to give the means, ability or authority'. Therefore empowerment in work setting involves giving people the means, ability and authority to do something they have not done before.

2. ***An operation definition of empowerment:*** "Empowerment is an environment in which people have the ability, the confidence, and the commitment to take the responsibility and ownership to improve the process and initiate the necessary steps to satisfy customer requirements within well-defined boundaries in order to achieve organizational values and goals."

Job Enrichment Vs Job Empowerment

Job enrichment is aimed at expanding the content of an individual's job. But job empowerment focuses on expanding on the context of the job such as its interactions and interdependencies to other functions of the organization.

GENERAL PRINCIPLES FOR EMPOWERING EMPLOYEES

The following general principles may be used to empower the employees.

- Tell people what their responsibilities are.
- Give them authority equal to the responsibility assigned to them.
- Set standards of excellence.
- Provide them with training that will enable them to maintain standards.
- Give them knowledge and information.
- Provide them with feedback on their performance.
- Trust them and create trust worthiness in the organization.
- Allow them to fail but guide them and counsel them when needed.
- Treat them with dignity and respect.

CONDITIONS TO CREATE THE EMPOWERED ENVIRONMENT.

The three conditions required to create the empowered environment are:

1. Everyone must understand the need for change.
2. The system needs to change to the new paradigm.

3. The organization must provide information, education, and skill to its employees.

CHARACTERISTICS OF EMPOWERED EMPLOYEES

Some important characteristics of empowered employees, identified by Hubert Rampersad, are that:

- They feel responsible for their own task.
- They are given a free hand in their work.
- They balance their own goals with those of the organization.
- They are well trained, equipped, creative, and customer oriented.
- They are critical, have self-esteem, and are motivated.
- They are challenged and encouraged.
- They monitor and improve their work continuously.
- They find new goals and change challenges.

Therefore, it is important to empower individuals and teams at all levels of the organization to achieve the continuous improvement process.

8. What is meant by a team and a team work? State its types.

TEAMS AND TEAM WORK

WHAT IS MEANT BY A TEAM AND TEAM WORK?

- ***A team*** can be defined as a group of people working together to achieve common objectives or goals.*
- ***Team work*** is the cumulative actions of the team during which each member of the team subordinates his individual interests and opinions to fulfill the objectives or goals of the group.
- ***TQM*** is based on the involvement of everyone in making improvements. So working in teams is an inseparable part of the TQM environment. Nowadays teamwork is adopted universally as the organizational mechanism for involving people in quality improvements.

BENEFITS OF TEAM WORK

The benefits of teamwork include:

1. Improved solutions to quality problems.
2. Improved ownership of solutions.

3. Improved communications.
4. Improved integration.

TYPES OF TEAMS

Teams can be classified into four major groups. They are:

1. Process improvement team,
2. Cross-functional team,
3. Natural work team, and
4. Self-directed / self-managed work team.

It can be seen from the figure that by the direction of quality council, several cross functional teams can be established. These teams address specific improvement problems of several functional areas. Within the functional areas, one or more process improvement teams may be established. In turn, one or each functional areas may establish a workgroup to address overall improvements to the particular area.

The use of teams throughout an organization

9. Mention the characteristics of a successful team.

CHARACTERISTICS OF SUCCESSFUL TEAMS

The effective team should have certain characteristics. These are :

1. Sponsor: In order to have effective liason with the quality council, there should be a sponsor. The sponsor is a person from the quality council, he is to provide support to the organization.
2. Team Charter: A team charter is a document that defines the team's mission, boundaries, the background of the problem, the team's authority and duties, and resources. It also identifies the members and their assigned roles – leader, recorder, time keeper and facilitator.

3. Team Composition: The size of the team should not exceed ten members except in the case of natural work teams or self-directed teams. Teams should be diversed by having members with different skills, perspective and potential. Wherever needed, the internal and external customers and suppliers should be included as a team member.

4. Training: The team members should be trained in the problem-solving techniques, team dynamics and communication skills.

5. Ground Rules: The team should have separate rules of operation and conduct. Ground rules

should be discussed with the members, whenever needed it should be reviewed and revised.

6. Clear Objectives: The objective of the team should be stated clearly. Without the clear objective, the team function is not to be effective.

7. Accountability: The team performance is accountable. Periodic status report of the team should be given to the quality council. The team should review its performance to determine possible team process weaknesses and make improvements.

8. Well-defined Decision Procedures: The decision should be made clearly at the right time by the team.

9. Resources: The adequate information should be given to the team wherever needed. The team cannot be expected to perform successfully without the necessary tools.

10. Trust: Management must trust the team to perform the task effectively. There must also be trust among the members and a belief in each other.

11. Effective Problem-Solving: Problem-solving methods are used to make the effective decision.

12. Open Communication: Open communication should be encouraged i.e., everyone feels free to speak in the team whatever they are thinking, without any interruptions.

13. Appropriate Leadership: Leadership is important in all the team. Leader is a person who leads the team, motivates the team and guides the team in a proper direction.

14. Balanced Participation: Everyone in a team should be involved in the team's activities by voicing their opinions, lending their knowledge and encouraging other members to take part.

15. Cohesiveness: Members should be comfortable working with each other and act as a single unit, not as individuals or subgroups.

ELEMENTS OF EFFECTIVE TEAM WORK

Main elements of effective teamwork are as follows:

1. Purpose
2. Role and responsibilities
3. Activities
4. Effectiveness
5. Decisions

6. Results, and
7. Recognition.

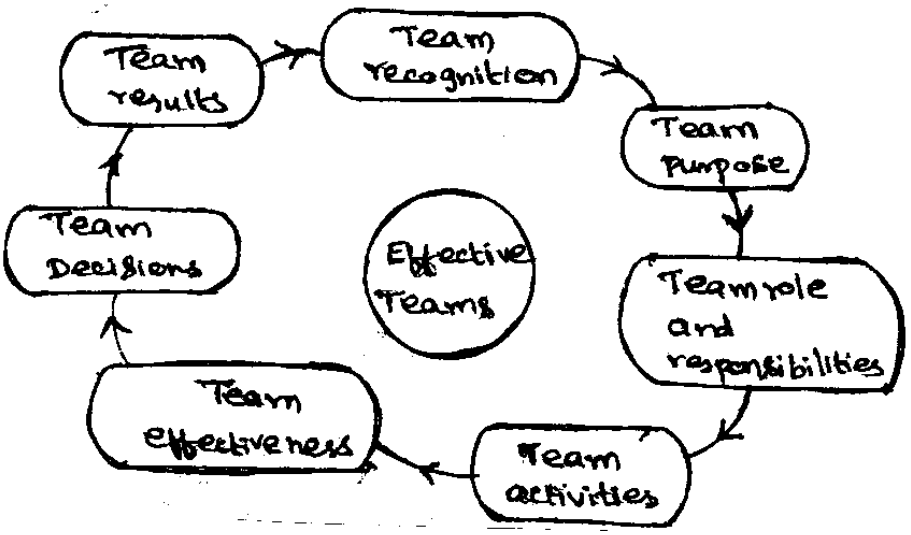


Figure depicts the seven main elements of effective teamwork.

10. Mention the states of team development? Also mention the barriers to team progress.

(i) STAGES OF TEAM DEVELOPMENT

Each term takes sometime to start functioning effectively towards problem solving. Each team goes through six distinct stages in its development. These are ***farming, storming, norming, performing maintenance and evaluating.***

1. Farming stage : When a team is created, it consist of group of individuals and team work does not exist at this stage. Team's purpose, members' roles, acceptance of roles, authority and process of functioning are learnt in the formation process.

2. Storming stage : Initial agreements and role allocations are challenged and re-established at this stage of team development. At this stage, hostilities and personal needs often emerge which may be resolved.

3. Norming stage : During norming stage of team development, formal and informal relationships get established among team members. Openness and cooperation have been observed as signs of team's behaviour.

4. Performing stage : At this stage, the team starts operating in successful manner. Trust, openness, healthy conflict and decisiveness of a group's performance can be reached at this stage.

5. Maintenance stage : Functioning of team does not deteriorate overtime. At this stage, the performance of teamwork at the earlier stage will be maintained for some period of time.
6. Evaluating stage : At this stage, team's performance is to be evaluated in view of the set targets. Both self-evaluation and management-based evaluation form this stage of team development.

BARRIERS TO TEAM PROGRESS

The various roadblocks to team progress are :

1. Insufficient training
2. Incompatible rewards and compensation.
3. First-line supervisor resistance
4. Lack of planning.
5. Lack of management support
6. Access to information systems
7. Lack of union support.
8. Project scope too large.
9. Project objectives are not significant.
10. No clear measures of success.
11. No time to do improvement work.

(ii) ROLE OF TEAM MEMBERS

For effective teamwork, team members are required to perform a number of roles and responsibilities. Thus all team members should:

i) Devote themselves to the common team goals based on a common mission and vision.
ii) Feel themselves responsible and equal.
iii) Be interested and motivated.
iv) Accept, appreciate, and respect each other.
v) Give high priority to continuous improvement.
vi) Participate actively with the activities of the team.
vii) Offer views, opinions and ideas freely and voluntarily.

11. Explain Juran Trilogy in detail.

About Juran

Dr. Joseph M. Juran has contributed a lot to the movement of total quality. He is well known for his monumental, nearly 1900 page, text book on '***Quality Control Handbook***' and other contributions to the total quality. He highlighted managerial responsibility for quality and

emphasized that quality can be achieved through people rather than techniques. He stressed both the management and technical aspects of quality management.

Juran's Quality Trilogy

Juran divides quality management into three parts. They are :

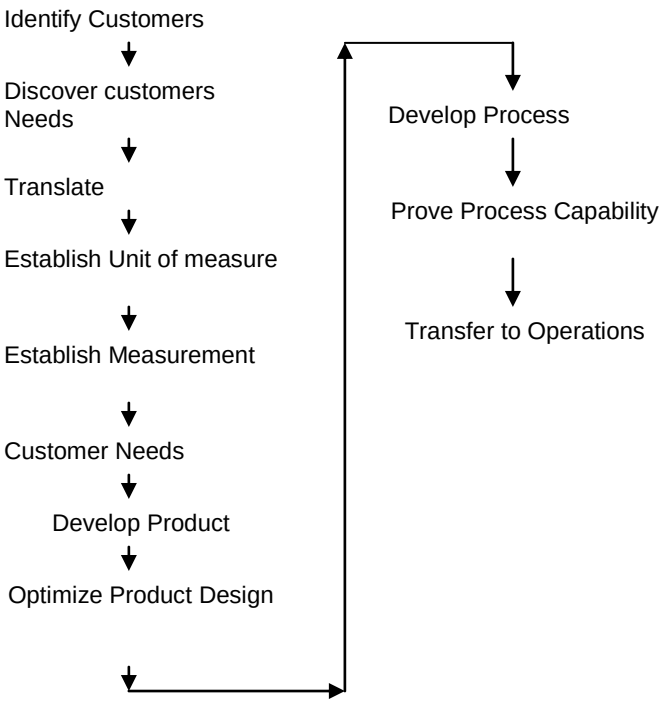
- Quality planning,
- Quality control, and
- Quality improvement.

According to Juran, the planning process is crucial for improvement to become a continuous activity. Therefore, planning has to be conducted with a long-term view rather than a project by project basis.

1. Quality Planning

For quality planning, Juran proposed, a self-explanatory planning road map, as shown in Figure. During this planning stage, an organization prepares to meet established quality goals.

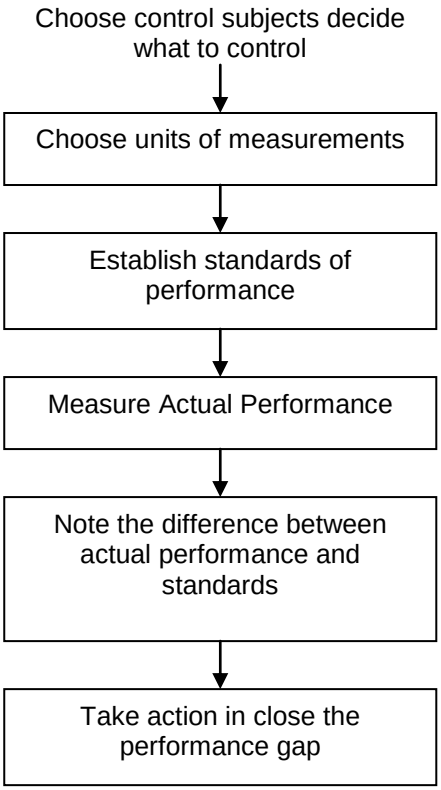
The Juran quality planning road map



2. Quality Control

At this stage, control processes are designed to meet and ensure the quality goals set in the planning stage. Figure illustrates Juran's quality control process.

Juran's quality control process



3. Quality Improvement

The third part of the trilogy provides managers the means to find and remedy the basic causes of poor quality. It aims to attain levels of performance that are significantly higher than current levels. Juran's ten steps to quality improvement is presented in Table.

Juran's ten steps to quality improvement

- **Build awareness of the need and opportunity for improvement.**
- **Set goals for improvement.**
- **Organise to reach the goals.**
- **Provide training.**
- **Carry out projects to solve problems.**
- **Report progress**
- **Give recognition**
- **Communicate results.**
- **Keep score.**
- **Maintain momentum by making annual improvement part of the regular systems and**

processes of the company.

Juran Trilogy Diagram

It describes the way in which Juran's trilogy is designed to reduce the cost of quality over time.

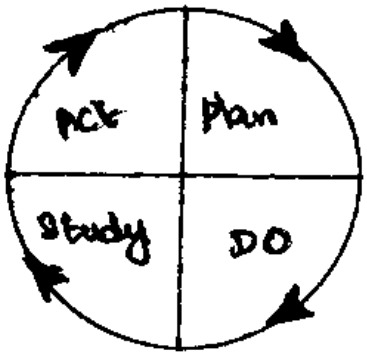
Juran has made clear distinction between sporadic waste and chronic waste. The sporadic waste can be identified and corrected through quality control; whereas the chronic waste requires an improvement process. It is also clear that Juran's trilogy is a cyclic and ever-ending continuous process improvement approach.

12. Explain PDSA Cycle (or) Deming Wheel.

PDSA CYCLE (OR DEMING WHEEL)

The basic Plan – Do – Study – Act cycle was originally developed by Walter A. Shewart. But it was popularized by Edward Deming and that's why it is often called the ***Deming Cycle*** or ***Deming Wheel.*** It is an effective continuous improvement technique.

The PDSA Cycle



What is PDSA Cycle?

- PDSA stands for Plan, Do, Study, and Act. It is a model for testing ideas that you think may create improvement.
- It is an extremely practical, common sense based approach that is easy to understand.
- It can be used to test ideas for improvement quickly and easily based on existing ideas, research, feedback, theory, review, audit, etc.
- It encourages starting with small changes, which can build into large improvements in the service through successive quick cycles of change.
- Illustrates the PDSA cycle.

Phases of PDSA Cycle

The four phases of PDSA cycle and their descriptions are presented in Table.

Phases of PDSA Cycle

Phases	Description
1. Plan	• Define the problem • Analyze the causes and draft an action plan for solving the problem. • Determine the quality objectives and the critical factors. • Define the performance indicators. • Collect and analyze the necessary process data. • Generate possible solutions • Select the most feasible solution; and work it out.
2. Do	• First, implement the plan on a limited scale or conduct an experiment to test the proposed improvement. Collection data is hereby essential. • Train all involved employees in the use of quality improvement methods and techniques. • Describe the process which is considered for improvement and form project teams to lead the process.
3. Check	• Evaluate the trial project with the performance indicators. • Verify whether the improvement has been successful or not.
4. Act	• Act to implement proven improvements. The choices are: introduce the plan, adjust or reject it. • The improvements are documented in standard procedures so all employees are well-informed on how to handle in future. • Usually, the cycle will be repeated under the different circumstances and conditions to test how consistent the results are.

Continuous Process Improvement Cycle Using PDCA

The relationship between the PDSA cycle and eleven steps to continuous process improvement are illustrated in figure.

Each phase of the PDCA cycle must undergo its own PDCA cycle for further improvements, as shown in figure.

Applying PDCA to its phases

Benefits of the PDSA Cycle

The benefits of the PDSA cycle can be experienced in the following areas:

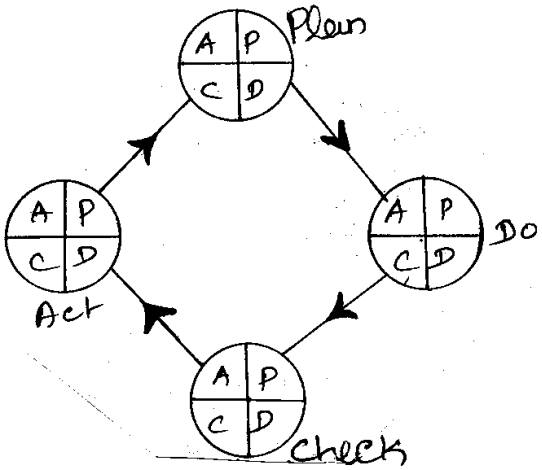
- Daily routine management – for the individual and / or the team.
- Problem-solving process.
- Project management
- Continuous development
- Vendor development
- Human resources development
- New product development
- Process trials

13. Explain the Principles of Customer / Supplier relations.

PRINCIPLES OF CUSTOMER / SUPPLIER RELATIONS

In order to ensure the practice of continuous process improvement, it is essential for the organizations to have partnering atmosphere with suppliers. In this regard, Dr. Kaoru Ishikawa has suggested ten principles, which are presented in Table.

Ishikawa's 10 principles of customer / supplier relations



- **Both the customer and the supplier are fully responsible for the control quality.**
- **Both the customer and the supplier should be independent of each other and respect each other's independence.**
- **The customer is responsible for providing the supplier with clear and sufficient requirements so that the supplier can know precisely what to produce.**
- **Both the customer and the supplier should enter into an non-adversarial contract with respect to quality, quantity, price, delivery method and terms of payments.**
- **The supplier is responsible for providing the quality that will satisfy the customer and submitting necessary data upon the customer's request.**
- **Both the customer and the supplier should decide the methods to evaluate the quality of the product or service to the satisfaction of both parties.**
- **Both the customer and the supplier should establish in the contract the method by which they can reach an amicable settlement of any disputes that may arise.**
- **Both the customer and the supplier should continually exchange information, sometimes using multifunctional teams, in order to improve the product or service quality.**
- **Both the customer and supplier should perform business activities such as procurement, production and inventory planning, clerical work and systems so that an amicable and satisfactory relationship is maintained.**
- **When dealing with business transactions, both the customer and the supplier should always have the best interest of the end user in mind.**

14. Discuss briefly on

(i) Supplier partnering

(ii)Supplier Rating

SUPPLIER PARTNERING

What is Supplier Partnering?

Partnering is a defined as a continuing relationship, between a buying firm and supplying firm, involving a commitment over an extended time period, an exchange of information, and acknowledgement of the risks and rewards of the relationship. The relationship between customer and supplier should be based upon trust, dedication to common goals and objectives, and an understanding of each party's expectations and values.

Benefits of Partnering

The benefits of partnering include:

(i) Improved quality;
(ii) reduced cost;
(iii) Increased productivity;
(iv) Increased efficiency;
(v) Increased market share;
(vi) Increased opportunity for innovation; and
(vii) Continuous improvement of products / services.

Key Elements to Partnering

The three important elements to achieve the customer / supplier partnering relationship are :

1. Long-term commitment: Long-term commitment provides both customer and supplier the much needed environment to achieve the planned objectives. Because to set up and solve the problem of continuous improvement, both parties may require the sufficient time.

2. Trust : Mutual trust between two parties forms the basis for a strong working relationship. Trust enables the partners to effectively combine their resources and knowledge. It results in a 'win-win' situation for both partners.

3. Shared vision : Both the customers and suppliers have the common goal i.e., to satisfy the end user. In order to ensure this goal, both particles should share and understand their goals and objectives.

Three types of supplier sourcing are:

- Sole sourcing;
- Multiple sourcing, and
- Single sourcing.

1. Sole Sourcing

Sole sourcing is the use of only one supplier for the organization. The organization does not have any choice. It is forced to use only one supplier.

This forced situation is because of the following factors : patents, technical specifications, raw material location, only one organization producing the item, etc.

2. Multiple Sourcing

Multiple sourcing is the use of two or more suppliers for an item.

The basic concept of multiple sourcing is that competition will result in better quality, lower costs, and better service. (The selection of suppliers from various alternatives is based on their performance in terms of prices, quality and delivery.

3. Single Sourcing

Single sourcing is the use of one supplier for an item when several sources are available. It leads to long-term partnering relationship.

SUPPLIER SELECTION

Usually suppliers are selected based on their performance in terms of cost, quality, and delivery reliability. In addition, supplier criteria includes factors such as management compatibility, goal congruence, and strategic direction of the supplier firm.

Table Ishikawa's ten conditions for selection and evaluation of suppliers

1. The supplier should understand and appreciate the management philosophy of the organization.
2. The supplier should have a stable management system.
3. The supplier should maintain high technical standards and have the capability of dealing with future technological innovations.
4. The supplier should provide those raw materials and parts required by the purchaser and those supplied meet the quality specifications.
5. The supplier should have the capability to produce the amount of production needed.
6. The supplier should not breach the corporate secrets.
7. The supplier should be easily accessible in terms of transportation and communication.
8. The supplier should be sincere in implementing the contract provisions.
9. The supplier should have an effective quality system and improvement program such as ISO/QS

9000.

10. The supplier should have a tract record of customer satisfaction and organization credibility.

SUPPLIER RATING

A supplier rating system, also referred as a scorecard system, is used to obtain an overall rating of supplier performance. It is analogous to students progress report.

Usually supplier rating is based on quality, price, performance and production capability, delivery, service.

Objective of Supplier Rating

The customer rates supplier in order to:
obtain an overall rating of supplier performance ;
ensure complete communication with suppliers;
provide each supplier about the details of problems for corrective action; and
maintain and improve the partnering relationship between the customer and the supplier.

Supplier Rating Format

Table shows a model supplier rating format, otherwise known as supplier scorecard.

A model supplier scorecard

Item : **Rated by:** **Date:**

Period :

Location :

Quality Performance	Maxi-mum points	Supplier A Actual points	Supplier B Actual points	Supplier C Actual points	Supplier D Actual points	Supplier E Actual points
I. QUALITY						
(i) Quality personnel						
(ii) Quality procedure						
(iii) Concern for quality						
(iv) Concern history						
II. PRICE						
(i) Price-quality						
(ii) Price-negotiation						
(iii) Financial ability						
iii. PERFORMANCE						
(I) Technical						

(ii) Delivery history	
(iii) Technical assistance	
IV.PRODUCTION CAPABILITY	
(I) Production capacity	
(ii) Manufacturing equipment	

Rating Scale : 5.0 = Very good 2.0 = Poor
4.0 = Good 1.0 = Very poor
3.0 = Average 0 = Negative

15. Mention the stages involved in supplier selection and their conditions of the performance measures.

Stages in Supplier Selection and Evaluation
There are four stages in supplier selection and evaluation. They are :

Survey Stage: In survey stage, based on the information available through catalogues, advertisements, brochures, etc., a list is drawn up for further investigation.

Enquiry Stage : In enquiry stage, a detailed analysis is made after obtaining required information. Standard enquiry forms are sent to the vendors, requesting them to furnish informations. This may be followed by plant visit if necessary to have first hand details. The vendor's present customers may be enquired regarding his performance, promptness in delivery, etc.

Negotiation and Selection Stage : During the enquiry stage itself, many of the vendors might have been dropped from the original list as unsatisfactory. The remaining vendors may be called for direct negotiations to discuss various terms and conditions like payment terms, discounts, supply procedures, quality control procedures, etc. As a result of this a final list of approved vendors is drawn up.

Experience Stage : In this stage, the performance of the supplier is evaluated mainly on basis of quality and promptness in delivery. A history card is maintained for each vendor. The card contains information like dates of supply of materials of by vendor, inspection, procedure adopted, acceptance of otherwise of the lost supplied. Frequent rejections may upset the production schedule in the buyer's company and result in heavy losses, hence such vendors might be dropped from the list. Similarly the later deliveries may cause stoppages in production,

otherwise large inventories may have to be carried in stock. Both the situations are not desirable and hence such vendors are also reviewed for continuance as suppliers.

REQUIREMENTS (OR CRITERIA) OF THE PERFORMANCE MEASURES

The organizations can adopt any of the performance measures listed in Table depending on its requirements. However, for successful implementation, the selected measures should try to satisfy the following requirements.

- **a.** Performance measures should be simple and understandable to the users.
- **b.** Instead of using many performance measures, it is preferable to use few number of key measures.
- **c.** While selecting measures, one should select the measures which are more relevant to customers.
- **d.** Performance measures should focus on continuous improvement, prevention and corrective action.
- **e.** Cost related performance measures should be preferred to better understand the financial position of the firm.
- **f.** The performance measures selected / used should be transparent and visible to all the employees.
- **g.** The performance measures should be time-based, preferably measures should be based on hourly, daily, or weekly rather than monthly or quarterly.
- **h.** The results of the performance measures should balanced the interests of all stakeholders.

UNIT - III

STATISTICAL PROCESS CONTROL (SPC)

PART - A

1. List the seven tools of quality.

1. Check sheets.
2. Histograms.
3. Cause and effect diagrams.
4. Pareto diagrams.
5. Stratification analysis.
6. Scatter diagrams, and
7. Control charts.

2. What is check sheet?

A check sheet or tally sheet is a form for systematic data gathering and registering to get a clear view of the facts.

3. When do you use the check sheet?

A check sheet is used to indicate the frequency of a certain occurrence.

4. What are the types of check sheets commonly used?

1. Process distribution check sheet.
2. Defective item check sheet.
3. Defect location check sheet, and
4. Defect factor check sheet.

5. What is histogram?

A histogram is a bar chart / diagram showing a distribution of variable quantities or characteristics. It is graphical display of the frequency distribution of numerical data.

6. When do you use histogram?

A histogram is used to show clearly where the most frequently occurring values are located and the data is distributed.
It enables the analyst to quickly visualize the features of a complete set of data.

7. What are the various types of histogram?

1. Bell-shaped.
2. Double-peaked.
3. Plateau.
4. Comb.
5. Skewed.
6. Truncated.
7. Isolated peak and
8. Edged peak.

8. What is cause and effect diagram?

The cause and effect diagram or Fishbone diagram is a graphical-tabular chart to list and analyze the potential causes of a given problem.

9. Under what situations, one can use cause and effect diagram?

The cause and effect diagram has unlimited application in research manufacturing, marketing, office operations, services, etc.

10. What are the uses of CE diagram?

The cause and effect diagrams are used:

To analyze cause and effect relationships
To facilitate the search for solutions of related problems.
To standardize existing and proposed operations and
To educate and train personnel in decision-making and corrective action activities.

11. What is Pareto diagram?

A pareto diagram is a diagnostic tool commonly used for separating the vital few causes that account for a dominant share of quality loss.

12. State the Pareto principle.

Pareto principle states that a few of the defects accounts for most of the effects.

13. What are the purposes of pareto principle.

Pareto analysis can be used in a wide range of situations, where one need to priorities problems based on its relative importance.

14. What is stratification?

Stratification is a method of analysis of data by grouping it in different ways.

15. What is scatter diagram?

The scatter diagram is a simple graphical device to depict the relationship between two variables.

16. When do you use the scatter diagram?

The purpose of the scatter diagram is to display what happens to one variable when another variable is changed.

17. What is control chart?

A control chart is a graph that displays data taken over time and the variation of this data.

18. What are the types of control charts?

Control charts for variables – for measurable data such as time, length, temperature, weight, pressure, etc.

Control charts for characteristics- for quantifiable data such as number of defects, typing errors in a report, etc.

19. When do you use control chart?

The purpose of control chart is to identify when the process has gone out of statistical control, thus signaling the need for some corrective action to be taken.

20. Define statistics.

Statistics is defined as the science that deals with the collection, tabulation, analysis, interpretation and presentation of quantitative data.

21. What are major functions of statistical analysis?

The major functions of statistical analysis are:

Reducing the complexity of the situation,
Making comparisons and drawing conclusions,
Estimating and predicating, and
Decision-making.

22. Write down the applications of statistical techniques?

Statistical techniques are applicable in all situations where quantification is possible. The statistical analysis has become indispensable to practically every field that exists.

23. Define data and information.

Data can be defined as a collection of related observations.
Information can be defined as processed data.

24. What are the types of graphs used in representing frequency distribution?

Histogram,
Frequency polygon and frequency curve, and
Cumulative frequency or the 'Ogive'

25. How to obtain frequency polygon?

Frequency polygon is obtained by plotting midpoints of the classes (on the X –axis) against the class frequencies (on the Y – axis) and then joining these plotted points by a straight line.

26. How do obtain frequency curve?

A frequency curve is obtained by drawing a smooth freehand curve through the points of the frequency polygon.

27. Why sometimes the frequency polygons are preferred to frequency histograms?

Because the frequency polygons of several distributions may be plotted on the same axis, thereby making certain comparison possible, whereas histograms cannot be employed in the same way.

28. How to obtain frequency curve?

The cumulative frequency curve (also called an Ogive) obtained by plotting upper class limits (or lower class limits) against the 'less than' (or 'more than') cumulative frequencies is known as 'less than' Ogive (or 'more than' Ogive).

29. What do you mean by measure of central tendency?

A measure of central tendency of a distribution is a numerical value that describes the central position of the data.

30. What are the three measures of central tendency?

1. Mean, 2, Median, and 3. Mode.

31. What are the three measures of dispersion?

Measures of dispersion tell us how the individual observations are spread on either side of the centre.

32. What are the three measures of dispersion?

1. Range, 2.Mean deviation, and
3. Standard deviation

33. What is meant by attribute?

An attribute refers to those quality characteristics that confirm to specifications or do not conform to specifications.

34. What is the use of control charts for attributes?

Control charts for attributes monitor the number of defects or fraction defects or fraction defect rate present in the sample.

35. What is the use of control charts for attributes used?

p chart: The chart for fraction rejected as non-conforming to specification
np chart: The control chart for number of non-conforming items.
c chart: The control chart for number of defects.
u chart: The control chart for number of defects per unit.

36. Define fraction defective (p).

It is defined as the ratio of the number of defective articles found in any inspection to the total number of articles actually inspected.
Mathematically, p = np/n

Where P= Fraction defective,
np = Number of defectives, and
n = Number of items inspected in the sub-group

37. When up chart is preferred over p chart?

When subgroup size is constant, the np chart is preferred over p chart.

38. Why a np chart is preferred over p chart?

In np chart, when the subgroup size is variable, the expected number of rejectable items per subgroup will also change. This means that a different central line as well as different control limits for every subgroup on the chart. This makes the chart very confusing and almost not understandable by shop personnel. Therefore when the subgroup size is variable, np chart is not recommended.

39. Write down the difference between a defect and defective.

An item is said to be defective if it fails to conform to the specifications in any of the characteristics. Each characteristics that does not meet the specifications is called defect. For example, if a casting contains undesirable hard sports, below holes, etc., the casting is defective and the hard spots, below holes, etc., are the defects.

40. When are c charts used?

The situations where c chart can be used are:
Number of typographical errors on the printed page.
Number of rust spots on steel sheets.
Number of defects such as cracks, blow holes, under cuts, etc., in a casting or a welded piece.

41. What probability distribution is used as a basis for c charts?

Poisson distribution is used as a basis for a chart.

42. When the u chart is used?

When the subgroup size varies from sample to sample, then the u chart is used.

43. Differentiate between producer's risk and consumer's risk.

Producer's risk: It is the probability of rejecting a good lot which otherwise would have been accepted.
Consumer's risk: It is the probability of accepting a defective lot which otherwise would have been rejected.

44. What is six sigma?

Six sigma is similar to Zero Defects (ZD), is a philosophical benchmark or standard of excellence proposed by Philip Crosby. Six sigma strives for perfection. It allows for only 3.4 defects per million opportunities (or 99.99966 percent accuracy).

45. What are the five phases in six sigma process?

The five phase in six sigma process are:

1. Define, 2. Measure, 3. Analyse,
4. Improve, and 5. Control

46. Brief the scope of six sigma principle.

The six sigma concept is originated from manufacturing field. Now it is applied to non-manufacturing processes also. Today one can apply six sigma to many fields such as services, medical and insurance procedures, call centres, etc.

PART – B

1. Explain briefly about check sheet (or) data collection sheet with an example.

Check sheet (data collection sheet)

i. What is it?

- A check sheet*, also known as tally sheet, is a form for systematic data gathering and registering to get a clear view of the facts.
- It is used to keep track of how often something occurs.
- The form of the check sheet is tailored for each situation / application.

ii. When do we use it?

- A check list is used to indicate the frequency of a certain occurrence.

iii. How do we construct it?

- A checklist may be constructed using the following steps:
- Formulate the objective for collecting data
- Decide which data is necessary.
- Determine who and how data will be analyzed.
- Draw a format to record data.
- Collect and record data problem-wise by putting tally lines.
- Start counting by tallying on the list; |, ||, |||, |||| and |||| represent the numbers 1,2,3,4 and 5 respectively.
- Mark on the list the total number of facts, which were noticed.

iv. Types of check sheets

The widely used different types of check sheets are:

Process distribution check sheet:
This check sheet is used to collect on process variability.

Defective item check sheet:
This check sheet is intended to specify the variety of defects occurring, together with their frequency of occurrence.

Defect location check sheet:
This check sheet is intended to identify where defects occur on the product.

Defect factor check sheet:

This check sheet is used to monitor the input parameters in a process that might affect the incidence of defects.

Illustration

Example Fig illustrates the check sheet of customer complaints by category

Check sheet / Tally sheet of customer complaints

S.No	Problems		Frequency
i)	Delivery	𝍸 | | | |	7
ii)	Packaging	| |	2
iii)	Quality / Performance	𝍸 | | 𝍸 | | |	11
iv)	Personnel	𝍸 | | 𝍸 | |	10
v)	Invoicing	𝍸 | | 𝍸 | | 𝍸 | | | |	18

2. Define Histogram. Mention its types. Illustrate with an example.

i. What is it?

A histogram is a bar chart / diagram showing a distribution of variable quantities or characteristics.
It is a graphical display of the frequency distribution of the numerical data.

The data are displayed as a series of rectangles of equal width and varying heights.

ii. When do we use it?

A histogram is used to show clearly where the most frequently occurring values are located and the data is distributed.

It is also a tool for determining the maximum process results.

It enables the analyst to quickly visualize the features of a complete set of data.

iii. How do we construct it?

A histogram may be constructed using the following steps:

1. After the data collection, count the number of data values collected.
2. Determine the range of the data.
Range = Highest value – Lowest value

3. Divide the data values in groups or classes and count the number of values in each class. Table shows the guidelines to divide the data values.

Guidelines to form classes

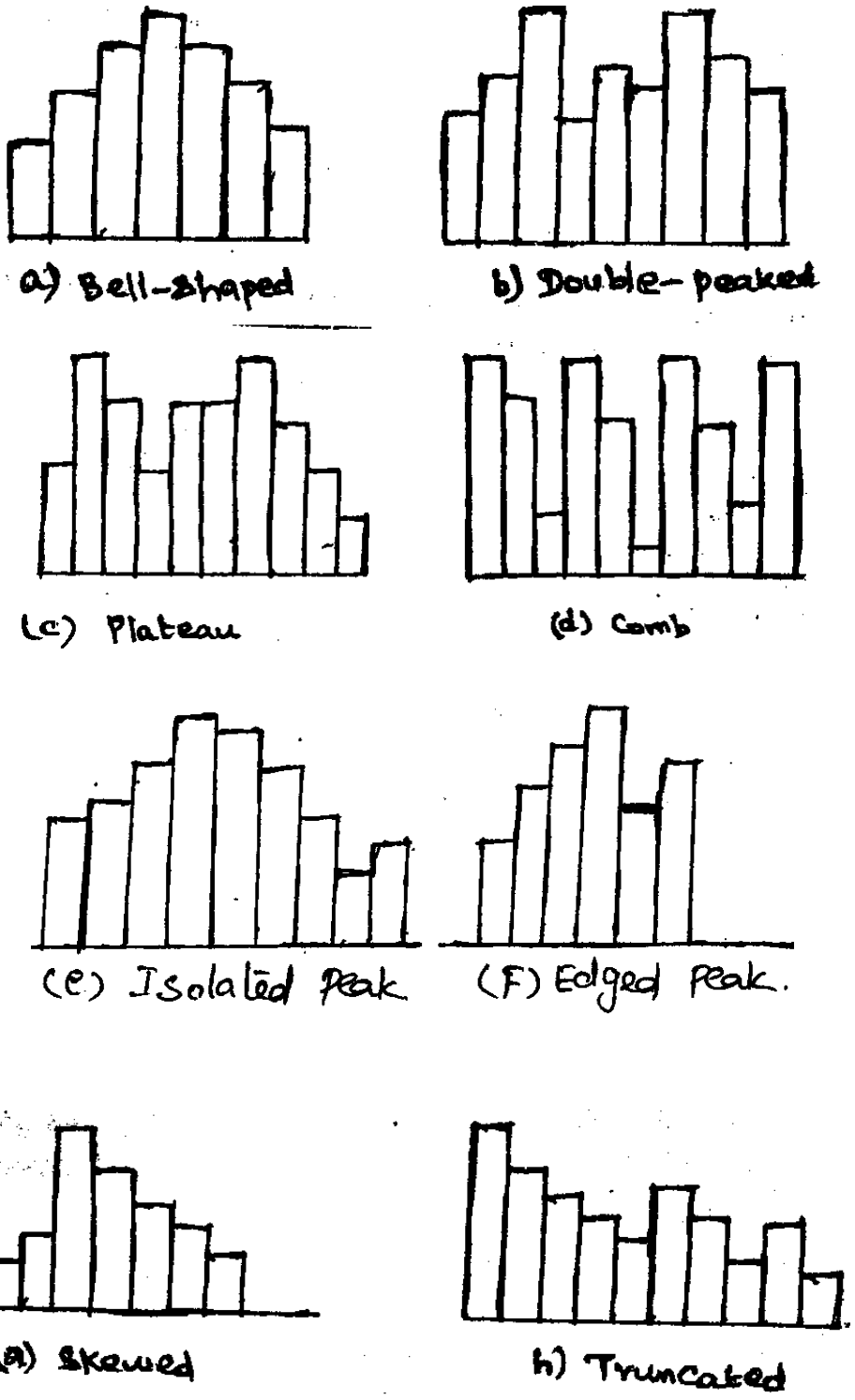
Number of values	Number of classes	Number of values	Number of classes
Lessthan50	5 -7	100 – 250	7 – 12
50 – 100	6 – 10	More than 250	10 - 20

Now determine the width of the class.
Width of the class =
Range / Number of classes selected from table

Draw a frequency table for all values.
Construct a histogram based on the frequency on the vertical axis.
Finally write the title and number of values on the diagram.

Types of Histograms and their interpretations

The various possible types of histograms are depicted in fig.



Types of histograms and their interpretations

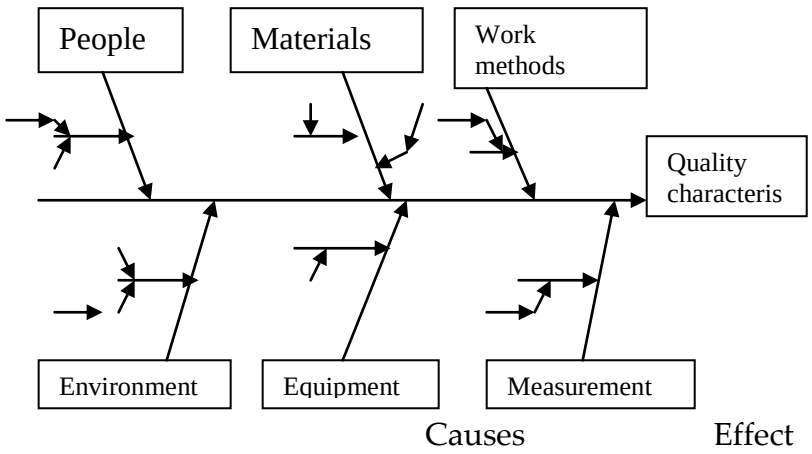
Shape		Description
Bell-shaped		Symmetrical shape with a peak in middle representing a normal distribution
Double Peaked	-	Two normal distribution with two peaks in middle indicating more than one distribution at work

Plateau	Flat top, no distinct peak and tails indicating more than one distribution at work.
Comb	Alternative peaks showing possible errors in data collection and analysis.
Skewed	An asymmetrical shape positively or negatively skewed – usually reflecting limits in the specification on one side.
Truncated	An asymmetrical shape with a peak at the end. Usually being a part of a normal distribution with part of it having been removed.
Isolated peak	Two normal distributions suggesting two processes taking place at the same time.
Edged Peak	A normal distribution curve with a large peak at one end indicating errors in data recoding.

4. Explain the cause and effect diagram (or) fishbone diagram.

What is it?

The cause and effect (CE) diagram is a graphical-tabular chart to list and analysis the potential causes of a given problem.
The cause and effect diagram is also called the fishbone diagram because of its appearance and the Ishikawa diagram after the man who developed it in 1943.
Fig illustrates the basic structure of a cause and effect diagram.



Cause and effect diagram

As shown in fig the diagram consists of a central stem leading to the effect (the problem), with multiple branches coming off the stem listing the various groups of possible causes of the problem.

When do we use it?

The CE diagram has unlimited application in research, manufacturing, marketing, office operations, services and so forth.

The CE diagrams are used:
To analyse cause and effect relationships;
To facilitate the search for solutions of related problems;
To standardize existing and proposed operations; and
To educate and train personnel in decision-making and corrective-action activities.

How do we construct it?

The cause and effect diagram may be constructed using the following steps:

- Define the effect (the problem) clearly and concisely.
- Mark the short description of the effect in a box. Then draw a line from this box towards left.
- List down all the possible minor and major causes through a brainstorming* session.
- Mark the major causes on the branches and minor causes in the sub-branches of the CE diagrams.
- Look for possible solutions for these causes.
- Introduce the changes.

5. Define pareto diagram. Explain how to construct it? Also explain the stratification Analysis.

PARETO DIAGRAM

What is it?

- ***A Pareto diagram*** is a diagnostic tool commonly used for separating the vital few causes that account for a dominant share of quality loss.
- This tool is named after Wilfred Pareto, the Italian economist, who devised this tool first.
- The Pareto diagram is based on the ***Pareto Principle,*** which states that few of the defects account for most of the effects.
- Pareto analysis is also called as ***80/20 rule*** and as ***ABC analysis.*** It means only 20% of problems (defects) account for 80% of the effects.
- This analysis is a method of classifying items, events or activities according to their relative importance.

When do we use it?

Pareto analysis can be used in a wide range of situations where one need to priorities problems based on its relative importance.
It can be used as a risk assessment technique from activity level to system level.

How can we construct it?

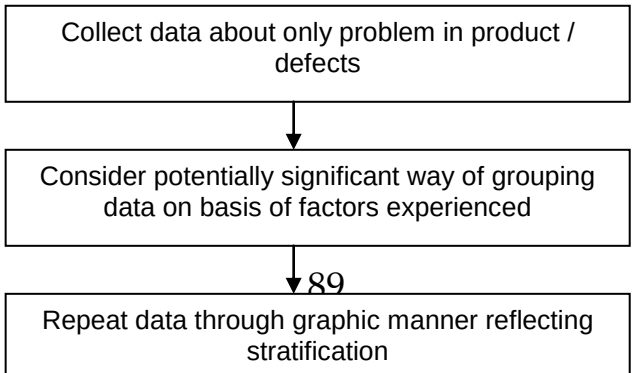
A Pareto diagram can be constructed using the following steps:

- Obtain data, using a check sheet or brainstorm.
- Arrange the data in descending order starting from the largest category to smallest.
- Calculate the total and percentage of the total that each category represents.
- Compute the cumulative percentages.
- Draw a bar chart with two vertical axis, mark the measured values for each cause, starting from zero till the total number of causes. The right vertical axis should have the same height and should go from 0 to 100%. This axis displays the cumulative percentages. List the different kinds of causes along the horizontal axis, from left to right in descending order of frequency or costs.
- Draw a bar above each item whose height represents the number for that cause.
- Plot a cumulative percentage line.
- Now draw a horizontal line from 80% (on the right vertical axis) to the left till the point of intersection with the cumulative line, and then draw a vertical line from this intersection down wards till the horizontal axis. Left from this intersection point are the 20% of causes (the most essential bottlenecks) which causes 30% of the damages.

STRATIFICATION ANALYSIS
What is it?

- ***Stratification*** is a method of analysis of data by grouping it in different ways.
- Literally, stratification means segregating a group of measurements, observations or any other data into several sub-groups on the basis of certain characteristics. These stratified data are used for identifying the influencing factors.
- Machines, suppliers, operators, tools gauges or time-dependent sources like shifts, prepost lunch, start or end of shifts, etc., are strata with respect to which the study of various is conducted for diagnosis and possible control/prevention of variations.
- Thus stratification is a simple, very effective QC tool for improving the quality.

Stratification ***Analysis procedure***



6. Define the scatter diagram. Mention its types.

SCATTER DIAGRAM

What is it?

- ***The scatter diagram*** is a simple graphical device to depict the relationship between two variables.
- A scatter diagram is composed of a horizontal axis containing the measured values of one variable (independent, i.e., cause) and a vertical axis, representing the measurements of the variable (dependent, i.e., cause) and a vertical axis, representing the measurements of the variable (dependent, i.e., effect).
- This diagram display the paired data as cloud of points. The density and direction of the cloud indicate how the two variables influence each other.
- Although this diagram cannot prove that one variable causes the other, but they do indicates the existence of a relationship as well as the strength of that relationship.

Types of Scatter Diagram Patterns

The possible patterns i.e., shapes of clouds are depicted in Fig.(a) to (f).

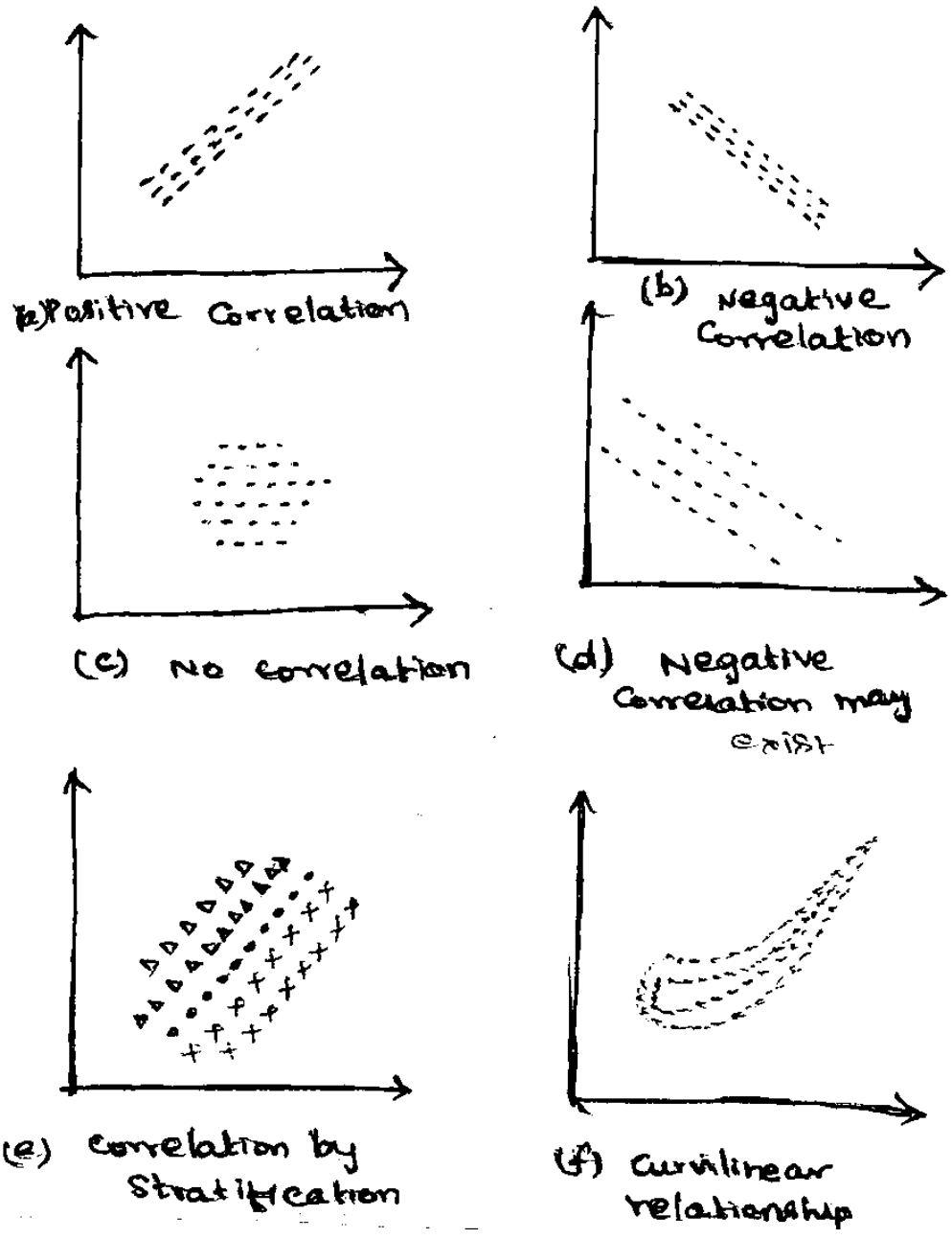
When do we use it?

- The purpose of the scatter diagram is, therefore, to display what happens to one variable when another variable is changed.
- This diagram is used to understand, why particular variations occur and how they can be controlled.

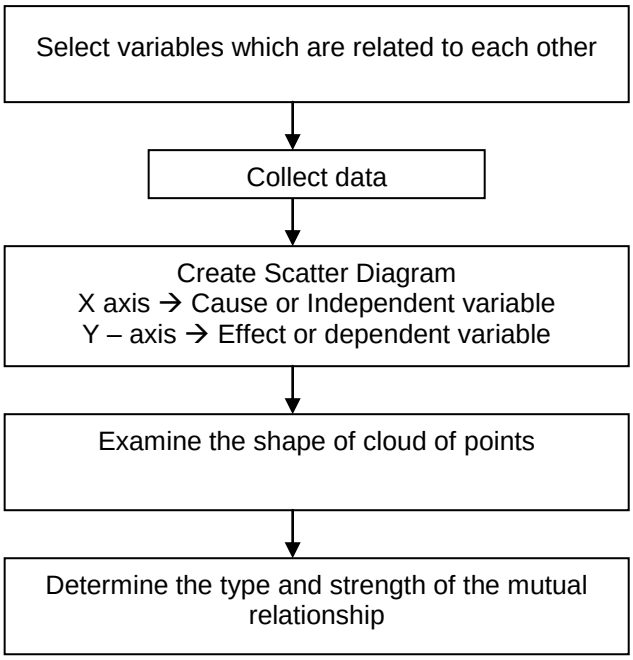
How do we construct it?

The sequence of steps used to construct the scatter diagram are outlined in Fig. 6.10.

Possible patterns in Scatter diagrams



Construction of a Scatter Diagram

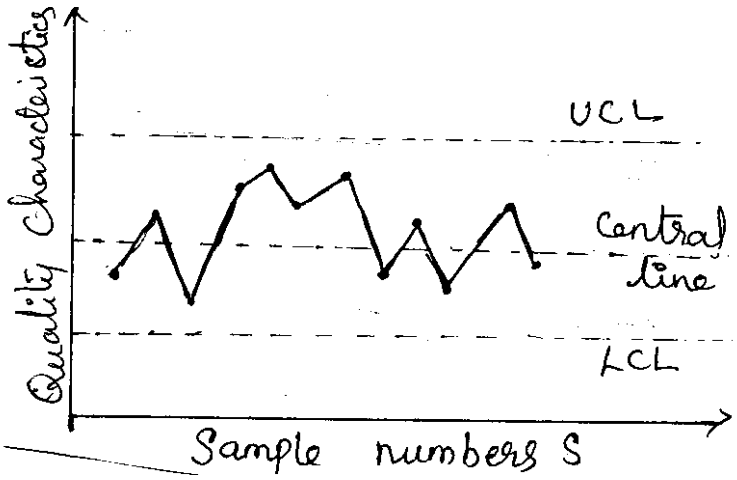


7. Define a control chart (or) shewart chart.

CONTROL CHART

What is it?

- ***A control chart,*** invented by Walter A. Shewart, is the most widely used tool in statistical process control (SPC).
- A control chart is a graph that displays data taken over time and the variations of this data.
- A histogram gives a static picture of process variability, whereas a control chart illustrates the dynamic performance (i.e., performance over time) of the process.
- The control chart is based on a series of random samples taken at regular intervals.
- The general form of the control chart is shown in Fig. 6.11.



The chart consists of three horizontal lines that remain constant over time: a center a lower control limit (LCL), and on upper control limit (UCL). The center is usually set at the normal design value. The UCL and LCL are generally set at +3 standard deviations of the sample means.

If a sample drawn from the process lies inside these (UCL and LCL) limits, it means ***the process is in control.*** On the other hand, if the sample lies outside these limits, then the process is said to be out of control. So appropriate corrective action is necessary to eliminate the condition.

Type of Control Charts

The two basic types of control charts are:

Control charts for variables* **-** for measurable data such as time, length, temperature, weight, pressure, etc.

Control charts for characteristics*- for quantifiable data such as number of defects, typing error in a report, etc.

When do we use it?

The purpose of a control is to identify when the process has gone out of statistical control, thus signaling the need for some corrective action to be taken.

8. Briefly discus the seven book of quality.

ANS : Please Refer the answer from question no (1) to (6) fully.

9. Given the following frequency distribution, calculate the mean.

Weekly wages (in Rs.)	Number of workers	Weekly wages (in Rs.)	Number of workers
125-175	2	375-425	4
175-225	22	425-475	6
225-325	19	475-525	1
275-325	14	525-575	1
325-375	3		

Weekly wages (in Rs.)	Mid-value x_i	Number of workers f_i	f_ix_i
125 – 175	150	2	300
175 – 225	200	22	4400
225 – 275	250	19	4750
275 – 325	300	14	4200
325 – 375	350	3	1050
375 – 425	400	4	1600
425 – 475	450	6	2700
475 – 525	500	1	500
525 – 575	550	1	550
		72	20050

We know that,

$$\bar{x} = \frac{\sum_{i=1}^{n} f_i x_i}{\sum f_i} = \frac{20050}{72} = \textbf{Rs.278.47Ans.}$$

10. Find the median wage of the following distribution:

Wages (Rs.)	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**
No. of labourers	**3**	**5**	**20**	**10**	**5**

Solution:

Wages (Rs.)	Mid-value x_i	Number of workers f_i	Cumulative frequency
20 – 30	25	3	3
30 – 40	35	5	8
40 – 50	45	20	28
50 – 60	55	10	38
60 – 70	65	5	43

$$\sum f_i = 43$$

Here $\frac{N}{2} = \frac{43}{2} = 21.5$

The cumulative frequency just greater than 21.5 is 28. Hence the class corresponding to the c.f 28 is 40 – 50 which is the median class.

We know that, Median $= l + \frac{\frac{N}{2} - c}{f} \times h$

Here l = Lower limit of the median class = 40
h = Length of the median class = 10
f = Frequency of the median class = 20
c = cumulative frequency of the class preceding the median class = 8

$$\therefore Median = 40 + \frac{\left(\frac{43}{2} - 8\right)}{20} x10 = \textbf{46.75 Ans.}$$

11. The following are scores of two batsmen Sachin and Dravid in a series of innings:

Sachin	**12**	**115**	**6**	**73**	**7**	**19**	**119**	**36**	**84**	**29**
Dravid	**47**	**12**	**16**	**42**	**4**	**51**	**37**	**48**	**13**	**0**

Who is the better score getter and who is more consistent?

Solution:

x	d(=x-51)	d^2	y	δ(=y-51)	δ^2
12	-39	1521	47	-4	16
115	64	4096	12	-39	1521

6	-45	2025	16	-35	1225
73	22	484	42	-9	81
7	-44	1936	4	-47	2209
19	-32	1024	51	0	0
119	68	4624	37	-14	196
36	-15	225	48	-3	9
84	33	1089	13	-38	1444
29	-22	484	0	-51	2601
Total	-10	17508		-240	9302

For Sachin : Arithmetic mean, $\bar{x} = 51 + \frac{\sum d}{n} = 51 - \frac{10}{10} = 50$

Standard deviation, $\sigma_1 = \sqrt{\frac{\sum d^2}{n} - \left(\frac{\sum d}{n}\right)^2}$

$= \sqrt{\left[1750.8 - (-1)^2\right]} = 41.8$

$\therefore$ Coefficient of variation $= \frac{\sigma_1}{\bar{x}} = \frac{41.8}{50} \times 100 = 83.6\%$

For Dravid: Arithmetic mean, $\bar{y} = 51 + \frac{\sum \delta}{n} = 51 - \frac{240}{10} = 27$

Standard deviation, $\sigma_2 = \sqrt{\frac{\sum \delta^2}{n} - \left(\frac{\sum \delta}{n}\right)^2}$

$= \sqrt{\left[930.2 - (-24)^2\right]} = 18.8$

$\therefore$ Coefficient of variation $= \frac{\sigma_2}{\bar{y}} \times 100 = \frac{18.8}{27} \times 100 = 69.6\%$

Conclusion:

Since the mean of Sachin > Mean of Dravid, therefore **Sachin is a better score getter than Dravid . Ans**

Since coefficient of variation of Dravid < coefficient of variation of Sachin, therefore **Dravid is more consident than Sachin . Ans**

12. Write down the steps for constructing $\overline{X}$ and R chart.

CONSTRUCTION OF $\overline{X}$ AND R CHARTS

Step 1: select the characteristics for applying a control chart.
Step 2: Select the appropriate type of control chart.
Step 3: Collect the data.
Step 4: Choose the rational sub-group i.e., sample.
Step 5: Calculate the average ($\overline{X}$) and range (R) for each sample.
For example, if a sub-group contains 5 items whose dimensions (say diameter or length or weight or etc.) are x_1, x_2, x_3, x_4 and x_5, then

Sub – group average, $\overline{X} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5}$

And subgroup range,

R=Maximum value – Minimum value

Step 6: Calculate the average of the averages ($\overline{\overline{X}}$) and average of range ($\overline{R}$).

Let N = Number of sub – groups.

Then, average of averages (or grand average is given by

$$\overline{\overline{X}} = \frac{\sum \overline{X}}{N}$$

Similarly average of range ($\overline{R}$) is given by

$$\overline{X} = \frac{\sum R}{N}$$

Step 7: Calculate the control limits for $\overline{X}$ and R charts.

(a) Control limits of $\overline{X}$ chart:

Control limit or centre line, $CL_{\overline{X}} = \overline{\overline{X}}$

Upper control limit, $UCL_{\overline{X}} = \overline{\overline{X}} + A_2\overline{R}$

And lower control limit, $LCL_{\overline{X}} = \overline{\overline{X}} + A_2\overline{R}$

Where A_2 = Factor or constant for $\overline{X}$ chart, taken from the Table.

Step 8: Plot CL, UCL and LCL on the chart.
Step 9: Plot individual $\overline{x}$ and R values on the chart.
Step 10: check whether the process is in control or not.
Step 11: Revise the control limits if the points are outside.

13. The following table gives the average and range in kilograms for tensile tests on an improved plastic cord. The subgroup size is 4. Determine the trial central line and control limits for $\overline{x}$ and R charts.

If any points are out of control, assume assignable causes, and determine the revised limits and central line.

Subgroup Number	$\overline{X}$	R	Subgroup Number	$\overline{X}$	R
1	476	32	14	482	22
2	466	24	✓15	506	23
3	484	32	16	496	23
4	466	26	17	478	25
5	470	24	18	484	24
6	494	24	✓19	506	23
7	486	28	20	476	25
8	496	23	21	485	29
9	488	24	22	490	25
10	482	26	✓23	463	22
11	498	25	24	469	27
✓12	464	24	25	474	22
13	484	24			

☺Solution: (a) to find control limits for $\overline{X}$ and R charts:

$$\overline{\overline{X}} = \frac{\sum \overline{X}}{N} = \frac{476+466+484+466+.....+469+474}{25} = \frac{12063}{25} = 482.52$$

$$\overline{R} = \frac{\sum R}{N} = \frac{32+24+32+26+.....+27+22}{25} = \frac{626}{25} = 25.04$$

For a subgroup size of 4, Table gives the following factors:

A_2 = 0.73;
D_3 = 0;
D_4 = 2.28

For $\bar{X}$ chart:

Control limit or central line, $CL_{\bar{X}} = \bar{\bar{X}} =$ **482.52Ans.** ☜

Upper control limit, $UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R} = 482.52 + 0.73(25.04)$ ☜
= **500.8Ans.**

Lower control limit, $LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R} = 482.52 - 0.73(25.04)$ ☜
=**464.24Ans.**

For R chart:

Control limit or central line, $CL_R = \bar{R} =$ **25.04 Ans.**
Upper control limit, $UCL_{\bar{X}} = D_4\bar{R} = 2.28(25.04) =$ **57.09Ans.**
Lower control limit, $LCL_{\bar{X}} = D_3\bar{R} = 0(25.04) =$ **0Ans.**

(b) To find the revised control limits for $\bar{X}$ and R charts:

For $\bar{X}$ chart: For present $\bar{X}$ chart, UCL = 500.8 and LCL = 464.24. It can be seen that subgroup numbers 12, 15, 19 and 23 are not within the points i.e., control limits. In other words, these four points are out of control. Therefore we conclude that the process is also 'out of control'.

Revised control limits for $\bar{X}$ chart can be determined by removing the out of control points.

$$\therefore \bar{\bar{X}} = \frac{\sum \bar{X} - (464 + 506 + 506 + 463)}{N - 4} = \frac{12063 - 1939}{25 - 4} = 482$$

Control limit or central line, $CL_{\bar{X}} = \bar{\bar{X}} =$ **482 Ans.**

Upper control limit, $UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R} = 482 + 0.73(25.04)$
=**500.28 Ans.**
Lower control limit, $LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R} = 482 - 0.73(25.04)$
= 463.72Ans.

14. Define p, np, C and u-charts. State their purpose in detail.

P CHART

In the p chart, the quality characteristic of interest is the proportion (p for proportion) of non-conforming or defective units.

Fraction defective p, may be defined a the ratio of the number of defective articles found in any inspection to the total number of articles actually inspected.

Generally fraction defective is expressed as a decimal fraction.

Mathematically, $p = \frac{np}{n}$

Where p = Fraction defective,
np = Number of defectives, and
n = Number of items inspected in the sub-group.

Per cent defective is 100p. that is 100 times the fraction defective.

For actual calculation of the control limits fraction defective is used. However for charging percent defect is used.

Control Limits:

Let $\bar{p}$ = Average fraction defective $= \frac{\sum np}{\sum n}$

Control line or central line, $CL_p = \bar{p}$

Upper control limit, $UCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

And lower control limit, $LCL_p = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Purpose of the p chart

The purposes of p chart are:

To discover, identity and correct causes of bad quality.

To discover, identity and correct the erratic causes of quality improvement.

To discover the average proportion of defective articles submitted for inspection, over a period of time.

To suggest where it is necessary to use $\bar{X}$ and R charts to diagnose quality problems.
To determine the average quality level.

np CHART

Generally p and np charts are quiet same.
Whenever subgroup size is variable, p chart is used **If subgroup size is constant, then** np (also known as pn) chart is used.

When and why np chart is preferred over p chart?
When subgroup size is constant, the np chart is preferred over p charts.

Reasons: (i) The np chart saves one calculation for each subgroup, the division of number of rejects by subgroup size to get p.
(ii) Some people may understand the np chart more readily.

Control Limits for np chart:

Control limit or central line, $CL_{np} = n\bar{p}$

Upper control limit, $UCL_{np} = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$

And Lower control limit, $LCL_{np} = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$

Where $\bar{p}$ = Average fraction defective = $\frac{\sum np}{\sum n}$, and

n = Number of items inspected in subgroup.

c – CHART

- In the c – chart (c for count), the number of defects in the sample are plotted over time.
- The c-chart applied to the number of defects in a subgroup of constant size.
- The p and np charts control the fraction defective in the product whereas the c – chart controls the number of defects in the product. In other words, the control chart for defects is called as c-chart.
- The c-chart is based on Poisson distribution.

The situations where c-chart can be used are:

- Number of typographical errors on the printed page.
- Number of defective rivets in an automobile body.
- Number of rust spots on steel sheets.

- Number of defects such as cracks, block holes, undercuts, etc., in a casting or a welded piece.

Control Limits for c – chart

Let c = Number of defects, and
= Number of samples.
Then, Average number of defects,

$$\bar{c} = \frac{\text{Total number of defects in all samples}}{\text{Total number of samples}}$$

i.e., $\bar{c} = \frac{\sum c}{n}$

Control limit or central, $CL_c = \bar{c}$

Upper control limit, $UCL_c = \bar{c} + 3\sqrt{\bar{c}}$

And Lower control limit, $LCL_c = \bar{c} - 3\sqrt{\bar{c}}$

u-CHART

When the subgroup size varies from sample to sample, then the u-chart is used. u-chart controls the number of defects per unit.

Control Limits for c – chart

In u-char, the control limits will vary from sample to sample.

$$\bar{u} = \frac{\text{Number of defects in a sample}}{\text{Number of units in a sample}} = \frac{c}{n}$$

$\therefore$ Control limit or central, $CL_u = \bar{u}$

Upper control limit, $UCL_u = \bar{u} + 3\sqrt{\frac{\bar{u}}{n}}$

And Lower control limit, $LCL_u = \bar{u} - 3\sqrt{\frac{\bar{u}}{n}}$

15. Compare the variable charts and Attribute charts.

Comparison of three types of control charts

Statistical measure plotted	Average $\bar{X}$ and range R	Percentage non-conforming (p)	Number of non-conformities (c)
Types of data required	Variable data (measured values of a characteristic)	Attribute data (Number of defective units of product)	Attribute data (number of defects per unit of product)
General field of application	Control of individual characteristics	Control of overall fraction defective of a process	Control of overall number of defects per unit
Significant advantages	Provides maximum utilization of information available from data Provides detailed information on process average and variations for control of individual dimensions	Data required are often already available from inspection records. Easily understood by all personnel. Provides an overall picture of quality.	Same advantages as p-chart but also provides a measure of defectiveness.
Significant disadvantages	Not understood unless training is provided, can cause confusion between control limits and tolerance limits. Cannot be used with go/no go type of data.	Does not provide detailed information for control of individual characteristics. Does not recognize different degrees of defectiveness in units of product.	Does not provide detailed information for control of individual characteristics.
Sample size	Usually 4 or 5	Uses given inspection results for samples of 25, 50 or 100	Any convenient unit of product such as 50 m of wire or one computer set.

16. Explain briefly the concept of Six Sigma.

WHAT IS SIX SIGMA?

- **Six sigma** stands for six standard deviation from mean (sigma is the Greek letter used to represent standard deviation in statistics).
- Six sigma, similar to Zero Defect (ZD), is a philosophical benchmark or standard of excellence proposed by Philip Crosby.
- Six sigma methodology provides the techniques and tools to improve the capability and reduce the defects in any process.
- It was started by Motorola in 1987, in its manufacturing division.
- Six sigma strives for perfection. **It allows for only 3.4 defects per million opportunities (or 99.999666 percent accuracy).** Here a defect can be anything from a faulty party to an incorrect customer bill.
- Six sigma improves the process performance, decrease variation and maintains **consistent quality** of the process output. This leads to defect reduction and improvements in profits, product quality and customer satisfaction.
- Six sigma incorporates the basic principles and techniques used in business, statistics and engineering.

The objective of six sigma principle is to achieve zero defects products/process. It allows 3.4 defects per million opportunities.

WHY DO WE NEED SIX SIGMA?

(Three sigma quality is not enough. Why?)

We know that, the three sigma quality, i.e., the natural variability ($\bar{x} \pm 3\sigma$) is equal to tolerance (= upper specification limit – lower specification limit). It means, in normal distribution curve, only 0.27% of the output would be expected to fall outside the specifications limits.

The real meaning of 3σ concept: A medium aircraft consists of 10,000 different parts. At 3σ quality, 27 of those parts in an assembled aircraft would be defective. So three sigma quality level cannot be accepted as good enough quality level. So we have to increase the sigma level (i.e., reducing the number of defectives). In fact, even four sigma quality also not sufficient for the aircraft case. That's why six sigma quality level is preferred than 3σ and 4σ quality levels.

THE CONCEPT OF SIX SIGMA

Before studying the concept of six sigma, first let us re-introduce the concept of process capability ratio (C_P)

Process capability ratio,

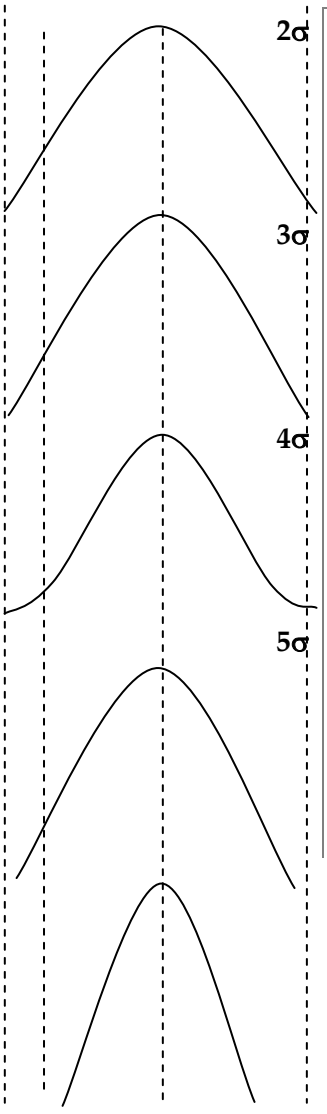
$$C_p = \frac{\text{Design width}}{\text{Process width}} = \frac{USL - LSL}{UCL - LCL}$$

USL = Upper Specification Limit;
LSL = Lower Specification Limit,

(Assumption is that process is centered midway the specification limits, i.e., there is no shift in process mean)

Process capability ratio measures how well the product requirements match with the process capabilities. The higher the value of Cp' the better the match between product and process.

Different Cp values with different process spreads (σ's)

Process variability	C_P	Total amount outside limits	Typical actions to be taken
 2σ	0.67	4.56% (45500 ppm)	Heavy process control, sorting rework, etc.
3σ	1.0	2700 ppm	Heavy process control, inspection
4σ	1.33	64 ppm	Reduced inspection, selected use of control charts
5σ	1.67	1 ppm	Spot checking, selected use of control charts

6σ	2	0.001 ppm	Reduced need for control, uniformity in process inputs

USL - Upper Specification Limit LSL – Lower Specification Limit

17. Describe the new seven management tools in detail.

MANAGEMENT TOOLS

Why?

It is a simple and effective tool. This approach focuses on the process (to reveal the causes), rather than the people.

Example: Why was there a delay in dispatch of good?

Cutting tool failed, resulting in delay in manufacture.
Why? The tools were reused?
Why? Ordered tool were not delivered?
Solution changes the dispatch schedule, if ever the tools were not delivered.

Forced Field Analysis

`Readers' attention is invited to the discussion in Chapter 2 on this topic.

Nominal Group Technique

This technique provides for ideas input from every one in the team and for effective decision making.

A team wants to decide upon a current complaint to attend. Every one in the team writes the problem on a paper, what they think is most important. They are listed in a chart and then the team members are asked to rank, from most important to least important. The ranking are given a numerical value starting from, say, on a 10 to 1 scale. Points for each problem is totaled and the ones with highest number of points, is considered o be the most important.

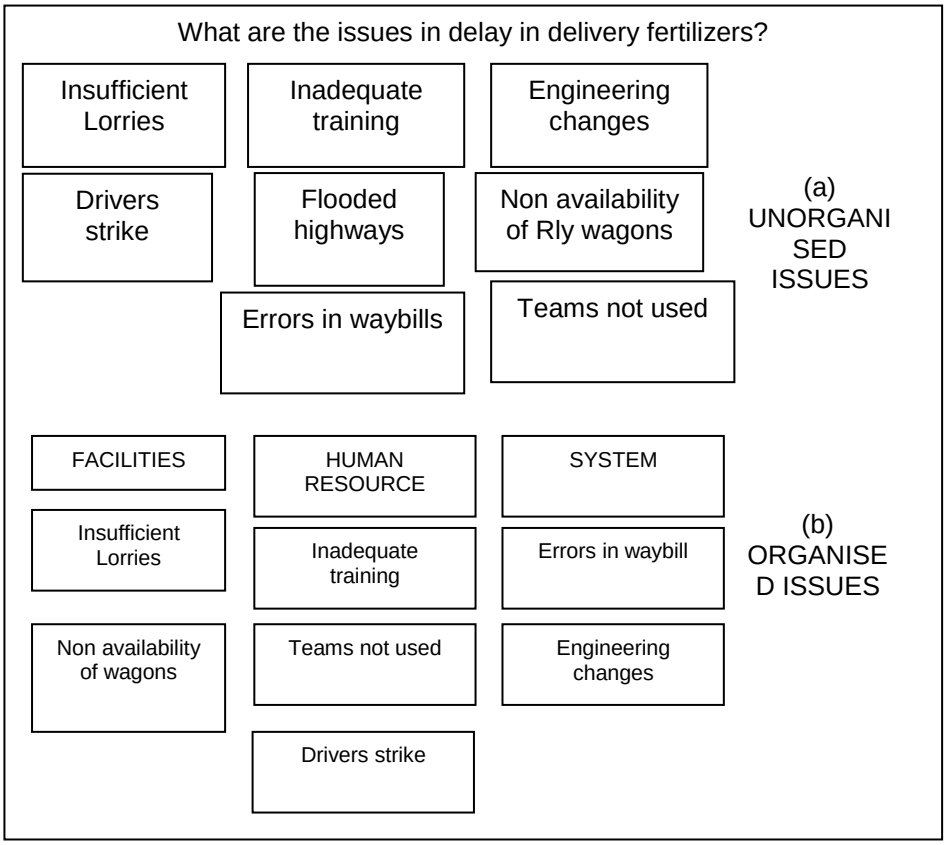
MANAGEMENT AND PLANNING TOOLS

Affinity Diagram

This diagram permits the team to creatively generate large number of ideas and then group them logically for understanding and possible solutions.

In this procedure, the issue is stated in full, then brainstormed using short sentences, posted them for the team to see. The ideas are sorted into logical groups and finally brief headings for each group are identified. The affinity diagram encourages team creativity, break down barriers, promote breakthroughs and motivate ownership of the process. Figure shows a typical example of this approach.

Affinity diagram



Inter-Relationship Diagram

This method is useful in clarifying the relationship in complex situations. The team will be able to classify the cause and effect relationship, so that the key elements can be used to solve the

problems.

Steps:

The team agrees on the statement of the problem.

Different ideas or issues from other methods are initially listed and named with alphabets, A B etc.

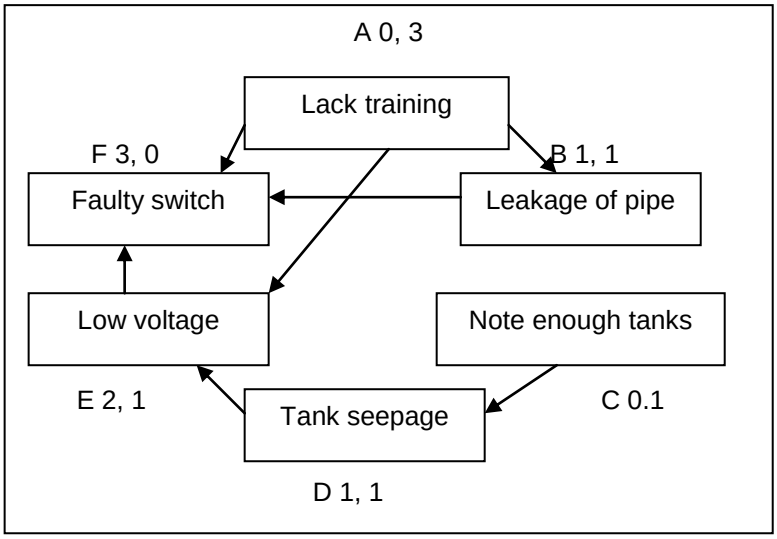
Begin with the issue A, and evaluate the cause and effect relationship with B. If A is stronger, draw the arrow A to B, by a thick line. Each issue is compared with A, one by one. Draw thick arrows wherever strong influence is identified. In this example, only issues B, E and F have relationship with A. The first trial is now over.

Second iteration is to compare B with issues C, D, E and F. The third step is to compare C with other issues. The fourth is compare issue D with E and F. The fifth step is to compare issue E with F.

The diagram may be reviewed and revised, if necessary.

The incoming and outgoing arrows are recorded as indicated, above the rectangle block. The completed diagram is shown in figure.

The issue with highest outgoing arrows (A), is the root cause and the issue with highest incoming arrows (F), is the critical issue. This method encourages the team work and effectiveness in identifying major problem and the root cause, to tackles further the problem.

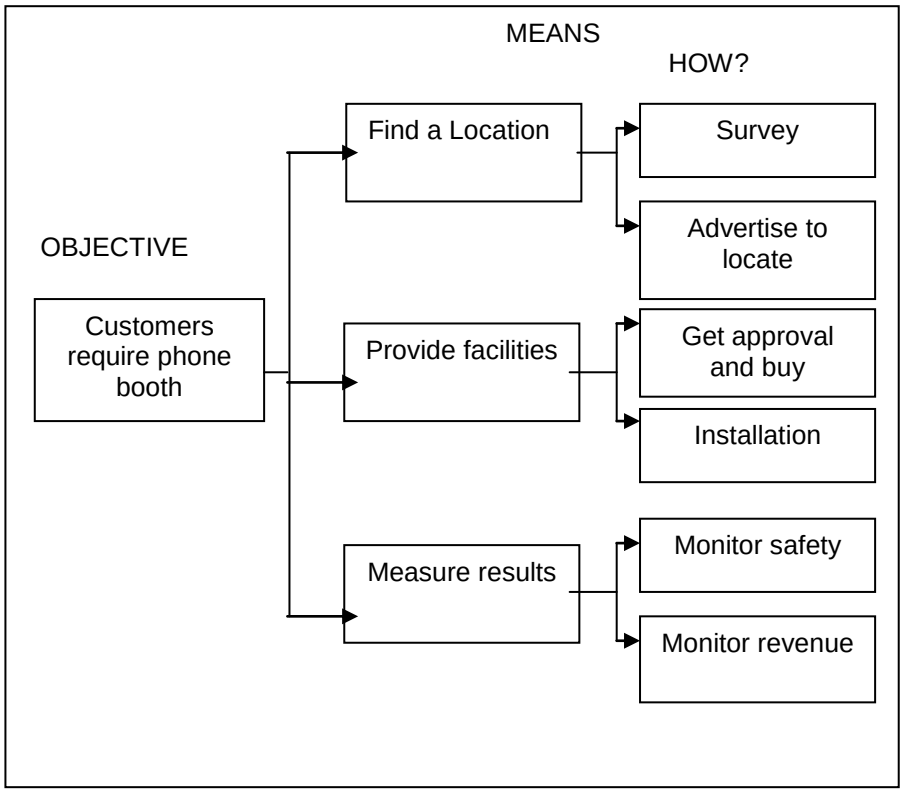


Interrelationship diagram

Tree Diagram

In the first step, the objective is traced from the interrelationship diagram, brainstorming and team participation. Using further brainstorming, major means are identified.

In the next step, the next level details are generated for study and solution. The question, "What is need next?" is repeated to two three levels, to complete the diagram. The diagram may be reviewed to find, if any actions are ignored or the action will yield expected results. An example of this approach is shown in figure. The merit of this method is that it encourages the team work and thoroughness.



Tree diagram

Matrix Diagram

The Matrix diagram helps to identify, analyse and rate the relationship among the variables. Data can be presented in tabular form, with numerical values or otherwise. Quality function Deployment, is a typical example of the matrix diagram. The standard formats that are used are: for 2 variables, L shaped; for 3 variables, T shaped, Y shaped and C shaped and for 4 variables, X shaped. L shaped matrix diagram for 2 variables are most frequently used.

Matrix diagram for uses of seven management tools

Tool	Use creativity	Analysis	Consen-sus	Action
Affinity diagram	⊙		O	Δ
Interrelationship diagram		O	⊙	
Tree diagram		⊙		⊙
Prioritisation matrix			O	
Matrix diagram		O	⊙	O
Process decision Program chart	⊙	⊙	⊙	O
Activity network Diagram			⊙	O

The seven management tools are presented in Table as matrix diagram. The steps involved in its construction are:
select the appropriate format

Determine the relationship symbols. Numerical values may be added when necessary
Complete the matrix, by analyzing each cell and insert appropriate symbol.

The matrix diagram approach encourages lateral thinking by the team, in terms of the relationships, their strengths and patterns.

Prioritization Matrix

In this method the issues, tasks, and characteristics are prioritized, based on weighted criteria, using a combination of tree and matrix diagram techniques. This is the most difficult, of the tools discussed.

Steps:

Construct an L shaped matrix combining the options, which are then lowest level of detail of the tree diagram with the criteria.

Determine the implementation criteria, using the nominal group technique or any other technique, with proper weight age criteria. Each team member submits the most important criteria on a piece of paper. They are listed on as flip chart and the team members submit the rank in another paper, ordering those listed criteria on the chart. Those criteria with greatest value are the most important. Three or four criteria are chosen.

Prioritize the criteria using the NGT. Each team member weighs the criteria so the total weight equals 100%. The results are shown in Table.

Table: Weightage for different criteria

Criteria	Member A	Member J	Member M	Total
Low cost	30	25	35	155
Easy to implement	40	30	30	210
Technology permits	15	20	25	100
Customer preference	20	25	20	110

Using NDT, the options are ranked, in terms of importance by each criterion; the results are averaged, and rounded to the nearest integer.

Compute the option importance score under each criterion, by multiplying the rank by the weight age of criteria. The details are shown in Table. The options with the highest total are those that should be implemented first.

Table: Improvement of a process by consensus criteria method

	CRITERIA							
Options	**Low cost**		**Easy to implement**		**Technology permits**		**Customer preference**	**Total**
1. Train supervisor	10x1.55	+	12x2.10	+	8x1.0	+	9x1.1	58.6
2. Purchase trucks	12x1.55	+	8x2.10	+	9x1.0	+	7x1.1	52.1
3. Have teams of 4 men	8x1.55	+	7x2.10	+	10x1.0	+	6x1.1	43.7
4. Training clerks	6x1.55	+	6x2.10	+	8x1.0	+	5x1.1	35.4

Process Decision Program chart

The Process decision program chart avoids unexpected developments and identifies possible counter measures. Figure shows an example of this technique.

Level 1 objective		**Plan Seminar**		
Activities	Call for paper & acceptance	Registration	Conduct Proceedings	Boarding & Lodging
Level 2 What if?	Power Supply fails	Minister arrives Late	Printed proceedings arrived late	Too long Session

Level 3 counter Measures	Have a stand by generator	Gave the collector to Inaugurate	Start the session	Send it by Post	Produce the present action

Initially the team states the objective that is to plan a successful industrial seminar. Those activities are listed in the first level, which are, call for papers, screening and acceptance, registration, and conduct proceedings and arranging Boarding and lodging facilities. The activity of conducting the proceedings is explained hereinafter. The team is brainstormed to determine what could go wrong with the seminar proceedings, and these are shown in Level 2 i.e., 'what if level'. Countermeasures are discussed and listed in the last level. Now the countermeasures are evaluated and the optimal ones are selected and marked O, and rejected ones are marked, X, as shown in the figure.

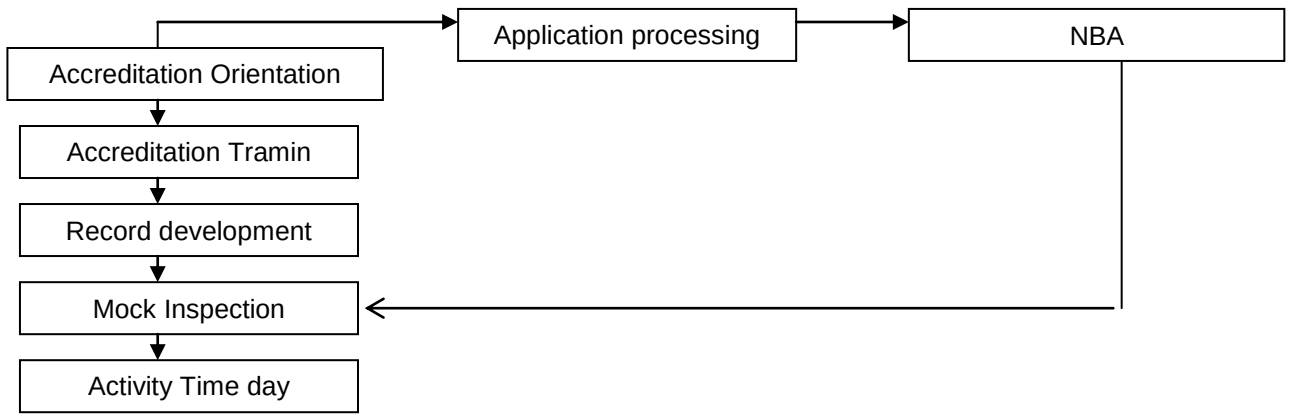
This method is preferred if the task is new or unique, complex, or potential failure has great risks. It provides a means to effectively minimize uncertainty in implementation stage.

Activity Network Diagram

PERT, CPM, and Arrow diagram are the typical variations of this diagram. They allow the team to schedule the project efficiently. The details such as the critical path, project completion time, simultaneous tasks, and precedence relationships are obtained from this diagram.

Steps:

- The team brainstorms or documents all the activities to complete the project.
- The first task is identified and fixed on the extreme left of the board.
- The tasks done simultaneously are placed in parallel.
- Steps (b) and (c) are repeated until all the tasks are located on the board in correct sequence, as shown in figure.
- Number all activities and draw the corresponding arrows. Activity times are recorded in the lower left box. It may be hours, days, weeks or months.
- Find the critical path, after completing the details of box in each activity.



Activity Network Diagram

The critical path is the path along which all the activities are completed in the minimum time.

The advantages of this method are:

a. A realistic project execution time is determined.
b. Bottlenecks are identified and when necessary, corrective actions can be planned.
c. Focus is made on the activities lying in the critical path. Time-cost trade off can be worked out, to complete the project earlier, with optimum additional cost.

UNIT – IV

PART - A

1. What is meant by benchmarking?

Benchmarking is defined as a systematic method. By which organizations can measure themselves against the best industry practices.

2. What are the six steps in benchmarking process?

a. Deciding what to benchmark
b. Understanding current performance
c. Planning
d. Studying others
e. Learning from the data
f. Using the findings and taking action.

3. What are the three types of benchmarking?

a. Internal benchmarking
b. Competitive benchmarking
c. Process benchmarking

4. What are the three techniques for studying other organizations?

1. Questionnaires

2. Site visits
3. Focus groups

5. What is meant by quality function deployment(QFD)?

Quality function deployment (QFD)is a TQM tool which ensures that customers requirements are met throughout the design process also in the production systems.

6. What are the three classes of customer needs?

- **a.** Dissatisfiers are the needs that are expected in a product (or) service.
- **b.** Satisfiers are needs that customers say they want.
- **c.** Excites Delighters are new (or) innovative features that customer do not accept.

7. What is meant by the voice of the customer?

The customers requirement is known as the voice of the customer. QFD provides of means of translating customer requirements (voice of the customer) in to the appropriate technical requirements for each stage of product development and production.

8. Write about house of quality?

The primary planning tool in QFD is the House of quality. House of quality is a set of matrix used to translate the voice of the customers in to technical design requirements that meet specific target values and characteristics of the final product. Because of its structure it is referred to as the house of quality.

9. What is the concept of QFD?

The concept of QFD is to ensure that the voice of the customer is carried through out the each stage.

10. What are the taguchi's quality loss functions?

Taguchi has defined quality as the loss imparted to society from the time a product is shipped.

There are three common quality loss functions.

- **a.** Nominal the best
- **b.** Smellers the betters
- **c.** Larger – the – betters

11. Define total productive maintenance (TPM).

Total productive maintenance is defined as keeping the running plant and equipment at its highest productive level with the co operation of all areas of organization.

12. What is meant by predictive maintenance and preventive maintenance?

Predictive maintenance is the process of using data and statistical tools to determine when a piece of equipment will fail.

Preventive maintenance is the process of periodically performing activities such as lubrication on the equipment to keep it running.

13. Name different loss measurement in TPM?

Down time losses planned-unplanned
Reduced speed losses
Poor quality losses.

14. What is meant by availability?

Down time losses are measured by equipment availability (A) using the equation.

Availability $A = \frac{T}{P} \times 100$

Where T= Operating time (P-D)
P- Planned operating time
D- Down time

15. What is meant by performance efficiency?

Reduced speed losses are measured by tracking performance efficiency using the equation

Performance efficiency $E= \frac{C \times N}{T} \times 100$

Where C – Cycle time

N- Number of units produced.

16. What is meant by failure mode and effect Analysis (FMEA)

Failure mode and effect analysis (FMEA) is an analytical technique which combines the technology and experience of the people.

. To identify foreseeable failure modes of a product (or) process.
. To plan for its elimination

17. Define reliability.

Reliability is defined as the probability of a product performing satisfactorily without failure of a specified function under specified conditions for a specified period of time.

18. What are the three main categories of failure?

a. Debug
b. Chance
c. Wear out

19. What is debug failure?

Debug includes a high failure rate at the initial stages because of inappropriate use or flows in the design (or) manufacturing.

20. What is meant by change failure?

Chance is the failure of the product due to accidents poor maintenance (or) limitations on the design

21. What is meant by wear out failure?

Wear out covers failure after the product (or) process has performed as expected for the amount of time given by the manufacturers as the product (or)process life.

A successful design (or) process should ideally fail only in the wear out method.

22. What are the two main techniques for reliability analysis?

Failure mode effect and critically analysis (FMECA) also called FMEA.
Fault tree analysis (FTA)

23. Explain FMEA?

a. In FMEA
b. Potential failures are first identified
c. Terms of failure modes
d. For each failure mode the effect on total system is them identified .finally a plan is developed and action is take to minimize the probability of failure or to minimize the effect of failure.

24. What are the two important types of FMEA?

Design FMEA
Process FMEA

25. What is the use of design FMEA?

Design FMEA is used in the design process by identifying known and fore seeable failure modes and them ranking failures according to relative impact on the product.

26. Write some effects of failure?

Noise
Vibration
Erratic operation
Poor performance
Lack of stability

27. What is meant by severity(s)?

Severity is the assessment of the seriousness of the effect of the potential failure to the next component, subsystem, system (or) customer.

28. Mention the stages of FMEA?

There are four stages in FMEA which are given below.

- Specifying possibilities
- Quantifying risk
- Correcting high risk causes
- Re evaluation of risk

29. Mention the types of FMEA?

There are several types of FMEA as follows

- **a.** Design FMEA
- **b.** Process FMEA
- **c.** Equipment FMEA
- **d.** Maintenance FMEA
- **e.** Concept FMEA
- **f.** Service FMEA
- **g.** System FMEA
- **h.** Environmental FMEA

30. Mention the steps of total productive maintenance (TPM).

i. Management should learn the new philosophy of TPM
ii. Management should promote the new philosophy of TPM.
iii. Training should be funded and developed for every one in the organization.
iv. Areas of needed improvement should be identified.
v. Performance goals should be formulated.

31. Define productive maintenance.

Productive maintenance is the process of using data and statistical tools to determine when a piece of equipment will fail.

32. Define preventive maintenance.

Preventive maintenance is the process of periodically performing activities such as lubrication on the equipment to keep it running.

33. Mention the objectives of total productive maintenance.

i. To maintain and improve equipment capacity
ii. To maintain equipment for life.
iii. To use support from all areas of the operation.
iv. To encourage input form all employers.
v. To use teams for continuous improvement

34. Define internal benchmarking.

Internal benchmarking involves seeking information from with in the same organization. For example from business units. Located in different areas. The main advantages of internal benchmarking are that access to sensitive data information is easier.

35. Define competitive benchmarking.

Competitive benchmarking is used where orga.organisations considers their positioning in relation to performance characteristics of key products and services . Product competitors are obvious choice to benchmark. Any organisations survival depend on its performance relative to competition.

36. Define process benchmarking.

Process benchmarking is also called functional benchmarking (or) genetic benchmarking . The process benchmarking is used when the fours on improving specific critical processes and operations.

37. Define debug.

Debug includes a high failure rare at the initial stages because of inappropriate use or flows in the design or manufacturing.

38. Define chance in categories of failure.

Chance is the failure of the product due to accidents poor maintenance or limitations on the design.

39. Define wear out in categories of failure.

Wear out covers failure after the product or process has performed as expected for the amount of time given by the manufacturers as the product or process life.

40. Mention the three common quality loss functions?

i. Nominal – the – best
ii. Smaller – the better
iii. Larger – the – better

PART - B

1. Explain briefly about benchmarking?

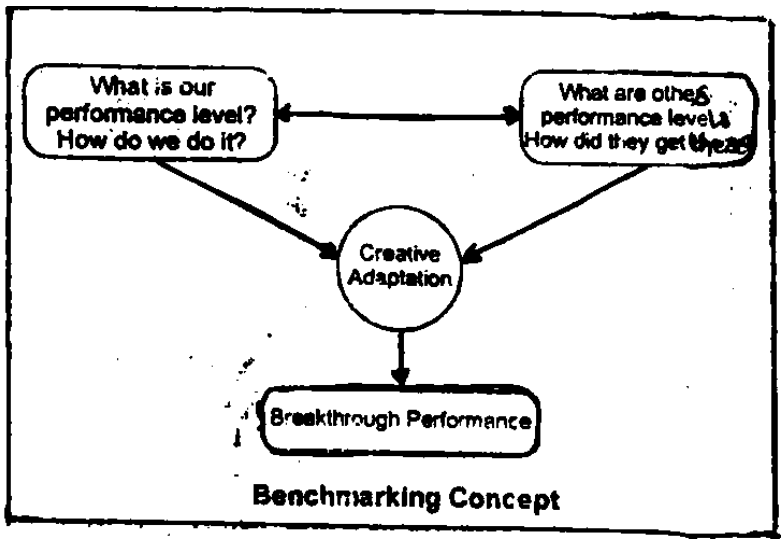
In military organizations, the process of gathering information about the enemy is known as Spying. In police department, the process of gathering information about particular people and their activities is called intelligence (or) vigilance. In industries the process of gathering information about other industrial activities are called industrial activities are called industrial intelligence. In the quality world the process of gathering information about the best quality product manufacturing company in order to copy follow and excel, is known as benchmarking. The foundation of all benchmarking is to gather data – from either internal (or) external sources-friendly or unfriendly –for future action to improve.

Hence Benchmarking is defined as a systematic method (or) popular TQM tool by which organizations can measure themselves against the best industry practices.

Benchmarking promotes superior performance and make organizations learn how the best in class do things, understand how these best practices differ from their own and implement change to close the gap. Benchmarking borrows ideas and adapts them to complete in the market. It is a tool for continuous improvement.

Benchmarking Concept

Benchmarking is the process of gathering, analyzing and evaluating the world outside your organisation and comparing it to your own. The concept of benchmarking is shown in fig.



Benchmarking measures performance of ' **best –in-class'** organizations determines how the best in class achieve those performance levels and uses the information as the basis for adaptive creativity and break through performance.

There are two key elements of benchmarking.

Measure performance of best in class with numerical values and fixit as a target. Given numerical value for your own performance and plot it against the target.

Now the managers have to find out reasons why their performance differs.

By understanding the differences, the managers are able to organize their improvement effort to meet the goal. Hence benchmarking is used to set the goals and objectives and meet them by improving processes.

2. Describe the reasons to benchmark?

i. Benchmarking helps organizations to develop their strengths and reduce their weaknesses.
ii. Benchmarking inspires managers and organizations to complete.
iii. Benchmarking arouses the organization to be alert whether it has fallen behind the competition or failed to take advantage of important operating improvements developed elsewhere.
iv. In traditional method the nest years goal is set by last years performance where as benchmarking allows goals to b e set based on external information.
v. When managers and workers are aware of external information they are usually much more motivated to attain the set goals.

vi. No one can argue that attaining the new goal is impossible since it can be proved that another organization have already achieved it.
vii. Benchmarking is time and cost efficient because benchmarking process involves imitation and adaptation rather than invention.
viii. Benchmarking reduces some of the planning, testing and prototyping effort since it copies the working model of an improved process.
ix. Benchmarking helps to identify the current position of a business and determine the priorities for improvement.
x. Benchmarking allows comparisons with previous benchmarking profiles and against recognised best practices.
xi. Benchmarking encourage regular monitoring of progress and continuous improvement.
xii. Benchmarking increases the competitiveness of the company by demonstrating environmental improvements to customers and shareholders.

3. Explain briefly about process of benchmarking?

There are six steps in benchmarking process which are given below.

i. Deciding what to benchmark
ii. Understanding current performance
iii. Planning
iv. Studying others
v. Learning from the data
vi. Using the findings and taking action

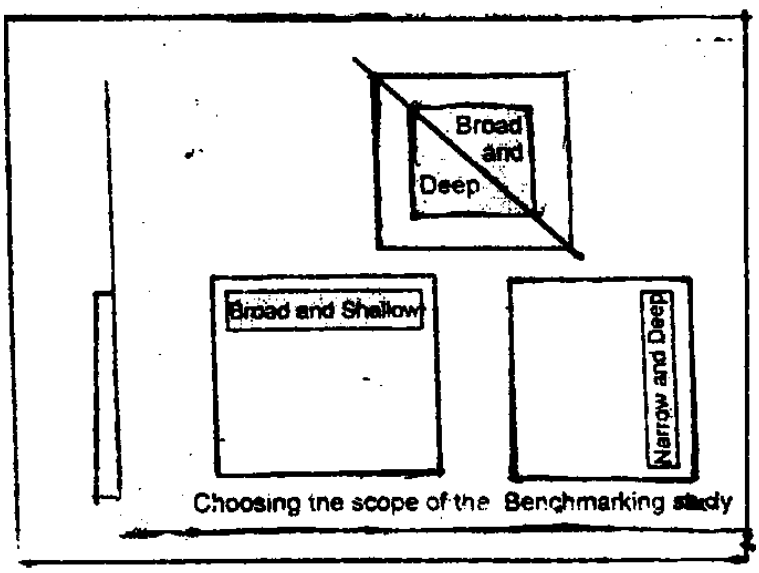
1. **Deciding what to benchmark**

The initial stage of benchmarking is to determine what to benchmark and against whom to do so. Improvements to best in class levels in some areas will contribute greatly to market and financial success, where as improvement in other areas will have no significant impact.

Benchmarking would be most appropriate if it is applied to high impact areas. By answering following questions, one can decide high impact areas to benchmark.

i. Which processes cause most trouble?
ii. Which processes contribute most to customer satisfaction and which do not perform up to expectations?
iii. What are the competitive pressures impacting the organization the most?
iv. What processes or functions have the most potential for differentiating out organization from the competition?

While benchmarking it is not advisable to choose too large a scope. The benchmarking study should be done quickly. If the scope is too large, then the benchmarking, team would find it difficult in the technicalities of benchmarking and take a year to complete study. Hence it is better to do 'Broad and shallow' bench marking study or 'narrow and deep' benchmarking study as shown in fig.



Pareto analysis also can be used for deciding what processes to benchmark.

2. Understanding current performance

Self analysis is an essential step in effective benchmarking. It is more important to know your own processes, products, and services before you attempt to understand the processes, products and services of another organization. Because without the thorough knowledge of your own products and processes, you may not realise the extent of your improvement opportunities.
Without an accurate understanding of yourself, it is very difficult to calculate the potential gap existing between your activities and those of best practice organization you wish to benchmark against.

The current performance can be understood by the following techniques.

i. Flow charts-This involves drawing of a diagram to show each step of the process to be analysed.
ii. Customer feedback This involves identifying customers and their needs to assess whether the process is performing well (or) not. Customers will be asked direct questions, and answers to these questions will show what aspects of process should receive priority.
iii. Measurement of the process
iv. Procedure manuals

3. Planning

One the internal processes are understood, a benchmarking team should be formed, A team represents different perspectives, special skills and a variety of business connections. The team will decide what type of benchmarking to perform, what type of data are to be collected, and the method of collection.

It is better to find appropriate benchmark partners. A benchmarking partner may be any person(or) organization that supplies you with information relating to the benchmarking process . The following are the benchmarking partners.

i. Literature sources (literature survey)
ii. Trade and Professional associations
iii. Consultants
iv. Stock holders
v. Suppliers of machinery process technology and materials.
vi. Customers

4. Describe briefly the types of benchmarking?

There are three types of benchmarking

i. Internal benchmarking
ii. Competitive benchmarking
iii. Process benchmarking

Internal benchmarking involves seeking information from within the same organization. For example from business units located in different areas. The main advantages of internal benchmarking are that access to sensitive data and information is easier. Standardised data are easy to obtain because problems of confidentiality don't exist. It needs less time and less resources

only. There are only fewer barriers to implementation as practices are relatively easy to transfer across the same organization. However real innovation will be lacking and '**best in class'** performance is most likely to be found through external benchmarking.

Competitive benchmarking performance benchmarking is used where organizations consider their positioning in relation to performance characteristics of key products and services. Product competitors are obvious choice to benchmark. Any organizations survival depends on its performance relative to competition. Benchmarking partners are drawn from the same sector. However it is a common for common for companies to benchmark though trade associations (or) third parties to protect confidentiality.

Process benchmarking is also called functional benchmarking (or) generic benchmarking . The process benchmarking is used when the focus on improving specific critical processes and operations. Benchmark partners are sought from best practice organizations that perform similar work (or) deliver similar services. Process benchmarking invariably involves producing process maps to facilitate comparison and analysis.

Hence the main function in the planning stage is to seek possible benchmark partners to get information.

The publicly available information are generated from trade journals, Internet, magazines published for industries, occupations and functions through success story articles, technical information and lists of top performing organizations.

Government agencies are also acting as source of technical information Government publications talking directly to government experts, having business contacts with the suppliers, consultants, customers and people within the organization are the **goal mines of information.**

Benchmarking planning process requires examination of several outside organizations. Normally a process is divided into number of sub processes. A single organization is not best in class for all sub processes. Hence multiple organizations should be studied for benchmarking.

B. Studying others

For studying other organizations there are three techniques used.

i. Questionnaires
ii. Site visits
iii. Focus Groups

Questionnaires are usually helpful to keep secrecy, ensure respondent anonymity and

confidentiality. The data are obtained from many external organizations and third party organizations. Questions can be asked through mail or by phone or in person. Questionnaires can be developed as preparation fro a site visit or as a check list during a site visit or as a follow up device.

Site visits are important to gain an in depth understanding of the systems and processes of the '**best in class** companies, who have been chosen as benchmark partners.

i. Site visits provide opportunity to see processes in action and for face to face contact with best in class operators. Site visits usually involve a tour followed by a discussion period. Site visits can be organized as follows.
ii. Send a letter to the quality director manager head of the concerned department.
iii. Follow up with a phone call to explain the reason for the project and its objectives.
iv. Obtain an agreement from the benchmark partner.
v. Plan the visit.
vi. Develop a site visit strategy and questionnaire.
vii. Conduct a visit in a processional manner. Be sure to stick to the agenda. The objective of the visit is to get answers for the important questions **not for entertainment.**
viii. Return some value to the host company benchmark partner.
ix. Send feedback to host company with thanks.

The initial contact for site visit can be made through marketing representatives, through occupational or trade groups (or) simply by on professional calling another.

Focus groups are nothing but panels of benchmarking partners brought together to discuss areas of mutual interest. The panels can be comprised of customers suppliers, members of a professional organization such as **American society for quality (ASQ)** and the people involved in joint benchmarking activities.

5. Learning from the Data

The Objective of this benchmarking process is to identify and analyse the gaps between the best practices and your own business process. Also these information and data are useful to identify performance gaps between benchmarking partners.

The answers for the following questions are objectives of the 'learning from the Data'.

i. In there a gap between organisation's performance and the performance of the best in class organizations?
ii. What is the gap?

iii. How much is it?
iv. Why is there a gap?
v. What does the best in class do differently to be better?
vi. If best in class practices were adopted what would be the resulting improvement?

There may be three types resulting from the benchmarking.

External process is better than internal process (a negative gap)
Internal process is better than external process (a positive gap)
Internal process performance is equal to external process performance (parity)
A major improvement are required for filling up negative gap,
Parity requires further investigations for improvement opportunities.
A positive gap revels the efficiency of the internal process and it leads to recognition for the internal process.

6. Using the findings and taking action

The objective of this process is to develop strategies and action plans to b ridge the negative gaps. The process should be changed to close the negative gap. To effect the change, the findings, should be communicated to the people within the organization who can enable improvement. The findings should be transformed as goals and objectives and action plans should be developed to implement new processes.

There are two groups of people who must agree on the change.

The process owners who are the people to run the process.
The top management who can enable the process by implementing changes into the planning process and providing necessary resources.

The process owners should be convinced and described how the best results were obtained from the external organizations studied.

The process changes will affect upstream and down stream operations as well as suppliers and customers. Therefore the top management should be well informed and convinced about the new goals and objectives in order to support the change.

The goals and objectives should be consistent with the implementation of the action plan so that the end result is the process superiority. The best results are obtained only when the process owners fully participate in the design and execution of the plan.

Benchmarking is a continuous process.

It is very much necessary to repeat the benchmarking process. In due course things are subjected to change. What was the state of the art yesterday may not be today. Hence benchmarking should be done continuously to pursue emerging new ideas. Some people may criticize that benchmarking comes from the idea of copying others. Benchmarking is find some one who executes a process better than you do and imitate what he does. But everyone should accept the truth. How can an organization even survive if it loses the track of its external environment?

5. Explain briefly about quality function deployment?

The Japanese have developed the concept of quality function deployment (QFD) **The Quality Function Development (QFD) is a TQM tool which ensures that customers requirements are met throughout the design process and also in the production systems.** QFD is basically a philosophy and a set of planning and communication tool that focuses on customer requirements in coordinating the design manufacturing and marketing of goods.

QFD provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production. The customer's requirement is known as the voice of the customer. These requirements are the collection of customer. These requirements are the collection of customer needs including all dissatisfies satisfiers and exciters delighters.

Note: There are three classes of customer needs

Dissatisfiers: are the needs that are expected in a product (or) service. In a car, **safety measures and cushioning seats** are known as dissatisfiers. These features are generally not stated by customers but assumed as given. If they are not present then the customer will b e **dissatisfied.**

Satisfier are the needs that customers say they want. **Air conditioning and compact Disc player** in a car are the examples of satisfiers. Fulfilling these needs creates **satisfaction.**

Exciters/delighters: are new (or) innovative features that customer do not expect. **Antilock brakes** and **collision avoidance systems** are known as examples of exciters delighters. The pressure of such unexpected features leads to high perceptions of quality.

While **satisfiers** are relatively easy to determine through routine marketing research, it takes special effort to elicit customer perceptions about **dissatisfiers** and **exciters/delighters.** In course of time exciters/delighters become satisfiers as customers become used to them and eventually satisfiers become dissatisfiers. Thus companies should continually innovate and study customer perceptions to ensure that needs are being met.

The customer requirements voice of the customer also referred to as **customer attributes.** Under QFD all operations of a company are driven by the voice of the customer, rather than discretion of top management (or) the opinions (or) desires of design engineers.

Technical features, also called **counter part characteristics** are the translation of the voice of the customer into technical language . QFD is employed to translate customer expectations, in terms of specific requirements into directions and actions in terms of engineering (or) technical characteristics that can be deployed through.

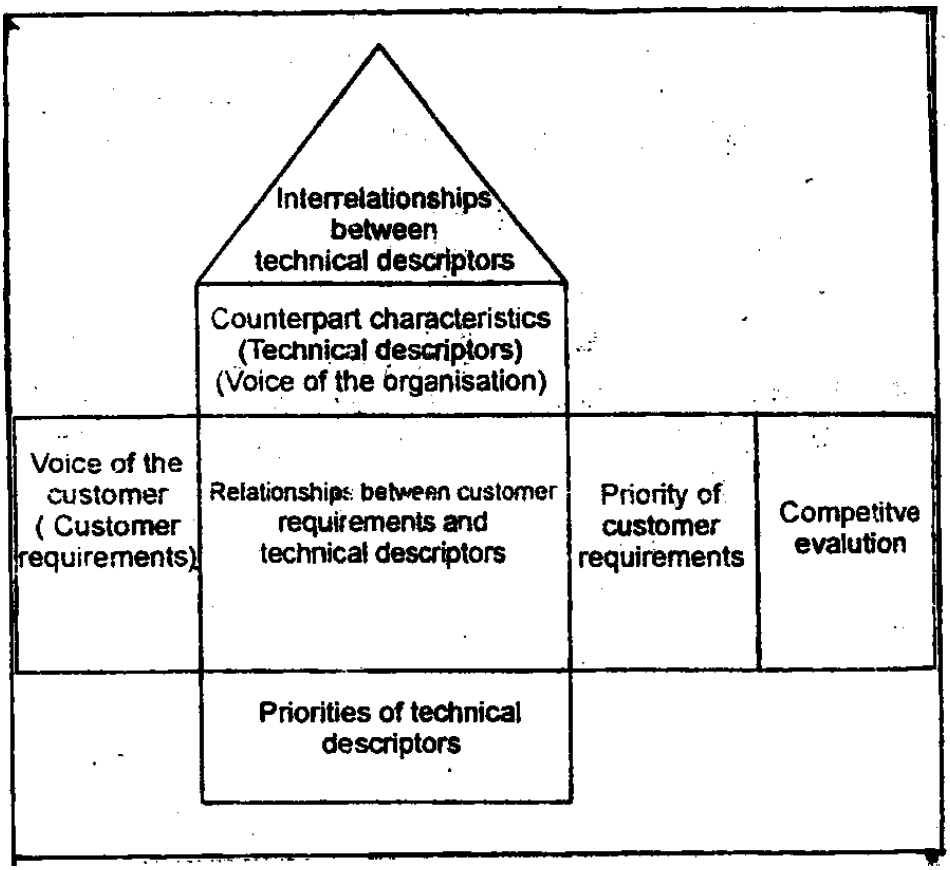
Product planning
Part development
Process planning
Production planning
Service industries

Organisations today use market research to decide what to produce to satisfy customer requirements. Some customers may not by able to explain their expectations. Confusion and misinterpretation are also a problem while a product moves from marketing to design to engineering to manufacturing. In this way the voice of customer is lost and the voice of the organization adversely enters the product design. Eventually, instead of working on what the customer expects work is concentrated on what the customer does not want . It is important that it is not advisable to improve something the customer did not want initially . By implementing QFD and organization will implement the voice of the customer in the final product (or) service.

Hence QFD enables the design phase to concentrate on the customer requirements thereby spending less time on redesign and modifications. This saved time reduces the developmental cost and also the additional income because the product enters the market sooner.

6. Explain briefly about house of quality?

The primary planning tool used in QFD is the House of Quality. House of Quality is a set of matrix used to translate the voice of the customers into technical design requirements that meet specific target values and characteristics of the final product. The customer requirement planning matrix is the basis for the QFD concept. Because of its structure as shown in fig it is referred to as the **House of Quality.**



Description of House of Quality

- On the left side is a listing of voice of the customer (or) customer requirements.
- On the right side are the priority of customer requirements and competitive products evaluation.
- The ceiling of the house contains technical descriptions
- The interior walls of the house are the relationships between customer requirements and technical descriptors. Customer expectations are translated into engineering characteristics technical descriptors.
- The roof of the house is the interrelationships between technical descriptors.
- The foundation of the house is the listing of priorities of technical descriptors.

Building the House of Quality and QFD process

- Building the House of Quality consists of six steps.
- Identify 'voice of the customer' (customer requirements)
- Identify technical descriptors.
- Relate the customer requirements to the technical descriptors.
- Conduct an evaluation of competing products.
- Evaluate technical descriptions and develop targets.
- Determine Which technical descriptors to deploy in the remainder of the production

process.

Note : Deploy means 'bring into effective action'

Step 1 : identify customer requirements

Market research plays an important role in determining what features are important to customers. `Questions such as

What does the customer expect from the product? and

"why does he buy the product ?' are important means of identifying customer requirements.

Beside market research information on customer needs comes from other sources also.

Sales people have first hand knowledge of customers needs, desires and comments about products. **Technicians** who repair products understand the reasons for product failure and hear the comments of customers. Other techniques such as **focus groups** can be used to learn about customer needs.

Example: to illustrate the development of '**House of Quality'** and QFD process we can use the design and development of a new text book- "Total Quality Management" by the publisher Air Walk publications.

The text book should meet the instructional needs and should enhance student ability to learn. The above two are the primary customer attributes. Such descriptions are not technical specifications but they represent the voice of the customer the **professor** who recommends the book and the **student** who uses it.

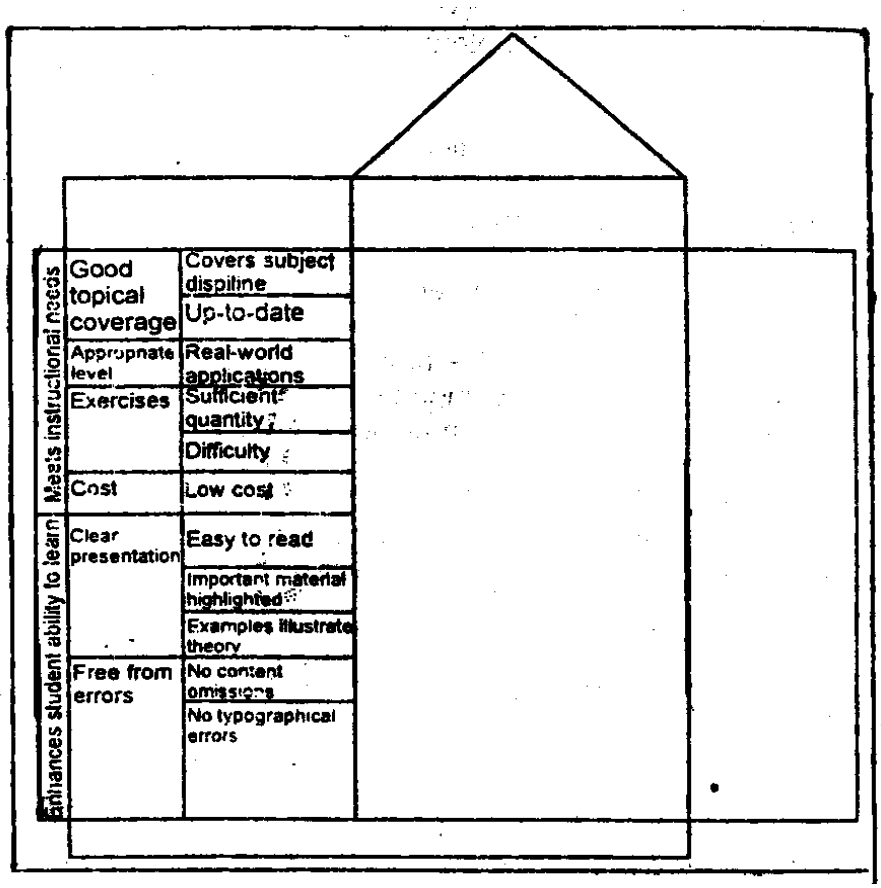
It is important that these attributes are the real needs of the customer and they should not be developed from the opinions of editors and authors. It is more important to hear the voice of **real customers,** and not rely on second hand opinions in determining customer needs.

While writing a text book authors must consider the needs of both professors and students. It is not advisable to solicit more information from professors and less information from students, because students are the end users of text books.

For medical representative the primary customer **is patient not a doctor**. Similar way for text book publisher, the primary customer is student not a professor. Because professor may recommend standard books with knowledge point of view while the **students the real end users** expect local author books with exam point of view.

Customer requirements are normally expanded into secondary and tertiary requirements as shown in figure. The figure shown the voice of the customer in the '**House of Quality'**

For a text book the primary customer requirement is to meet in structural needs. The secondary customer requirement is Good topical coverage appropriate level for the course and good exercises. Good exercise may be further expanded into sufficient quality and 'range of difficulty'. These are the **customer attributes** that are used as inputs to the **QFD** process.



Step 2 : identify technical descriptors (Design attributes)

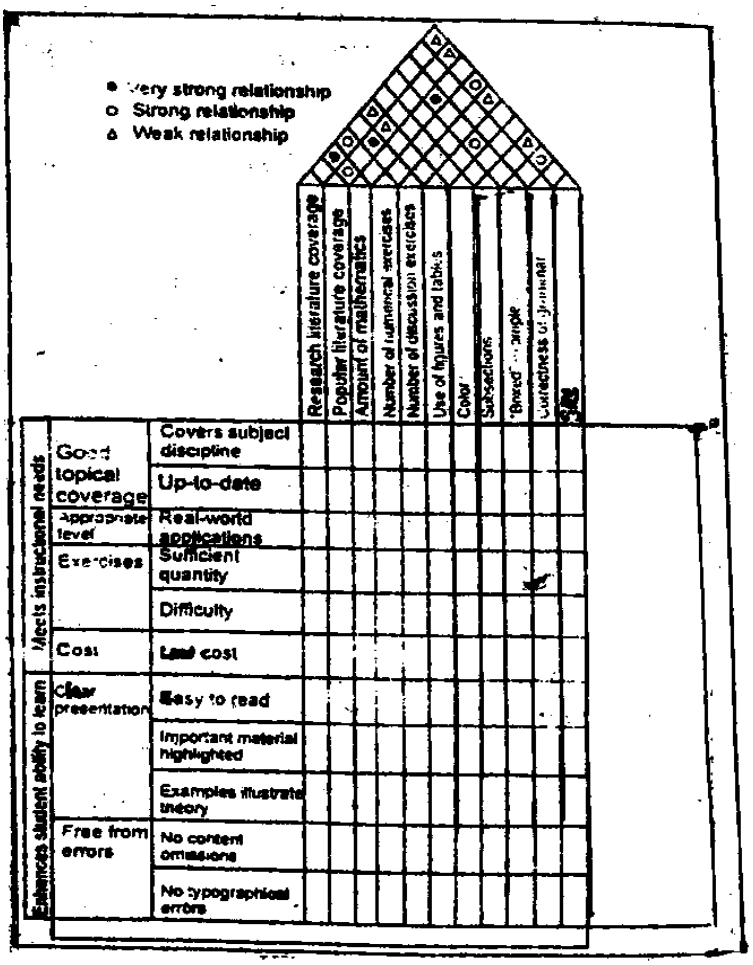
The technical descriptors are design attributes expressed in the language of designer and engineer. They represent the technical characteristics that should be deployed throughout the design manufacturing and service processes.

- The author and publisher of a textbook have a variety of technical characteristics including
- The amount of research literature to cite,
- The amount of popular literature for reference
- The number of numerical exercises
- The number of discussion exercises

Figures and tables etc
The roof of the 'House of Quality' interrelationships between any pair of technical descriptors. Various symbol are used for denoting these relationships.

• - Solid circle denotes a very strong relationship.
O - Circle denotes for a strong relationship.
Δ - Triangle denotes for a weak relationship.

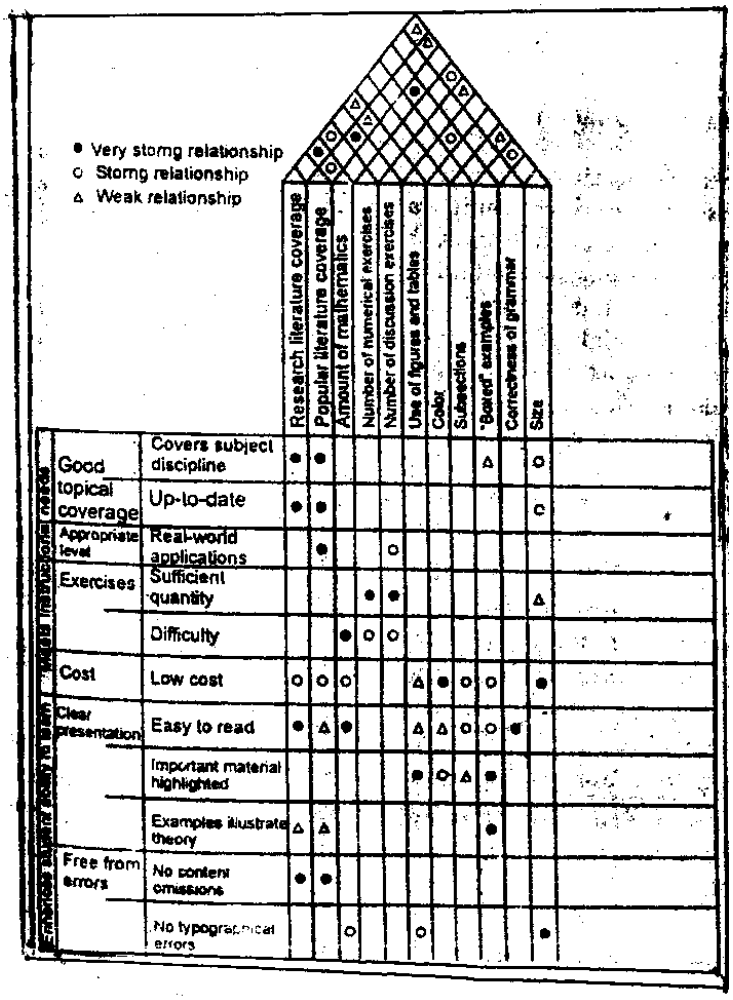
For example increasing popular literature improves the number of discussion exercises included in the book. However it will increase the size of the book, Thus a strong relationships exist among these characteristics. The roof and first floor of House of Quality shows these information as shown in figure.



Step 3 : Develop a relationship matrix between customer requirement and technical descriptors

We know that customer requirements are listed in the left column while technical characteristics are listed in the top. Various symbols are used to indicate the degree of relationship

in a manner similar to that used in the roof of the House of Quality. The lack of a strong relationship between a customer requirement and any technical characteristics shows that the final products will have difficulty in meeting customer needs.



For example the amount of research literature referenced in a textbook would have a strong relationship to the customer requirements namely
"covers subject matter"
"up to date" "easy to read"
"No content omissions" as shown in the figure.

Step 4: Competitive Evaluation

The customer competitive assessment is marked in the right side of the relationship matrix in the House of Quality. The numbers 1 through 5 are listed in the competitive evaluation column to indicate a rating of 1 for worst and 5 for best. Competitive evaluation helps to highlight the strength and weaknesses of our product when comparing with the competitive evaluation helps to highlight the strength and weaknesses of our product when comparing with the competitive products. This step enables designers to seek opportunities for improvements. The customer competitive assessment also contains an appraisal of where an organization stands relative to its major competitors in terms of each customer requirement.

This step links QFD to a company's strategic vision and allows priorities to be set in the design process. For example if an attribute receives a low evaluation on a competitors products then focusing on this attribute can help to gain a competitive advantages. Such attributes become a key selling points and help to establish promotion strategies.

In designing a text book the author and the publisher find that two competing text books A and B receive low evaluation 3 in easy to read. We know that this is an highly desirable attribute by the students. Hence by focusing on the attribute and using it as a key selling point a competitive advantage can be gained. Competitive evaluation matrix is shown in the right side of House of quality.

Step 5: Technical competitive Assessment

This Technical Competitive Assessment matrix is shown beneath the relationship matrix as shown in fig.

Similar to the customer competitive assessment, the test data are converted to the numbers 1 through 5; 1 for worst and 5 for best. These rankings can then be entered below each technical descriptor using the same numbers as used in the customer competitive assessment.

The technical competitive assessment is very mush useful for uncovering gaps in engineering judgment. If an organizations technical assessment shows its product to be superior to the competition then the customer assessment should show a superior assessment. If it is not so then there is a mistake in engineering judgment which should be corrected.

Target value

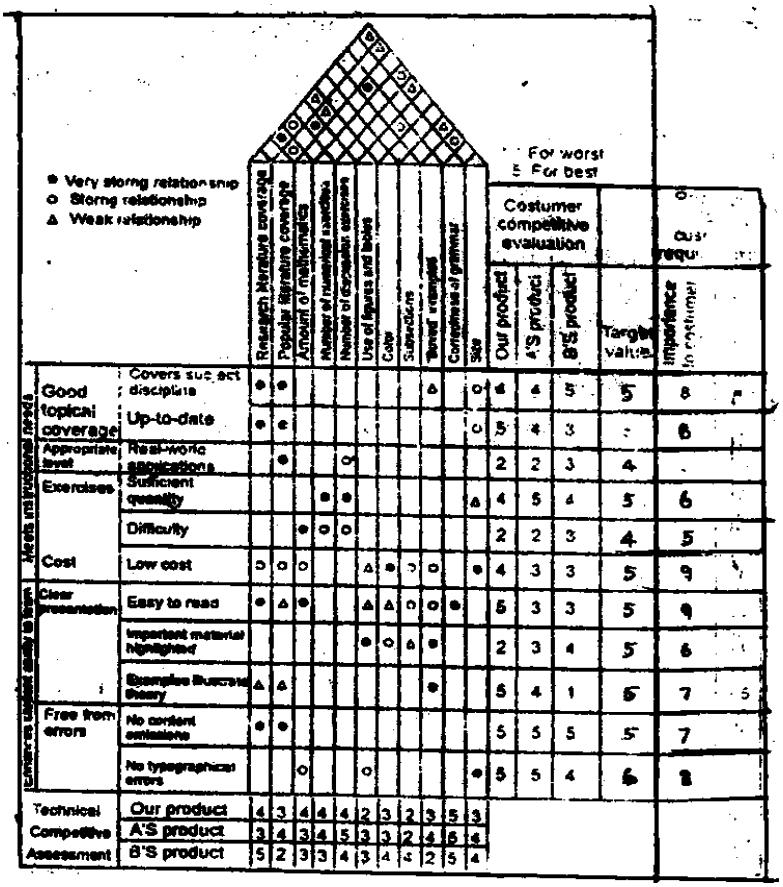
The target value column is used by the QFD team to decide whether they want to keep their product unchanged, improve the product (or) make the product better than the competition.

Step 6 Determine the priorities of customer requirements

In this step the matrix of priorities of customer requirements are listed In the extreme right side of House of quality. These prioritized customer requirements contain columns for importance to customer and sales point.

Importance to Customer

The QFD team ranks each customer requirement by assigning it a rating. Numbers 1 to 10 are used for ranking in which 1 is for least important and 10 is for most important i.e. the more important the customer requirement the higher the rating as shown in fig.
Covers subject discipline has ranking 8



'Low cost ' has ranking 9 and
'Easy to read' has ranking 9. These are the key customer requirements which should be given importance.

Sales point Sales point is a value in between 1 and 2 with 2 being the highest. The sales point indicates the QFD team how well a customer requirement will sell. The objective here is to promote the best customer requirement and remaining customer requirement that will help in the sale of the product.

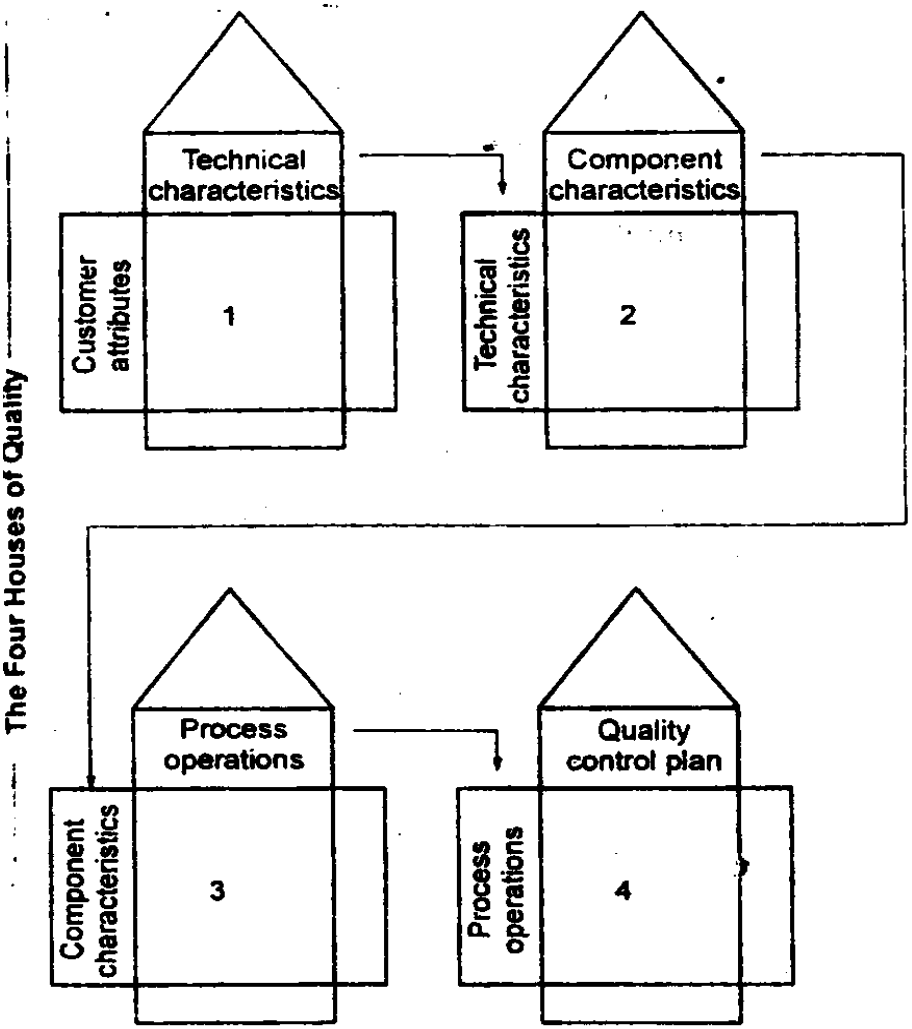
Step 7: Determine priorities of Technical Descriptors:

These prioritized technical descriptors contain degree of technical difficulty and target value. The QFD team identifies technical descriptors that are most needed to fulfill customer requirements and need improvement. These prioritized technical descriptors make up a block of rows corresponding to each technical descriptor in the house of quality below the technical competitive assessment.

7. Describe briefly about process of quality function deployment QFD?

The 'House of Quality' Provides marketing with an important tool to understand customer needs and it gives top management strategic decision. However it is only the first step in QFD process. The size of the customer must be carried throughout the production process by using three other 'House of Quality"

There are three other 'House of Quality ' Which are used to deploy the voice of the customer to Component part characteristics



Process operations

Quality control plan

As shown in fig.

The text book production process can be expressed with following stages.

Stage	Function
Acquisition	Proposal
	Review
	Contracting
Development	Writing
	Editing
Preproduction	Galleys
	Proofs
	Page make up

	Cover design
Production	Printing

The text book production process begins with proposal in which the author sends a manuscript to the publisher. After simultaneous review by eminent professors in that field, the author is given green signal to proceed with writing stage. After further reviews and editing the text goes into the preproduction stages of galleys, proofs, page layout and cover page design.

Galleys are used to check whether wordings, citations and other details are correct. Proofs provide a check on the final typesetting process. Page layout involves addition of pictures figures and complex tables. Cover page design involves the design of attractive cover. Finally the production of text book starts. In this stage various processes such as

- Film making
- Plate exposing
- Offset printing
- Cutting
- Folding of forms
- Composing
- Perfect binding
- Cutting and then
- Packing

The concept of QFD is to ensure that the voice of the customer is carried through out each stage.

The second house is similar to the first house but applies to subsystem and components.

In the third house the process plan is developed relating the component characteristics to key process operations. It represents the transition from planning to execution.

In the fourth house Quality control plans are developed and executed. In this house the appropriate level of quality is achieved by using proper control methods sample sizes and so on. In this preproduction stage, statistical process controls are taken by the printer and binder to ensure that a quality product is produced.

8. Mention the benefits of quality function deployment (QFD)

Quality Function Deployment (QFD) House of Quality is an effective management tool to

drive the design process and production process with the main aim of satisfying the customer needs. The benefits of QFD are

i. A systematic way of obtaining information and presenting it.
ii. Shorter product development cycle.
iii. Considerably reduced start up costs.
iv. Fewer engineering changes
v. Reduced chance of overnights during design process.
vi. An environment of team work
vii. Consensus decision
viii. Everything is preserved in writing.
ix. it facilitates identification of the causes of customer complaints and makes it easier to take prompt remedial action.
x. It is a useful tool for improving product quality.
xi. It is a useful tool for competitive analysis of product quality.
xii. It is a useful tool for competitive analysis of product quality.
xiii. It cuts down on rejects and rework at the production site.
xiv. It decreases claims substantially.
xv. Marketing benefits are obtained by identifying sales point.

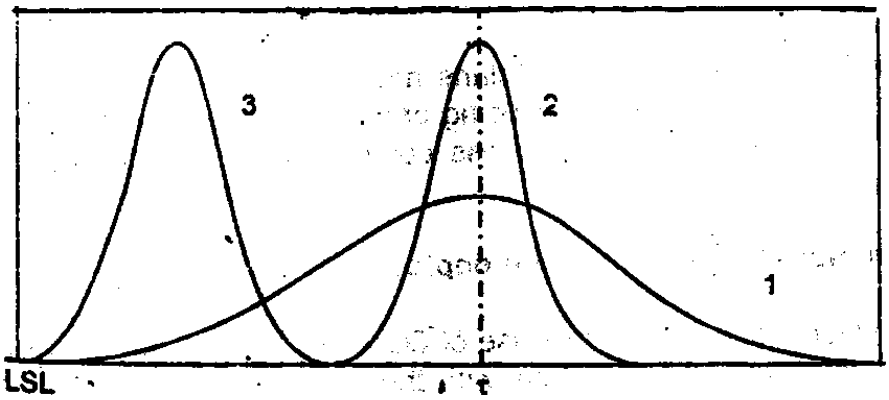
QMD makes the entire organization to constantly be aware of the customer requirements. Every QFD chart ie **House of Quality** is a result of the original customer requirements.
The main benefit of QFD is the customer Satisfaction

9. Explain briefly about taguchi's quality loss function?

Dr. Genichi Tauchi, a mechanical engineer who has won four Deming awards, has introduced the quality Loss Function concept which combines cost target and variation in one metric with specifications being of secondary importance. Further more he developed Robust Design in which noise factors are taken into account to ensure that the system functions correctly.

Taguchi has defined quality as the loss imparted to society from the time a product is shipped. Societal losses include failure to meet customer requirements failure to meet ideal performance and harmful side

Total loss = Producer's loss + Customer's loss



Polythene bag thickness loss to society

Effects. The various losses due to production are raw material, energy and labour consumed on unusable products or toxic by products.

Consider the following example to illustrate loss to society concept. There are three stages in the evolution of polythene bag thickness.

At (1) the process is just capable of meeting the specifications (USL and LSL) However its target is τ . By continuous effort, the production process can be improved by reducing the variations from the target τ as shown in curve (2)

When the efforts are taken to reduce the production cost the organization shifted the target closer to the LSL as shown in curve (3) This curve is a result of lowering the cost to the organization. However the polythene covers were not a strong as before. When farmers used the covers to protect rice, they tore and a substantial loss occurred to the farmers. In addition, the cost of rice increased as a result of supply and demand factors, thereby causing an increasing in rice prices and a further loss to society. As a result the company's reputation was suffered which lead t

a **Loss of market share.**

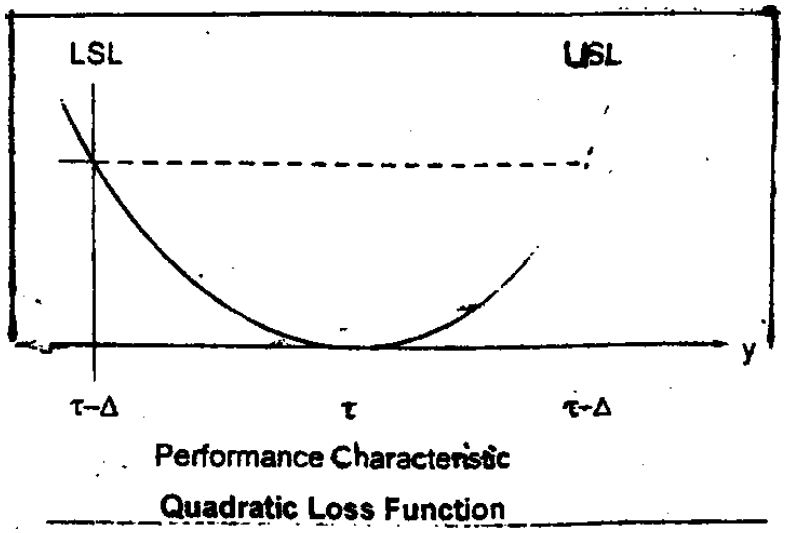
From this it is clear that **customers perceived quality as meeting the target rather than just meeting the specifications.**

There are three common quality loss functions

Nominal the best
Smaller the better
Larger the better

Nominal the best

Although Taguchi developed so many loss functions, many situations are approximated by the quadratic function which is called the nominal the best type.



The quadratic function is shown in figure. In this situation, the loss occurs as soon as the performance characteristic y departs from the target

At τ the loss is Rs .0
At LSL (or) USL the loss is Rs .A
The quadratic loss function is described by the equation
$L = k(y-y)^2$
Where L = cost incurred as quality deviates from the target.
Y = performance characteristic
τ = target
k == Quality loss coefficient

The loss coefficient is determined by setting $\Delta = (y - \tau)$ the deviation from the target. Where Δ is the USL (or) LSL the loss to the customer of repairing (or) discarding the product is Rs.A

Thus

$$k = \frac{A}{(y-\tau)^2} = \frac{A}{\Delta^2}$$

Problem

If the specifications are 9 ± 2 for a particular quality characteristic and the average repair cost is Rs. 150 determine the Quality loss function. Determine the loss at y=10

Solution

$A = 150; \Delta = y - \tau = 2$

Loss coefficient $k = \frac{A}{\Delta^2} = \frac{150}{2^2} = 37.5$

Thus L=k $(y-\tau)^2$ Quality loss function.

At y=10

L= $37.5(10-9)^2$

=37.5

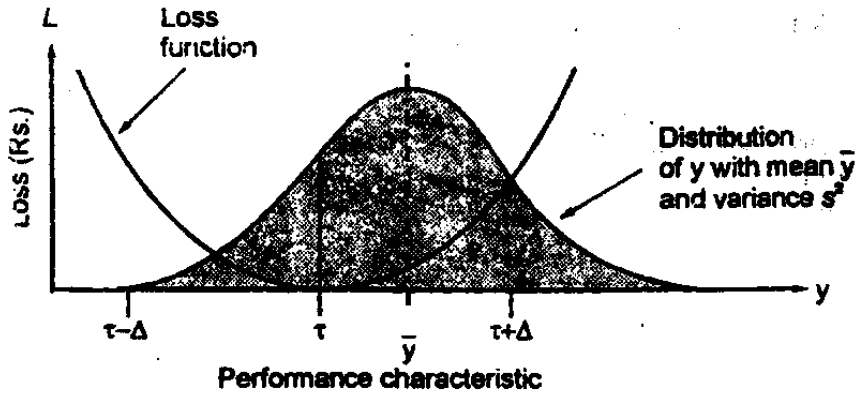
Loss is Rs.37.5 When y = 10.

Average loss and noise factor

In this last section the loss function is developed assuming that the quality characteristic is static. But in real world hitting the target τ is not possible. It is varying due to Noise and the loss function will reflect the variation of many pieces rather than just one piece due to the noise factors.

A refrigerator temperature control system clarifies the noise concept. External noise is due to action of the user like the number of times the door is opened and closed amount of hot food inside the initial temperature and so forth. The initial noise is due to variation in production such as seal tightness control sensor variations and so on. Every effort should be made to minimise these external and internal noises. These noise factors cause deviation from the target which causes a loss to society.

The following figure shows the nominal the best loss function with the distribution of the noise factors.



Average or Expected Loss

Average loss or Expected loss $\bar{L} = K(\sigma^2 + y - \pi)^2$. Instead of population standard deviation σ the sample standard deviation 'S' can be substituted.

Problem 2 : Compute the average loss for a process that produces steel shafts. The target value is 8.40 mm and the coefficient is 8500. Eight sample give 8.36. 8.40, 8.38, 8.43, 8.39, 8.46 and 8.42.

$$S = \sqrt{\frac{\Sigma(y-y)^2}{n-1}}$$

$$\bar{y} = \frac{8.36+8.40+8.38+8.39+8.43+8.39+8.46+8.42}{8}$$

$$= 8.40375mm$$

$$S = \sqrt{\frac{0.04375^2 + 0.00375^2 + 0.2375^2 + 0.01375^2 + 0.02625^2 + .0.01375^2 + 0.05625^2 + 0.01625^2}{8-1}}$$

$$= 0.031594529$$

Average Loss

$$\bar{L} = k(S^2 + (\bar{y} - \tau)^2$$

$$= 8500(0.031594529^2 + (8.40375 - 8.4)^2$$

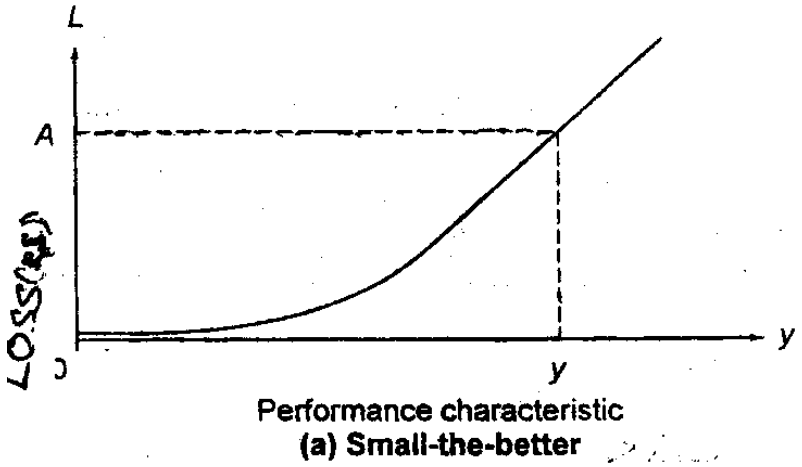
$$= Rs.8.60$$

Smaller the better:

The following figure shows the smaller the better concepts.

The target value for **smaller the better** is 0. There are no negative values for the performance characteristic.

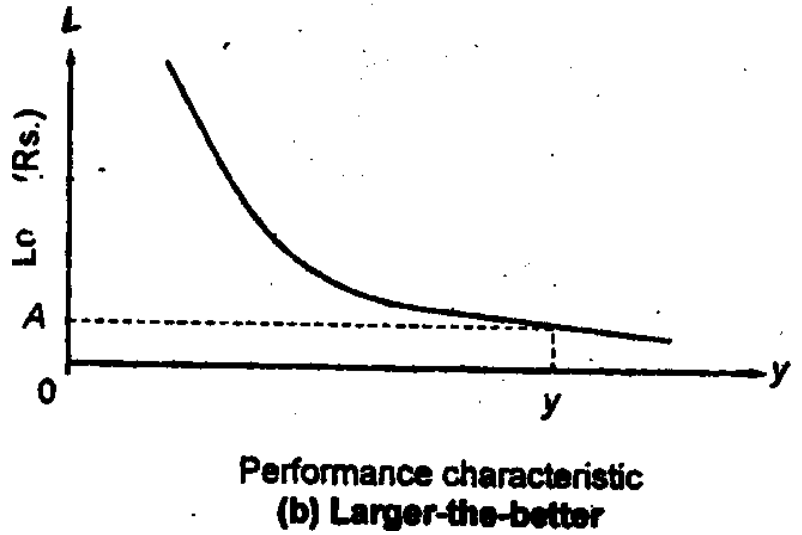
The radiation leakage from a microwave appliance the response time from a microwave appliance, the response time for a computer pollution from an automobile, out of round for a hole etc, are the performance characteristics for this concept.



Larger the better

The following figure shown the concept of the larger the better.

In the larger the better concept the target value is ∞ infinity which gives a zero loss . There are no negative values and the worst case is at y=0 . Actually larger the better is the reciprocal of smaller the better. The performance characteristics in Larger the better are bond strength of adhesives welding strength etc.



The following table gives a summary of equations for the three common quality loss functions. It also shows the relationship of the loss function to the **mean squared Deviation (MSD)**

Three Quality Loss Functions

Nominal the best $L=k(y-\tau^2)$ where $k=\frac{A}{\Delta^2}$

Average Loss $\bar{L}=k(MSD)$

where $MSD=\text{å}(y-\tau)^2/n$

$\bar{L}=k(\sigma^2+(\bar{y}-\tau)^2$

smaller the better $L=ky^2$ where $l=A/y^2$

Average Loss $\bar{L}=k(MSD)$ *where* $MSD=\left(\sum y^2\right)/n$

$$\bar{L}=k(\bar{y}^2+\sigma^2)$$

L arg er the better $L=k\left[1/y^2\right]$

Where $k=Ay^2$

$\bar{L}=k(MSD)$ *where* $MSD=\left[\sum 1/y^2\right]/n$

$\bar{L}=k\left[\sum 1/y^2\right]$

The above three common loss functions cover most of the situations.

Smaller the better

Problem 3 A manufacture who makes speedometer cable casings for cars knows that the shrinkage of the casings can be a problem ideally the shrinkage must be zero. When the shrinkage exceeds. 1.5% about 50% of the customers complain. When the customer does complain the average cost of replacing the casing is Rs. 80.000

Establish the Quality Loss Function.

The rework cost at the end of the production line is Rs. 8.00 per piece. What are the realistic production tolerances for the shrinkage?

In the data below materials, A and B have different shrinkage properties. If both materials cost the same which of them is the better materials?

Material	**Data**							
A	0.28	0.24	0.33	0.3	0.18	0.26	0.24	0.33
B	0.08	0.12	0.07	0.03	0.09	0.06	0.05	0.03

Solution

Material									Y
A	0.287	0.2	0.33	0.3	0.18	0.26	0.24	0.33	0.27
For a $y-\bar{y}$	+0.01	-0.03	0.06	0.03	-0.09	-0.01	-0.03	-0.0.	
B	0.08	0.12	0.07	0.03	0.09	0.06	0.05	0.03	0.066
For B $y-\bar{y}$	0.013	0.053	0.003	0.037	0.023	0.007	0.017	0.037	

Taguchi's Quality Loss Function for the smaller the better is $K(y)=ky^2$

Where

$$k=\frac{A}{\Delta^2}\left[A=80;\Delta=1.5\right]$$

$$k=\frac{80}{1.5^2}=35.56$$

$$k=35.56$$

Quality loss function $L = 35.56\ (y^2)$

(ii) $L = 35.56\ y^2$

$8 = 35.56\ y^2$

$y^2 = 0.225$

$y = 0.4743$

If shrinkage is below 0.47 we need not repair. If it is above 0.47 we have to repair.

(iii) **using Average Loss function for multiple factor**

$$\bar{L}=k\left[\bar{y}^2+\sigma_{n-1}^2\right]$$

$$\Sigma(y-\bar{y})^2A=0.0182$$

$$(\sigma_{n-1})^2A=\frac{\Sigma\left(y-\bar{y}\right)^2A}{n-1}$$

$$=\frac{0.0182}{8-1}=2.6\times10^{-3}$$

$$\left(\sigma_{n-1}\right)^2=2.6\times10^{-3}$$

For material B

$$\bar{y}B = \frac{0.53}{8} = 0.067$$

$$\Sigma(y-\bar{y})^2 B = 6.592\times10^{-3}$$

$$(\sigma_{n-1})^2 B = \frac{\Sigma y-\bar{y})^2 B}{n-1}$$

$$= \frac{6.592\times10^{-3}}{7}$$

$$= 9.417\times10^{-4}$$

$$\sigma^2_{(n-1)_B} = 9.417\times10^{-4}$$

Loss For A

$$k\left[(\sigma_{n-1})^2 A + \bar{y}^2 A\right]$$

$$= = 35.56\left[2.6\times10^{-3} + 0.27^2\right]$$

$$= 2.6848$$

Loss for B

$$k\left[(\sigma_{n-1})^2 B + \bar{y}^2 B\right]$$

$$= 35.\left[9.417\times10^{-4} + 0.067^2\right]$$

$$= 0.19312$$

Since material B has less loss B is better.

Larger the better

Problems 4: The weld strength of motor protector terminals needs to be maximized. When the weld strength is 0.5 jg/cm^2 some welds have been known to break, resulting in an average replacement cost of Rs. 100 to the customer.

i. Determine the Quality Loss Function
ii. The rework cost at the end of the production line is Rs.10 per weld. What are the realistic production tolerances for the weld strength?
iii. An experiment was conducted to compare the existing semi manual welding processes A and B which of the process is the better?

Process	**Data**								**Y**
A	2.3	2	1.9	1.7	2.1	2.2	1.4	2.2	1.975

B	2.1	2.9	2.4	2.5	2.4	2.8	2.1	2.6	2.475

Solution:

Weld strength has to be maximized. So larger the better Quality loss function should be taken

$$L(y)=\frac{k}{y^2}$$

Where $k=Ay^2$ A=100;y=0.5

$=100\times 0.5^2=25$

$k=25$

Quality Loss function $L(y)=\frac{25}{y^2}$

$$L(y)=\frac{25}{y^2}$$

(ii) $10=\frac{25}{y^2}$

$$y^2=\frac{25}{10}=2.5$$

$$y=1.581$$

Realistic production tolerance for weld strength is 1.581 kg/cm^2

The loss function for larger the better for the multiple factor is

$\bar{L}=k\left[\Sigma 1/y^2\right]/n$

For process A

$$L(y)_A=k\left[\frac{1}{y_1^2}+\frac{1}{y_2^2}.....\frac{1}{y_8^2}\right]$$

$$=25\left[\frac{1}{2.3^2}+\frac{1}{2.9^2}+\frac{1}{2.4^2}+\frac{1}{2.5^2}+\frac{1}{2.4^2}+\frac{1}{2.8^2}+\frac{1}{2.1^2}+\frac{1}{2.6^2}\right]$$

$=55.306$

For process B

$$L(y)_B=25\left[\frac{1}{2.1^2}+\frac{1}{2.9^2}+\frac{1}{2.4^2}+\frac{1}{2.5^2}+\frac{1}{2.4^2}+\frac{1}{2.8^2}+\frac{1}{2.1^2}+\frac{1}{2.6^2}\right]$$

$=33.878$

Since loss is less for process B the welding process B is better

Nominal the best

Problem 5 : Television sets are made with a desired target value for the output voltage of $\tau = 115$ volts . When the output voltage lies beyond the range of 115+20 volts and the set is sold to a customer the average cost of repairing or replacing the set if Rs. 200

i. Find the cost coefficient k and establish quality loss function
ii. The repair cost at the end of the production line is Rs. 400 per set. What are the realistic production tolerances for the output voltage?
iii. Two different processes are being considered for producing Television sets. Which process has the smaller loss?

A	**113**	**116**	**115**	**113**	**117**	**115**	**115**	**114**
B	113	112	113	112	113	113	112	114

Solution

									Σ	**Y**
A	113	116	115	1113	117	115	115	114	918	114.75
For a $\left(y-\bar{y}\right)_A$	1.75	1.25	0.25	-1.75	2.25	0.25	0.25	-0.75		
B	113	112	113	112	113	113	112	114	902	112.75
For B $\left(y-\bar{y}\right)_B$	0.25	-0.75	0.25	-0.25	-0.75	0.25	0.25	-0.75	1.25	

Since the target value is given it is the type of nominal the best. . Hence the quality loss function for nominal the best is

$L(y) = k(y-\tau)^2$ for single factor

Where

$$k = \frac{A}{\Delta^2}\left[A = 200; \Delta = 20\right]$$

$$\frac{200}{20^2}$$

$$= 0.5$$

$$k = 0.5$$

Quality Loss function $L(y) = 0.5\ (y - \tau)^2$

$$L(y) = 0.5(y-\tau)^2$$
$$4 = 0.5\left(y-\tau\right)^2$$
$$\left(y-\tau\right)^2 = \frac{4}{0.5} = 8$$
$$y-\tau = 2.828 \qquad [\because \tau = 115]$$
$$y = 2.828 + \tau = 2.828 + 115$$
$$= 117.83$$

Realistic tolerance is y = 117.83 for the output voltage.

(iii) For the nominal the best for multiple factor the quality loss function is

For the nominal the best for multiple factor the quality loss function is
$$\bar{L} = k\left(\sigma_{n-1}^2 + \left(\bar{y}-\tau\right)^2\right)$$

For process A

$$\bar{y}A = 114.75$$
$$\Sigma\left(y-y\right)_A^2 = 13.5$$
$$\left(\sigma_{n-1}^2\right)A = \frac{\Sigma\left(y-\bar{y}\right)_A^2}{n-1} = \frac{13.5}{8-1} - 1.929$$

Loss in process A, L (y) =
$$k\left(\sigma_{n-1}\right)_A^2 + \left(\bar{y}A-\tau\right)^2$$
$$= .05\left(1.929 + 114.75 + 115\right)^2$$
$$= 0.99575$$
$$L(y)_A = 0.99575$$

For process B

$$\bar{y}B = 112.75$$
$$\Sigma\left(y-y\right)_B^2 = 3.5$$
$$\left(\sigma_{n-1}\right)_B^2 = \frac{\Sigma\left(y-\bar{y}\right)_B^2}{n-1}$$
$$= \frac{3.5}{71} = 0.5$$

Loss in process B.L(y) =

$$k\left(\sigma_{n-1}\right)_B^2 + \left(\bar{y}B - \tau\right)^2$$
$$= .05\left(0.5 + 112.75 - 115\right)^2$$
$$= 2.78125$$
$$L(y)_B = 2.78125$$

Since loss in process A is less 0.99575 the process A is better

10. Explain briefly about total productive maintenance (TPM)

Total productive Maintenance (TPM) is defined as keeping the running plant and equipment at its highest productive level with the cooperation of all areas of the organisation. By TPM the maintenance and production personnel work together to break down the traditional barrier between them.

Predictive and preventive maintenance are essential to building a foundation for a successful TPM environment. **Predictive maintenance** is the process of using data and statistical tools to determine when a piece of equipment will fail. **Preventive maintenance** is the process of periodically performing activities such as lubrication on the equipment to keep it running.

TPM is a system of maintenance covering the entire life of equipment in all divisions including planning, manufacturing and maintenance. Because of its target to increase equipment productivity, the term **TPM is also known as total productivity Management.**

TPM involves everyone from top management to workers to promote productive maintenance and to maximise equipment efficiency.

TPM implies utilising plant capability to its fullest extent.

To reduce equipment stoppages
To enhance equipment capability quantitatively and qualitatively.
To improve safety health and environmental factors in the expectation that such improvements will contribute to better quality and higher profit.
To utilize small group activities for preventive maintenance.

TPM aims at the elimination of unplanned equipment and plant maintenance. The maintenance activities are planned in such a way that it will not interfere with the production process and prevent the sudden equipment break downs.

To objectives of TPM are

- To maintain and improve equipment capacity.
- To maintain equipment for life.
- To use support from all areas of the operation
- To encourage input from all employees
- To use teams for continuous improvement.

Organisations which apply TQM Failure Mode Effect Analysis (FMEA) Employee involvement, Continuous Improvement, Just in Time manufacturing, Statistical Process Control and so on can not be successful, unless they apply TPM

When equipments fail irregularly how can an organisation implement just in Time manufacturing?

How can organizations practice employee involvement without the involvement of maintenance people?

11. Explain the concept of total productive of maintenance TPM?

Total Productive Maintenance (TPM) is an extension of the total quality management (TQM) philosophy to the maintenance function.

TPM has the following steps

- Management should learn the new philosophy of TPM
- Management should promote the new philosophy of TPM
- Training should be funded and developed for everyone in the organisation.
- Areas of needed improvement should be identified.
- An implementation plan should be developed
- Autonomous work groups should be established.

1. Management should learn the new philosophy of TPM

Senior management should learn about TPM and how it will affect their operations through other successful organizations with the help of **benchmarking.** TPM is merely trying to tap into an unused resource the brain power and problem solving ability of all the organizations employees.

Senior management has to deal with a cultural change because of TPM any cultural change takes a special dedication, by management to provide long term top to bottom support for

improvement. Initially this change may require more work by management. In course of time, it will require less work as all individuals start solving their own problems.

Management should promote the philosophy of TPM

Senior management should spend more time in promoting TPM concept. They must encourage employees so that they are totally committed to TPM's success. One of the best ways to implement a new concept is just start doing it. Once the employees realize that management is serious about taking the organisation in a new more positive direction toward TPM employees usually respond.

3. Training

Training in the area of TPM concept should be given to managers at all levels. Beginning with senior management. Training should be given up to first line supervisors and workers.

Through training, senior management must spend time to learn about and understanding the ramifications of applying new TPM concept to their organisation. Middle management must learn how to deal with the team approach and become familiar with how small autonomous work groups function.

When people are allowed to make their own decisions, then many layers of managers are not necessary as employees do their job correctly. Supervisors must learn their role and understand through training that the day of autocratic manager has disappeared. Practically supervisor has duties only to coach their team.

4. Improvement needs

Employees working with equipments should identify some machines that seem to be on the verge of breaking down or require an excessive amount of maintenance. The operators and maintenance technicians should tell management which machines and systems need most attention. An implementation coordinates this process. This action makes the organisation start towards TPM.

The following **Loss measurements** are developed by the Japanese to identify improvement needs

Down time losses – Planned unplanned
Reduced speed losses
Poor Quality Losses

1. Down time losses

(i) Planned Down time Losses

Start ups
Shift changes
Coffee and lunch breaks
Planned maintenance shutdowns

(i) **Unplanned down time losses**

Equipment breakdown
Change overs
Lack of material

Reduced speed losses

Idling and minor stoppages
Slow downs

3. Poor Quality Losses

Process non conformities
Scrap

Three losses can be summarized into one **equipment effectiveness** metric

Down time losses are measured by equipment availability A using the equation

$$Availability\ \text{A}=\left(\frac{\text{T}}{\text{P}}\right)\times 100$$

Where T = Operating time P-D
P= Planned operating time
D = Down time

Reduced speed losses are measured by tracking performance efficiency using the equation.

Performance Efficiency $E=\frac{C\times N}{T}\times 100$

C = Cycle time theoretical

N = Number of units produced processed quantity.

Poor Quality Losses are measured by tracking the rate of quality products produced using the equation

Rate of quality products $R = \left(\frac{N - Q}{N} \right) \times 100$

Where N= number of units produced processed quantity
Q = Quantity of defective parts non conformities.

Equipment Effectiveness is measured as the product of three precious metrics using the equation.
Equipment Effectiveness EE = A x E x R

The target for improvement is 85% equipment effectiveness.

Problem 6: A week's production numbers on a machining center are given below.
Scheduled operation = 12 hours /day ; 6 day /week

Manufacturing downtime due to meetings, material outages, training, breaks and so on = 450 min/ week
Maintenance down time scheduled and equipment break down = 250 min/ week

Theoretical standard cycle time = 0.5 min/unit

Production for the week = 6000 units

Defective parts made = 16 units

Equipment Availability A

$$A = \frac{T}{P} \times 100$$

P= planned operating time
= 12 hours/day x 6 days/week x 60 min/hr
=420 min/week
D= Down time =450 min/week +250 min/week
=700 min/ week
T = operating time =P-D= 4320-700
= 3620 min

Now $A=\left(\frac{T}{P}\right)\times 100$

$=\frac{3620}{4320}\times 100$

83.79%

Equipment Availability A = 83.73%

Performance Efficiency E

$$E=\frac{C\times N}{T}\times 100$$

C = Cycle time theoretical = 0.5 min/ unit

N = Number of units = 6000 units

$E = E=\frac{0.5\times 6000}{3620}\times 100=82.87\%$

Rate of Quality Products R

$$R=\frac{C\times N}{T}\times 100$$

Where Q = Defective parts made =16

$$R=\frac{600-16}{6000}\times 100$$

$=99.73\%$

Equipment Effectiveness EE

$EE=A\times E\times R$

$=0.8379\times 0.8287\times 0.9973$

$=0.69$ or 69%

From this we infer that the equipment availability should be improved to reach the goal of 85% equipment effectiveness.

Goal

Once the improvement needs are identified goal should be set to establish the time frame for fixing the first prioritized problem. Identifying improvement needs and setting goals make the organisation work together as a team

Developing plans

An overall plan of action for training all employees should be developed and implemented to develop the autonomous work groups.

A team of maintenance technicians and operators should be planned to work on particular trouble some problems. The team approach will develop the autonomous work groups meant for daily operations.

Autonomous work Groups

Autonomous work groups are established to make decisions about keeping the equipment in first class running order. In autonomous work groups an operator is made responsible for an equipment. He will do maintenance work to some extent. The maintenance personnel having certain skills should be identified. Both operator and maintenance people are brought together to establish an autonomous work group.

Maintenance technicians are made as consultants to train operators how to do certain tasks such as oiling, minor trouble shooting and set ups. The overall goals of the autonomous work groups an operator is made responsible for an equipment. He will do maintenance work to some extent. The maintenance personnel having certain skills should be identified. Both operator and maintenance people are brought together to establish an autonomous work group.

Maintenance technicians are made as consultants to train operators how to do certain tasks such as oiling minor trouble shooting and set ups. The overall goal of the autonomous work group is to reduce the occasions for maintenance activity and to free up highly skilled maintenance technicians from more routine works.

12. Explain briefly about failure mode and effect analysis (FMEA).

Failure Mode and effect analysis (FMEA) is an **Analytical technique** which combines the technology and experience of the people.

To identify foreseeable failure modes of a product or process
To plan for its elimination

Reliability

Before studying about FMEA we should know something about Reliability.

Reliability is defined as the probability of a product performing satisfactorily without failure of a specified function under specified conditions for a specified period of time.

Failure Rate

A majority of products follow a very familiar pattern of failure. The failure of a product component, system or process, can be modeled by an exponential distribution. The reliability or the probability of survival of this type of product using an exponential distribution may be expressed as

$$R_t = e^{-t\lambda} = e - \frac{t}{\theta}$$

Where R_t The reliability or probability of survival
T = The time specified for operation without failure.
λ = The failure rate
θ = The mean time to failure

Problem 7. A product has a constant failure rate of
$\lambda = 0.003$ per hour. What is the probability that will survive or be reliable during the first 150 hours of operation?

$$R_t = e^{-t\lambda} = e - ^{(150\times 0.003)} = 0.6376$$

There is a 63.76% chance that the product will survive during the first 150 hours of operation.

Categories of Failure:

The failures of most products are classified into three main categories.

- Debug
- Chance
- Wear out

Debug includes a high failure rate at the initial stages because of inappropriate use or flaws in the design or manufacturing.

Chance is the failure of the product due to accidents, poor maintenance or limitations on the design.

Wear out covers failure after the product or process has preformed as expected for the amount of time given by the manufacturer as the product or process life.

Wear out covers failure after the product or process has preformed as expected for the amount of time given by the manufacturing as the product or process life.

A successful design or process should ideally fail only in the wear out method.
Technique for Reliability Analysis

Two main techniques for Reliability Analysis are

Failure mode effect and criticality Analysis (FMECA)
Fault tree Analysis (FTA)

These techniques provide a systematic way to examine the proposed design for possible ways in which failures can occur.

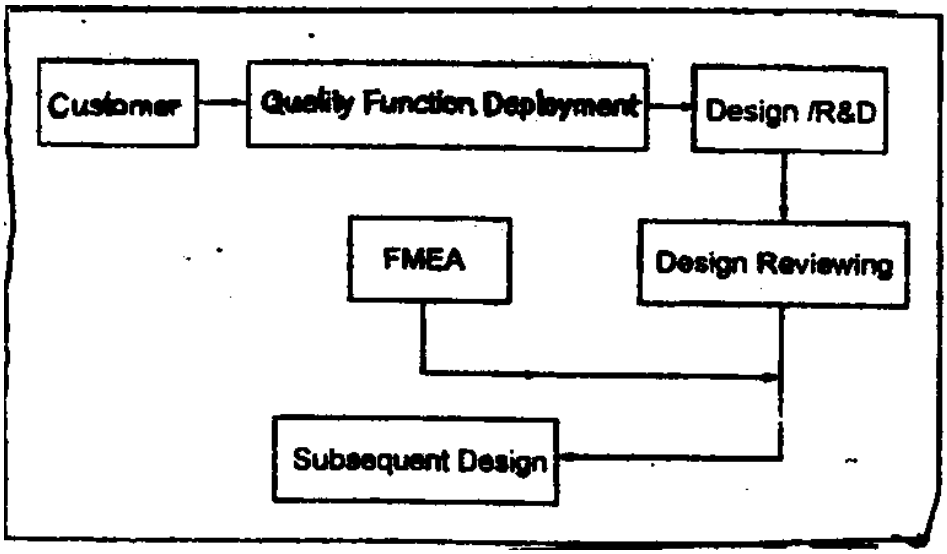
Failure mode effect and Criticality Analysis (FMECA) is also called FMEA.

In FMEA.

i. Potential failures are first identified in terms of failure modes.
ii. For each failure mode the effect on total system is then identified
iii. Finally a plan is developed and action is taken to minimise the probability of failure or to minimise the effect of failure.

The FMEA provide a structural means of determining the impact of different modes in which a product may fail while in operation . The information obtained while completing FMEA , serves as a useful input to modify the design of product or process under consideration.

The following block diagram shows the importance of FMEA



FMEA gives information such as ease, difficulty in detection of failure and indicates to the designers the changes needed in product to simplify maintenance, its basic assembly or factors related to safety.

Purpose of FMEA

i. FMEA is an analytical technique that combines the technology and experience of people in identifying various failure modes of a product or process and planning for its elimination.
ii. FMEA is implemented in both the design and the process areas to identify potential failure modes and the effect of those on customers
iii. FMEA attempts to detect the potential product related failure modes.
iv. FMEA anticipates the causes of failure and prevents them from happening.
v. FMEA debugs and prevents problems that may occur in the manufacturing process.
vi. FMEA compares the design characteristics relative to the planned manufacturing or assembly methods to ensure that the product meets the customer requirements.
vii. Corrective actions are taken after a failure mode is identified.
viii. FMEA provides justification for setting up a process in a certain manner
ix. FMEA is used by engineers to analyse all possible non conformities and problems that may arise in a given process or with a certain product.

Mention the stages of FMEA?

Stages of FMEA

There are four stages in FMEA which are given below

Specifying possibilities

Functions
Possible Failure Modes
Root causes
Effects
Detection / Prevention

2. Quantifying Risk

Probability of cause
Severity of Effect
Effectiveness of control to prevent cause
Risk Priority Number

3. Correcting High risk causes

Prioritising work
Detailing Action
Assigning action responsibility
Check points on completion

4. Reevaluation of risk
(a) Recalculation of Risk Priority Number.

14. Describe briefly about different types of FMEA

There are several types of FMEA as follows

i. Design FMEA
ii. Process FMEA
iii. Equipment FMEA
iv. Maintenance FMEA
v. Concept FMEA
vi. Service FMEA
vii. System FMEA
viii. Environmental FMEA

The above all types can be broadly categorized under either Design FMEA or Process FMEA. Because equipment service and environmental FMEA are just slightly modified versions of process FMEA and system FMEA is a combination of design and process FM EA

Design FMEA document

Design FMEA is used in the design process by identifying known and foreseeable failure modes and then ranking failures according to relative impact on the product. Design FMEA reduces development time and cost of manufacturing process by eliminating many potential failure modes prior to operation of the process.

The general format form of design FMEA is shown here.

FMEA number space is given on the top right corner of the document which is needed for reference.

Item space is used for component or process to be analysed.

Design Responsibility space is used for the team in charge of the design or process or the name and the department of the person responsible for preparing the document.

Model Number year of the component should be included in the space provided to avoid confusion between similar components.

FAILURE MODE AND EFFECT ANALYSIS (DESIGN FMEA)

FMEA Number_____
Page _____ **of**_____

Item _____ **Design Responsibility** _____ **Prepared by**_____

Model Number/year_____ **Key date** _____ **FMBA Date (Orig.)**_____ **(Rev.)**___

Code Team _____

Item/ Function	Potential/ Failure Mode	Potential Effect(s) Of Failure	S	CLASS	Potential Cause(s)/ Mechanism(s) of Failure	O	Current Design Control	D	RPN	Recommended Actions	Responsibility and completion Dates	Action Results				
												Actions Taken	SEV	OCC	DET	RPN

Key data space is used for initial Due date of FMEA

FMEA date original and FMEA date latest revision should be filled

In the core team space the names of the responsible individuals and departments having authority to perform tasks should be filled up

Item function

In this column, the name and code number of the item being analysed is recorded.
The function of the item should be entered.
If the item has more than one function. They should be listed and analysed separately .

The environment temperature, pressure, humidity etc in which the system operates should be completely given.

Potential Failure Mode

All potential failure modes must be considered, including those that may occur under particular conditions and certain usage conditions, Consider past failures concerned reports and conduct group brain storming

Some failure modes are given here

i. Crack
ii. Deformation
iii. Loosening
iv. Leakage
v. Sticking
vi. Short circuited
vii. Oxidisation
viii. Fracture

Potential Effects of Failure mode

In this column the effects of failure perceived by the customer are recorded. The effects of failure must be described in terms of what the customer will notice or experience. It is important to state whether the failure will impact personal safety or break any product regulations.

Some effects of failure are given here

i. Noise
ii. Vibration
iii. Erratic operation
iv. Poor performance
v. Lack of stability
vi. Intermittent operation
vii. Impaired operation

Severity (S)

Severity is the assessment of the seriousness of the effect of the potential failure to the next component, subsystem, system or customer. Severity Seriousness is applicable only to effect of failure not the potential failure mode. Severity is rated by ranking as shown in table in which 1 s for no effect and 10 for the most severe serious effect.

Rankings of Severity of effect for Design FMEA

Effect	Severity of Effect	Ranking
Hazardous without warning	Failure occurs without warning. Very high ranking because it affects safety	10
Hazardous with warning	Failure occurs with warning. This failure also affects safety.	9
Very High	Item or product becomes inoperable with loss of function. Customer is highly dissatisfied	8
High	Item or product operates with poor performance. Customer is dissatisfied	7
Moderate	Item or product operate with loss to comfort or convenience. Customer experiences discomfort	6
Low	Item or product is operable but with less loss of comfort and convenience. Customer has some dissatisfaction	5
Very Low	Certain item characteristics do not conform. Most of the customers notice this effect	4
Minor	Certain item characteristics do not conform. Only some customers notice this effect	3
Very Minor	Certain item characteristics do not conform. It is noticed only by very few customers	2
None	No effect	1

Classification : (CLASS)

This column is used to classify any special product characteristics for components, subsystems or systems that may require additional process controls.

Potential cause and mechanism of failure

Some causes of failure include

- Incorrect material
- Inadequate design
- Inadequate life assumption
- Over stressing
- Insufficient lubrication capability
- Poor environmental protection
- Incorrect algorithm

Some mechanisms of failures include

- Yield strength
- Creep
- Fatigue
- Wear
- Material instability
- Corrosion

All potential failure causes and mechanisms must be listed completely, and each of these must be examined and reviewed with equal weight.

Occurrence (o)

Occurrence is the chance that one of the specific cause mechanism will occur. The likelihood of occurrence is based on 1 to 10 scale. 1 is for least chance of occurrence and 10 is for the highest chance of occurrence.

Current design control

The control activities like prevention measures design validation and design verification are listed in this column.

There are three types of design controls which
Prevent the causes and mechanisms of failure or effects of failure from occurring or reduce the rate of occurrence.
Detect the causes mechanisms for corrective actions.
Detect only the failure mode.

Detection (D)

In this column the relative measure of ability of the design control to detect the causes mechanism of failure is recorded. If the design control certainly detect the cause mechanism of failure then it is ranked. 1 if the design control can not detect a cause mechanism of failure then it is ranked 10.

Risk priority Number (RPN)

Risk Priority Number (RPN) is the product of the severity (S) occurrence (O) and detection (D) ranking, as given here

$$RPN = (S) \times (O) \times (D)$$

RPN ranges from 1 to 1000. 1 is for the smallest design risk possible. IF there is high RPN then the engineering team should take efforts for corrective actions to reduce RPN.

Recommended Action

The items having high RPN and more severity should be examined to take corrective actions. The purpose of the recommended actions is to reduce one or more of the recommended actions is to reduce one or more of the criteria that constitute the risk priority number.

Some recommended actions to reduce RPN include.

Design of experiments
Revised Test plan
Revised Material selection specification

Responsibility and Target completion Dates:

In this column the individual or group responsible for recommended actions are noted. Also the target completion date should be entered for future reference.

Actions Taken and Action Results

After an action is taken the action results should be re estimated i.e the resulting severity occurrence and detection rankings should be re-estimated. Then the resulting RPN should be recalculated and recorded.

Process FMEA document

The process FMEA document is almost similar and identical to that of the design FMEA document.

UNIT – V

PART - A

1. What is a quality system?

Quality system refers to the organizational structure responsibilities, procedures, processes and resources for implementing quality management. It is a system put in place to assure and achieve quality. TQM ISO are Quality systems.

2. What all things a QMS define?

QMS define organizational structure, responsibilities, policies, procedures, processes, standards, and resources required to deliver quality products and services.

3. What are the two interrelated aspects of QMS?

The two interrelated aspects of QMS are

The suppliers needs and interests. The supplier needs to reach and maintain the desired and agreed quality at an optimum cost.

The customers needs and expectations The customer needs to have confidence in the ability of the supplier to deliver and maintain that quality

4. What are the factors for the success of a quality management system?

The factors responsible for the success of a QMS are a participative approach, management commitment, staged implementation and quality management support.

5. What is a standard?

A standard is a generally approved and an accepted specification that guides product design and saves time and cost. It is a set of specifications for parts, materials or processes intended to achieve uniformity, efficiency and a specified quality.

6. What is the purpose of ISO?

The purpose of ISO is to facilitate global consensus agreements on international quality standards. It has resulted for certifying suppliers to make sure they meet internationally accepted standards for quality management.

7. What is a standard in the context of ISO?

The word standard in the context of the ISO refers to documented agreements containing technical specifications or other criteria to be used consistently as rules or guidelines. The ISO 9000 family of standards focuses on management systems.

8. What are the major benefits of ISO?

The major benefits of ISO are

- Provide the path for advancing to new levels of competitiveness,
- It's a contractual requirement
- In some regions, the need is to be more competitive and in other may b e a reason to be excluded from some business activities.
- A fundamental management system basis for the integration of methods and techniques.

9. Why are the standards of ISO designed?

The standards are designed to establish consistent languages and terminology to provide baseline quality practices that are accepted internationally and to reduce the need for costly on site supplier assessments.

10. What are the requirements of ISO standards?

The ISO standards require (1) A standard language for documenting quality practices (2) A system to track and manage evidence that these practices are instituted throughout the organization and 3 a third party audition model to review certifies and maintain certification of organizations.

11. What is Quality as per ISO 9000?

As per ISO 9000 quality refers to all those features of a product or service which does the customer require.

12. Explain ISO 9000 series standards.

The ISO 9000 series of standards is generic in scope. By design, the series can be tailored to fit any organizations needs. It can be applied to all types of manufacturing and service organizations. Its purpose is to unify quality terms and definitions used by industrialized nations and use those terms to demonstrate a suppliers capability of controlling its processes.

13. What is the principle of customer Focus?

Organizations depend on their customers. They must understand current and future customer needs. They should meet customer requirements and strive to exceed customer expectations.

14. What is Leadership?

Leaders establish unity of purpose and direction of the organization. They create and maintain the internal environment of trust and co operation. People can become fully involved in achieving the organizations objectives in such an environment.

15. What is the advantage of peoples involvement?

Peoples involvement results in motivated, committed and involved people within the organization. People become accountable for their own performance. IT creates innovation and creativity in furthering the organizations objectives. It makes people eager to participate in and contribute to continual improvement.

16. What are the benefits of a process approach?

A process approach lower costs and shorter cycle times through effective use of resources. It makes focused and prioritized improvement opportunities resulting in improved consistent and predictable results.

17. What is the systems approach?

System approach involves identifying understanding and managing interrelated processes as a system. This contributes to the organizations effectiveness in achieving its objectives.

18. What are the benefits of factual approach to decision making?

Factual approach to decision makes informed decisions. It increases the ability to demonstrate the effectiveness of past decisions through reference to factual records . It also increases the ability to review challenge and change opinions and decisions.

19. Explain mutually beneficial supplier relationships.

A mutually beneficial supplier relationship increases the ability to create value for both parties. IT gives flexibility and speed of joint responses to changing market or customer needs and expectations. It also optimizes of costs and resources.

20. What are the eight clauses ISO 9000?

The eight clauses of ISO 9000 are scope, Normative Reference, Terms and Definitions, Quality Management System, Management Responsibility, Resource Management, Product Realization and Measurements, Analysis & Improvement.

21. What are the six essential documented procedures for ISO9000?

The six essential documented procedures for ISO 9000 are the procedures for Control of Documents, Control of Records, Internal Audit, Control of Non conforming Product, Corrective Action and Preventive Action.

22. What is the main difference between the 1994 standard and 9000 2000?

The main difference is that the 1994 standard was based on a life cycle model and the ISO 9000 2000 standard is based on a process model.

23. What are the pitfalls to successful implementation of ISO?

Some pitfalls to successful implementation are 1 over documentation or documentation that is too complex 2 Using external consultants without internal ownership and involvement (3) Lack of top management's involvement And (4) developing a system that does not represent the actual system.

24. What is Quality Policy?

Quality policy refers to the statement from Top management regarding their commitment relative to quality products and services. They are basically the purpose and vision of the organization.

25. What are the four levels of ISO 9000 documentation?

The four levels of ISO 9000 documentation are Quality manual Quality Procedures, Work instructions and Quality records.

26. Give some example of Quality Documents?

Examples of Quality Documents are drawings, Specifications inspection instructions, Blueprints, Test procedures, Work instructions, Operation sheets, Quality manual etc.

27. Give some examples of Quality Records?

Examples of Quality Records are inspection reports , Test data Qualification reports, Defect Checklist, Validation reports, Audit reports Calibration data, Factory log etc.

28. What is a controlled document?

A controlled document is a document that if changed, effects some part of the process or product. These can be procedures, process documents, product or part drawings prints or other similar documents, Forms are typically controlled documents.

29. Define Quality Audit.

Quality Audit can be defined as a systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether there arrangements are implemented effectively and are suitable to achieve the stated objectives.

30. What is the purpose of Quality Audit?

The purpose of Quality audit is to collect objective evidence to permit an informed judgment about the status of the systems or product being audited.

31. What are the four phases of Auditing?

The four phases of Auditing are (1) planning and preparing for the audit (2) Execution of the audit plan (3) Reporting the audit results and (4) Close out of corrective actions.

32. What is an internal Audit?

Internal auditing is an independent objective assurance and consulting activity designed to add value and improve an organizations operations.

33. What is a compliance Audit?

A compliance audit is typically an audit that compares a company's defined systems against those required by the standard being audited against.

34. What is a process Audit?

A process Audit is where the company's procedures are validated . Processes are sub parts of a system. As such they are typically a part of a system audit.

35. What is QS 9000?

QS 9000 is a quality management system standard for the automotive industry. It was originally developed by and for the Big Three of the American auto industry.

36. What are the three types of elements of QSO 9000.

The three types of elements of QS9000 are 1) All the twenty (20) ISO-9001 elements plus certain automotive requirements 2) System requirements defined by the 'Big Three' for their own use. These are referred to as 'Additional Requirements' in the stand' and 3) Customer specific requirements.

37. What is ISO 14000.

ISO 14000 is primarily concerned with "environmental management". It is a set of standards that address environmental issues. This initiative began in 1993 when the ISO formed TC207 (technical committee).

38. Define Environment as per ISO 14000.

Environment is defined as the global surroundings in which an organization operates. It includes air, water, land, natural resources, flora, fauna, humans and their interaction.

39. What are the standards involved in ISO 14000.

ISO 14000 consists of the standards as under 1) Environmental Management Systems (EMS) 2) Environmental Auditing and Related Environmental Investigations (EA) 3) Environmental Labeling (EL) 4) Environmental Performance Evolution (EPE) and Life Cycle Assessment (LCA).

40. What is the basic concept of ISO 14000.

ISO 14000 is primarily concerned with "environmental management". In plain language, this means what the organization does to minimize harmful effects on the environment caused by its activities.

41. What are the four sections of the ISO 14000.

The four sections of the ISO 14000 standard are scope, Normative reference definitions and EMS requirements.

42. What are the steps for ISO 14000 Implementation.

Five steps for ISO 14000 Implementation are 1) Definition of the organizations environmental policy 2) Planning of the organizations environmental activities to support the policy 3) Implementation of the organizations environmental plans/programs 4) Monitoring of the implementation of the environmental plans/programs and correction of non-conformances and 5) Management review of the organizations environmental policy and programs.

PART – B

1. Explain briefly about need to quality system?

Quality includes safety reliability, durability performance and acceptability of products by the consumers or customers. In order to assure the quality of a product, the manufacturer must ensure its quality. So to ensure this quality it is necessary to make a systematic study and control cheek at every stage of production. It is also essential to take critical review of efforts and achievements of the company with respect to the quality of the product. For making this systematic study and control check, the cooperation of every employee is required because quality depends on the involvement of each and every person working in the organisation. When a quality system is implemented, the manufacturer of the company and give better customer relations and customer relations and customer satisfaction. A company with a poor o no quality assurance system will result in a production of low quality products or services. Thus it is necessary to develop a standard quality system.

Although several systems of quality can be created, the quality system o one particular organisation might not be accepted by another. Consider a two party system in which the supplier of the product or service would develop a quality system that would conform to his standard. The customer would then audit this system for acceptability. Here the supplier and the customer form the two parties. After auditing it may be found that the customer's quality requirements are not met. In order to avoid this and also the cost incurred in multiple audits, a standard quality system must be developed and audited by a third party registration system. The ISO 9000 QS9000 ISO 14000 and other quality systems are such third party registration systems that indicate to customers or potential customers that the supplier has a quality system in place and it is being monitored.

2. Describe ISO9000 series of standards.

The ISO 9000 series of standards was created by the international standard organisation in order to develop an internationally uniform quality standard system. These standards were developed jointly by all the ISO member countries 92 countries in the world.

The ISO 9000 system is a quality management system that can be adopted by all types of organizations belonging to government, public private or joint sectors which supply goods, services and software of all kinds. The ISO 9000 system shows the way in creating products by preventing deficiencies, instead of conducting expensive post product inspections and rework.

There are five standards in the ISO 9000 series ISO 9000 -9004

ISO 9000 provides the guidelines for the selection and use of the ISO 9000 series of standards and also provides information on their implementation assessment and verification.

ISO 9001 is used when conformance to the specified requirements is to be assured by the supplier. These requirements is to be assured by the supplier. These requirements are during all the states of design production installation and servicing. The manufacturer must open his manufacturing stages to the customer so that the customer can judge the suppliers capability in meeting his requirements. After the product has been manufactured, the product must be installed at the customers premises and a test run should be conducted. Even after installation, the supplier must provide necessary maintenance to the product for trouble free performance.

ISO 9002 standard for quality is used when conformance to the specification is to be assured by the supplier during production and installation. In this case the manufacturer gives his own design to meet the customers requirements and should see that the production process is capable of producing the products according to those requirements. He should also see that the product can be installed in the customers premises satisfactorily.

ISO 9003 standard is used when conformance to the specified requirements is to be assured by the supplier solely at final inspection and test. Here the customer is not concerned as to how the product is manufactured. He is interested only in getting the product of his desired quality as stated by the supplier. Most of the consumer items fall in this category.

Note : The ISO 9001-9003 provide guidelines for external quality assurance purposes in contractual situations. The purchaser and the supplier should refer to these standards and determine which of them is the most relevant to their contract.

ISO 9004 Provides guidelines on the technical administrative and human factors affecting the product or service. IT is used in non contractual situations and can be used for internal quality assurance.

3. Explain briefly about requirements of ISO 9001?

The standard has eight clauses. Scope Normative References, Definitions, Quality Management Systems, Management Responsibility, Resource Management Product and or Service Realisation and Measurement, Analysis and Improvement. The first three clauses are for information while the last five are requirements that an organisation must meet. The numbering system used in the standard is followed in this section.

The application of a system of processes within an organisation together with their identification and interactions and the managing of these processes, is referred to as the process approach.

This approach emphasizes the importance of Understanding and fulfilling the requirements.
The need to consider processes in terms of value added.

Obtaining results of process performance and effectiveness.

Continual improvement of process based on objective measure.

For the five required clauses the system is shown in figure.

1. SCOPE :

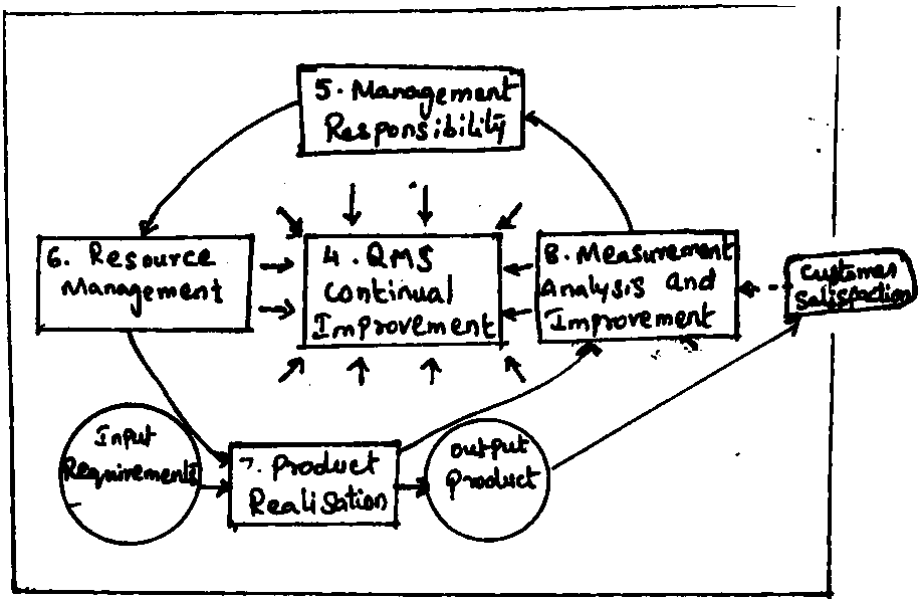


Fig Model of a Process based Quality Management System.

The purpose of the standard is for the organisation to demonstrate its ability to provide a product 13 that meets customer and regulatory requirements and achieves customer satisfaction. This purpose is accomplished by evaluating and continually improving the system rather than the product. The requirements of the standard are intended to be applicable to all types and sizes of organisations Requirements in Clause 7 product realization that are not appropriate to the organisation can be excluded.

2. Normative Reference

ISO 9000 2000 Quality Management Systems Fundamentals and vocabulary are a normative reference that provides applicable concepts and definitions.

3. Terms and Definitions

For the purposes of this standard the terms and definitions given in ISO 9000 ; 2000 apply In addition the supply chain is defined as

Supplier → Organisation → Customer

4. Mention general requirements of quality management system?

The organisation shall establish document implement and maintain a QMS and continually improve its effectiveness. The organisation shall

Identify needed processes such as management activities, provision of resources, product realization and measurement.

Determine their sequence and interaction.
Determine criteria and methods for effective operation and control of these processes.

Ensure the availability of resources and information necessary to support and monitor these processes.

Monitor measure and analyze these processes and
Implement actions to achieve planned results and continual improvement of these processes. Out sourced processes that affect the quality of the product shall be identified and included in the system.

5. Describe general documentation of quality management system?

Statements of a quality policy and quality objectives.

- A quality manual
- Required documented procedures
- Needed documents to ensure effective planning operation and control of processes and
- Required records

A procedure or work instruction is needed if its absence could adversely affect the product quality. The extent of the documentation will depend on the organisations size and type of activities the complexity of the processes and their interactions and the competency of the employees.

For example: a small organization may verbally notify a manager of an upcoming meeting whereas a large organisation would need written notification. The standard should satisfy the contractual statutory and regulatory requirements and the needs and expectations of customers and other interested parties. Documentation may be in any form or type of medium.
Quality Manual: A quality manual shall be established and maintained that includes.

The scope of the QMS with details and justification for any exclusions
The documented procedures or reference to them and
A description of the interaction among the QMS processes.

Control of Documents required by the QMS shall be controlled. A documented procedure shall be in place to define the controls needed to

Approve documents prior to use
Review update and re approve as necessary
Identify the current revision status
Ensure that current versions are available at the point of use
Ensure that documents are legible and readily identified
Identify and distribute documents of external origin and
Provide for the prompt removal of obsolete documents and suitable identify any that may be retained.

Documented procedure means that the procedure is established, documented, implemented and maintained.

Control of records: Records shall be established and maintained to provide evidence of conformity to requirements and the effective operation of the QMS. They shall be legible readily identifiable and retrievable. A documented procedure shall be established to define the controls needed for the identification storage, protection, retrieval, retention, time and disposition of records. Records can be used to document traceability and to provide evidence of verification preventive action and corrective action.

6. Explain briefly about management responsibility of QMS?

Top management shall provide evidence of its commitment to the development implementation and continual improvement of the QMS by

i. Communication the need to meet customer legal and regulatory expectations.
ii. Establishing a quality policy
iii. Ensuring that quality objectives are established

iv. Conducting management reviews and
v. Ensuring the availability of resources.

Top management is defined as the person or group of people who directs and controls an organisation.

CUSTOMER FOCUS

Top management shall ensure that customer requirements are determined and met with the aim of enhancing customer satisfaction.

QUALITY POLICY

- Top management shall issue that the quality policy's appropriate to the organisation's purpose or mission.
- Includes a commitment to comply with requirements and continually improve the effectiveness of the QMS
- Provides a framework for establishing and reviewing the quality objectives.
- Is communicated and understood within the organisation and
- Is reviewed for continuing stability. The quality policy gives the overall intention and direction of the organisation related to quality.

PLANNING

QUALITY OBJECTIVES

Top management shall ensure that quality objectives are established at relevant functions and levels within the organisation and include product requirements. They shall be measurable and consistent with the quality policy. In addition they should ensure that customer expectations are met. Quality objectives are something sought or aimed for related to quality. For example finishing department scrap will be reduced from 5% to 4.3% and the first line supervisor is the person responsible.

Quality Management System Planning

Top management shall ensure that the planning of the QMS is accomplished in order to meet the requirements of the QMS as stated in the General Requirements Element 4.1 as well as the quality objectives in addition the integrity of the QMS is maintained when changes are planned and implemented.

RESPONSIBILITY, AUTHORITY AND COMMUNICATION.

Responsibility and Authority

Top management shall ensure that responsibilities and authorities are defined and communicated within the organisation. Responsibilities can be defined in job descriptions, procedures, and work instructions. Authorities and interrelationships can be defined in an organisation chart.

Management Representative

Top management shall appoint a member of management regardless of his her other duties that shall have the responsibility and authority that includes.

- Ensuring that processes needed for the QMS system are established implemented and maintained.
- Reporting to top management on the performance of the QMS and any need for improvement and
- Ensuring the promotion of awareness of customer requirements throughout the organisation. Appointment of a member o top management as the representative can contribute to the effectiveness of the QMS

Internal Communication

Top management shall ensure that appropriate communication channels are established within the organisation and that communication takes place regarding the QMS. Typical communication techniques are management work place briefing, recognition of achievement bulletin boards, e-mail and in house news brochures.

MANAGEMENT REVIEW

General

Top management shall review the QMS at planned intervals to ensure its continuing suitability, adequacy and effectiveness. This review shall include assessing opportunities for improvement and the need for changes to the QMS including the quality policy and quality objectives. Records from he reviews shall be maintained.

Review Input

The input to the review shall include information on

- Results of audits
- Customer feed back

- Process performance and product conformity
- Status of corrective and preventive performance
- Follow up actions from previous management reviews
- Changes that could affect the QMS and
- Recommendations for improvement

Review output

The output from the review shall include any decision and actions related to

i. Improvement of the effectiveness of QMS and its processes
ii. Improvement of the product related to customer requirements and
iii. Resource needs
iv. Top management can use the output as inputs to improvement opportunities

7. Describe the provision of resources in QMS?

The organisation shall determine and provide the resources needed

To implement and maintain the QMS and continually improve its effectiveness and
To enhance customer satisfaction by meeting customer requirements

Resources may be people infrastructure work environment information suppliers natural resources and financial resources. Resources can be aligned with quality objectives.

HUMAN RESOURCES

Personal performing work that affects product quality shall be competent on the basis of appropriate education training skills and experience.
The organisation shall

Determine the necessary competence for personnel performing work affecting product quality.
Provide training or take other actions to satisfy these needs.
Evaluate the effectiveness of the actions taken
Ensure that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the quality objectives and
Maintain appropriate records of education training, skills and experience.

Competency is defined as the demonstrated ability to apply knowledge and skills. It can be contained in the job description by function group or specific position. Training effectiveness can

be determined by before and after tests performance or turnover 14 ISO 10015 Guidelines for Training will help organisations comply with this standard.

INFRASTRUCTURE

The organisation shall determine provide and maintain the infrastructure needed to achieve conformity to product requirement. Infrastructure includes as applicable

- Buildings workspace and associated utilities
- Process equipment both hardware and software and
- Supporting services such as transport or communication

WORK ENVIRONMENT

The organisation shall determine and manage the work environment needed to achieve conformity to product requirements can have a positive influence on employee motivation satisfaction and performance.

8. Describe briefly about planning of product realization?

PLANNING OF PRODUCT REALISATION

The organisation shall plan and develop the processes needed for product realisation. Planning of product realisation shall be consistent with the requirements of the other process of QMS. In planning product realisation the organisation shall determine the following as appropriate.

i. Quality objectives and requirements for the product
ii. The need to establish processes documents and provide resources specific to the product
iii. Required verification validation monitoring inspection, and test activities specific to the product acceptance and
iv. Records needed to provide evidence that the realisation processes and resulting product or service meet requirements.

The output of this planning shall be in a form suitable for the organisation's method of operations. A document specifying the processes of the QMS including the product realisation processes and the resources to be applied to a specific product project or contract can be referred to as a quality plan. The organisation may also apply the requirements given in 7.3 to the development of the product realisation processes.

CUSTOMER RELATED PROCESSES

Determination of requirements Related to the product

The organisation shall determine

i. Requirements specified by the customer including the requirements for delivery and post delivery activities.
ii. Requirements not stated by the customer but necessary for specified or intended use where known.
iii. Statutory and regulatory requirements related to the product and
iv. Any additional requirements determined by the organisation

Review of Requirements Related to the product

The organisation shall review the requirements related to the product. This review shall be conducted prior to the organisation's commitment to supply a product to the customer for example submission of tenders, acceptance to contracts or orders, acceptance of changes to contracts or orders and shall ensure that

Product are defined
Contract or order requirements differing from those previously expressed are resolved and
Its organisation has the ability to meet the defined requirements.

Records of the results of the review and actions arising form the review shall be maintained. Where the customer provides no documented statement of requirement the customer requirements shall be confirmed by the organisation before acceptance. Where product requirements are changed the organisation shall ensure that relevant documents are amended and that relevant personnel are made aware of the changed requirements . In some situations, such as internet sales, a formal review is impractical for each order. Instead the review can cover relevant product information such as catalogs or advertising material.

Customer Communication

The organisation shall determine and implement effective arrangement for communicating with customers in relation to

Product information
Inquiries contracts or order handling including amendments and
Customer feedback including customer complaints

DESIGN AND DEVELOPMENT

design and Development planning

The organisation shall plan and control the design and development of the product. During the design and development planning the organisation shall determine
The design and development stages

The review verification and validation that are appropriate to each design and development stag and
The responsibilities and authorities for design and development

The organisation shall manage the interfaces between different groups involved in design and development ensures effective communication and clear assignment of responsibility. Planning output shall be updated as appropriate as the design and development progresses.

Design and Development inputs

Inputs relating to product requirements shall be determined and records maintained. These shall include

Functional and performance requirements
Applicable statutory and regulatory requirements
Where applicable information derived from previous similar designs and
Other requirements essential for design and development

These inputs shall be reviewed for adequacy. Requirements shall be complete, unambiguous and not in conflict with each other.

Design and Development Outputs

The outputs of design and development shall be provided in a form that enables verification against the design and development input and shall be approved prior to release. Design and development outputs shall

Meet the input requirements for design and development.
Provide appropriate information for purchasing, production and for service provision
Contain or reference product acceptance criteria, and
Specify the characteristics of the product that are essential for its safe and proper use.

Design and Development Review

At suitable stages reviews of design and development shall be performed in accordance with planned arrangements

To evaluate the ability of the results of design and development to meet requirements and
To identify any problems and propose necessary actions.

Participants in such reviews shall include representatives of functions concerned with the design and development stages being reviewed. Records of the results of the reviews and any necessary actions shall be maintained. Risk assessment such as FMEA reliability prediction and simulation techniques can be undertaken to determine potential failures in products or processes.

Design and Development Verification:

Verification shall be performed in accordance with planned arrangements to ensure that the design and development outputs have met the design and development input requirements. Records of the results of the verification and any necessary actions shall be maintained. Verification confirms through objective evidence, that the specified requirements have been fulfilled. Confirmation can comprise activities such as performing alternate calculations comparing the new design specification to a similar proven design specification undertaking tests and demonstrations and reviewing documents prior to issue.

Design and Development Validation

Design and development validation shall be performed in accordance with planned arrangement to ensure that the resulting product is capable of meeting the requirements for the specified application or intended use when known. Wherever practicable validation shall be completed prior to the delivery or implementation of the product. Records of the results of validation and any necessary actions shall be maintained. Validation confirms through objective evidence that the requirements for a specific intended use have been fulfilled.

Control of Design and Development changes

Design and development changes shall be identified and records maintained. The changes shall be reviewed verified and validated as appropriate and approved before implementation. The review of design and development changes shall include evaluation of the effect of the changes on constituent parts and product already delivered . Records of the results of the review of changes and changes and any necessary actions shall be maintained.

9. Describe briefly about purchasing of quality management system?

Purchasing Process

The organisation shall ensure that purchased product conforms to specified purchase requirements. The type and extent of control applied to the supplier and the purchased product shall be dependent upon the effect of the purchased product on subsequent product realisation or the final product. The organisation shall evaluate and select suppliers based on their ability to supply products in accordance with the organisation's requirements. Criteria for selection evaluation and re evaluation shall be established. Records of the results of evaluations and any necessary actions arising from the evaluation shall be maintained. This standard does not apply to items such as office and maintenance supplies unless they are products.

Purchasing Information

Purchasing information shall describe the product to be purchased including where appropriate

i. Requirements for approval of product procedures, processes, and equipment
ii. Requirements for qualification of personnel and
iii. QMS requirements

The organisation shall ensure the adequacy of specified requirements prior to their communication to the supplier

Verification of Purchased Product

The organisation shall establish and implement the inspection or other activities necessary for ensuring that purchased product meets specified purchase requirements. Where the organisation or its customer intends to perform verification at the supplier's premises, the organisation shall state the intended verification arrangements and method of product release in the purchasing information.

10. Describe briefly about control of production and service provision?

Control of production and Service Provision

The organisation shall plan and carry out production and service provision under controlled conditions. Controlled conditions shall include as applicable

i. The availability of information that describes the characteristics of the product
ii. The availability of work instructions as necessary

iii. The use of suitable equipment
iv. The availability and use of monitoring and measuring devices.
v. The implementation of monitoring and measurement and
vi. The implementation of release delivery and post delivery activities

Validation of Processes for Production and Service Provision

The organisation shall validate any processes for production and service provision where the resulting output cannot be verified by subsequent monitoring or measurement. This includes any processes where deficiencies become apparent only after the product is in use or the service has been delivered. Validation shall demonstrate the ability of these processes to achieve planned results. The organisation shall establish arrangements for these processes including as applicable

i. Defined criteria for review and approval of the processes
ii. Approval of equipment and qualification of personnel
iii. Use of specific methods and procedures
iv. Requirements for records and
v. Revalidation

Identification and Traceability

Where appropriate the organisation shall identify the product by suitable means, throughout product realisation. The organisation shall identify the product status with respect to monitoring and measurement requirements. Where traceability is a requirement the organisation shall control and record the unique identification of the product. In some industry sectors, configuration management is a means by which identification and traceability are maintained. Identification can frequently be accomplished with a production router or traveler.

Customer Property

The organisation shall exercise care with customer properly while it is under the organisation's control or being used by the organisation. The organisation shall identify verify protect and safeguard customer property provided for use or incorporation into the product. If any customer property is lost damaged or otherwise found to be unsuitable for use this shall be reported to the customer and records maintained. Customer property can include intellectual property.

Preservation of Product

The organisation shall preserve the conformity of product during internal processing and delivery to the intended destination. This preservation shall include identification handling

packaging, storage and protection. Preservation shall also apply to the constituent parts of a product.

11. Explain briefly about control of monitoring and measuring devices for quality management system?

The organisation shall determine the monitoring and measurement to be undertaken and the monitoring and measuring devices needed to provide evidence of conformity of product to determined requirements. The organisation shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements. Where necessary to ensure valid result measuring equipment shall

- Be calibrated or verified at specified intervals or prior to use against measurement standards where no such standards exist the basis used for calibration or verification shall be recorded.
- Be adjusted or readjusted as necessary
- Be identified to enable calibration status to be determined
- Be safeguarded from adjustments that would invalidate the measurement result and
- Be protected from damage and deterioration during handling maintenance and storage.

In addition the organisation shall assess and record the validity of the previous measuring results when the equipment is found not to conform to requirements. The organisation shall take appropriate action on the equipment and any product affected. Records of the results of calibration and verification shall be maintained. When used in the monitoring and measurement of specified requirements the ability of computer software to satisfy the intended application shall be confirmed. This shall be undertaken prior to initial use and reconfirmed as necessary.

Measurement Analysis and improvement

GENERAL

The organisation shall plan and implement the monitoring measurement analysis and improvement processes needed

i. To demonstrate conformity of the product
ii. To ensure conformity of the QMS and
iii. To continually improve the effectiveness of the QMS

This shall include determination of applicable methods including statistical techniques and the extent of their use.

MONITORING AND MEASUREMENT

Customer Satisfaction

As one of the measurements of the performance of the QMS the organisation shall monitor information relating to customer perception as to whether the organisation has met customer requirements. The methods for obtaining and using this information shall be determined.

Internal Audit

The organisation shall conduct internal audits at planned intervals to determine whether the QMS

Conforms to the planned arrangements to the requirements of this standard and to the requirements established by the organisation and is effectively implemented and maintained

An audit program shall be planned, taking into consideration the status and importance of the process and areas to be audited as well as the results of previous audits. The audit criteria, scope frequency and methods shall be defined. Selection of auditors and conduct of audits shall ensure objectivity and impartiality of the audit process. Auditors shall not audit their own work. The responsibilities and requirements for planning and conducting audits and for reporting results and maintaining records shall be defined in a documented procedure. The management responsible for the area being audited shall ensure that actions are taken without undue delay to eliminate detected nonconformities and their causes. Follow up activities shall include the verification of the actions taken and the reporting of verification results.

Monitoring and Measurement of processes

The organisation shall apply suitable methods for monitoring and where applicable measurement of the QMS process. These methods shall demonstrate the ability of the process to achieve planned results. When planned results are not achieved, correction and corrective action shall be taken appropriate to ensure conformity of the product.

Monitoring and Measurement of Production and Service

The organisation shall monitor and measure the characteristics of the product to verity that product requirements have been met. This shall be carried out at appropriate stages of the product realisation process in accordance with the planned arrangements. Evidence of conformity with the acceptance criteria shall be maintained. Records shall indicate the persons authorizing release of product. Product release and service delivery shall not proceed until the planned arrangements have been satisfactorily completed unless otherwise approved by a relevant authority and where applicable by the customer.

CONTROL OF NONCONFORMING PRODUCT

The organisations shall ensure that product which does not conform to product requirements is identified and controlled to prevent its unintended use or delivery. The controls and related responsibilities and authorities for dealing with nonconforming product shall be defined in a document procedure. The organisation shall deal with non conforming products in one or more of the following ways.

- By taking action to eliminate the detected nonconformity
- By authorising its use release or acceptance under concession by a relevant authority and where applicable by the customer and
- By taking action to preclude its original intended use or application

Records of the nature of nonconformities and any subsequent actions taken including concessions obtained shall be maintained. When nonconforming product is corrected it shall be subject to re verification to demonstrate conformity to the requirements.

When nonconforming product or service is detected after delivery or use has started the organisation shall take action appropriate to the effects or potential effects of the nonconformity.

ANALYSIS OF DATA

The organisation shall determine collect and analyze appropriate data to demonstrate the suitability and effectiveness of the QMS and to evaluate where continual improvement of the effectiveness of the QMS can be made. This shall include data generated as a result of monitoring and measurement and from other relevant sources. The analysis of data shall provide information relating to

- Customer satisfaction
- Conformity to product requirement
- Characteristics and trends of processes and products including opportunities for preventive action and
- Suppliers

IMPROVEMENT

Continual Improvement

The organisation shall continually improve the effectiveness of the QMS through the use of the quality policy, quality, objectives, audit results, analysis of data corrective and preventive actions and management review.

Corrective Action

The organisation shall take action to eliminate the cause of non conformities in order to prevent recurrence. Corrective actions shall be appropriate to the effect of the non conformities encountered. A documented procedure shall be established to define requirements for

- Reviewing nonconformities including customer complaints
- Determining the causes of nonconformities
- Evaluating the need for action to ensure that conformities do not recur
- Determining and implementing action needed
- Records of the results of action taken and
- Reviewing corrective action taken.

Preventive Action

The organisation shall determine action to eliminate the causes of potential nonconformities in order to prevent their occurrence. Preventive actions shall be appropriate to the effects of the potential problems. A documented procedure shall be established to define requirements for

- Determining potential nonconformities and their causes
- Determining and implementing action prevent occurrence of nonconformities
- Determining and implementing action needed.
- Records of results of action taken and
- Reviewing preventive action taken

Preventive action is taken to prevent occurrence while corrective action is taken to prevent reoccurrence.

Eight total quality management principles form the basis for the QMS standards. They are customer focus, leadership, employee involvement, process approach, system approach to management continual improvement, factual approach to decision making and mutually beneficial supplier relationships. These principles are similar to the correct value of the malcom Baldrige National Quality Award

12. Explain briefly about implementation of quality system in an organisation?

In order to implement a quality system in an organisation the following steps must be followed.

1. Top Management support

This is the most important step in implementing a quality system. While implementing a system which must be on par with the ISO 9000 or even a higher standard, the full support of the

management is necessary. The managers of the organisation must be willing to make available the resources required to get the quality system certified. Without the support from the management the process will run into several problems or even might fail. The top level management has a specific involvement in the quality system and they must be involved with its implementation.

2. Appointed the Management Representative

Once the support of the top level has been obtained the next step in the process would be to appoint a management representative. This would be like any other business undertaking. The job of the management representative is to coordinate and maintain the quality system. All the parties both internal and external who are involved in the certification process must be in contact with the representative. This representative can be a member of the management who must see that the quality system is being effectively put into practice documented and maintained.

3. Creating Awareness

The process of implementing a quality system must involve all the employees of the organisation. An awareness program should b e conducted for all the employees to instruct them about the quality system. They should be made to understand how the system is going to affect their everyday system. The potential benefits of the quality system must also be explained. In order to create this awareness short seminars can be conducted.

4. Appoint an implementation Team

Once the awareness has been created among the employees of the organisation an implementation team should be made. The job of this implantation team is to identify the quality system processes their sequence and interactions. The personal in the implementation team should be taken from all the levels and all the areas of the organisation. This is done so that no area is left without being represented in the quality management system. Committees can also be created to see that each cause of the quality system is implemented.

5. Training

Training must be carried out for the implementation team supervisors of the processes and the internal audit team. Training can be carried out by sending the team leaders fro the training programs. The leaders can than train the other team members by conducting seminars for them.

6. Time Schedule

The time required for the implementation of the quality system within the organisation must be calculated. The amount of time required will vary depending on the size of the

organisation and the extent of its existing quality system. Effectively the procedure can be completed in about less than 1.5 years. The time schedule must be planned in such a way that implementing the quality system can be completed within the specified time.

7. Appointed Element owners

The clauses in the implementation program contain elements. An element owner can be selected for each of these elements. The element owners are selected by the implementation team and can be form the team itself. Each of the element owners is given the capability of selecting a team to assist them. The more people involved, the more effective the system.

8. Review the existing system

The existing quality system should be examined. Copies of all the quality manuals, procedures work instructions and forms presently in use are obtained. These documents are checked and sorted into the system elements. The changes that must be made to the existing system are noted. This activity can be performed by either the element owners or it can be given out to an external consultant.

9. Prepare the documentation

The quality policy and the procedure manuals must be given in writing. Instructions to maintain the quality in the work processes must be written. The best person to write these process instructions is the employee who is doing the job. By using this method the employees can also be asked to expose the flaws in the current system and how to eliminate them. Although documentation is necessary long and complicated documentation should be avoided. Written documentation must be easy to understand and easy to put into practice.

10. Install the new system

Policies procedures and work instructions should be made use of in the everyday activities of the organisation and what is being done should be documented. All the improvements in the quality system that have been indicated by the employees in the above stage can be made use of here. IT is not necessary that all the elements should be implemented at the same time. This can be done is stages. Make sure that all the people are trained to follow the new system.

11. Internal Audit

An internal audit must be conducted for the quality system, The internal audit is used to show that the system is working properly and to give information to the management for a

review. The audit might find some problems in the system which must be corrected. The audit team should consist of trained personnel from different departments of the organisation.

12. Management Review

The management review is conducted in order to determine the effectiveness of the quality system. The ability of the system to achieve the set goals is checked in this stage. Any necessary changes can be made.

13. Pre assessment

This step is used to check if all the systems are performing their required functions before an external auditing party is called upon. If a proper job has been done in the previous steps, this step can be skipped.

14. Registration of the Quality System

Registration of the system can be divided into three parts. Choosing a registrar, submitting an application and conducting the registrar system audit. The factors that should be looked into while choosing a registrar are cost lead time registrar's accreditation, customer's acceptance of registrar and the familiarity the registrar has with the organisation. The application for registration must include the policy and the procedure manuals for the review. The time taken by the registrar the registrar to audit the company wills very depending on the size of the organisation and the number of auditors involved. The audit will usually take around one to three days. It will consist of an opening meeting to tell the auditors what process to follow the actual audit and a closing meeting to discuss the findings of the audit.

13. Explain briefly about quality auditing?

The term audit refers to a regular examination and checking of accounts or financial records settlement or adjustment of accounts. It also refers to checking, inspection and examination of production processes. The International Organisation for Standardisation (ISO) defines an audit as "as systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and suitable to achieve objectives. A quality audit is always performed against a documented system.

Main features of Quality Audit

- A Quality audit must evaluate a sample of activities and draw and inference on the quality system as a whole
- The audit must be based on a documented procedure which is represented by quality system documentation specifications and drawings.
- The audit must be conducted by persons who are not directly linked with the activity being performed. This is done so that no bias exists.

Purpose of Quality Audit

The quality audit must provide data and information for making managerial decisions. It examines the adequacy and effectiveness of a system. The main components of the audit process are the documentation under which the audit is conducted. The auditors first establish a documented system and then its efficiency before conducting a meaningful audit.

The purpose of the audit is to

- Establish the adequacy of the system
- To determine the effectiveness of the system
- To afford opportunities for system analysis
- To help in problem solving
- To make decision making easier
- To help involve the employees
- Help in establishing the capability of the process
- To ensure meeting the legal requirements
- To aid communication and facilitate training

14. Describe briefly about types of quality audit.

Quality audit can be classified into two types internal and external audit. An internal audit is conducted by personnel within the organisation. An external audit is conducted by people from outside the organisation such as the purchasing party second party audit or a certified auditing agency third party audit.

First party audit

This audit is carried out by a supplier on his own system to evaluate its performance. The personnel conducting this audit are not directly connected with the process being audited. These types of audit can also be carried out by an external agency. An internal audit confirms that the quality system is working properly. It helps to correct any non conformities in the system.

Second party audit

This type of audit is conducted by the organisation that is going to buy the goods from the supplier. The purpose of this audit is to give the purchasing organisation a level of confidence in the suppliers abilities. IT also assists the supplier to improve the quality of his system. A disadvantage of this type of audit is that the purchasing organisation takes into account only the areas which directly affect his purchase and ignores the other areas.

Quality audit can also be classified on the basis of the area taken into account for the audit such as

i. System Audit
ii. Process Audit
iii. Product Audit
iv. Adequacy Audit
v. Compliance Audit

System Audit

The system audit is carried out in order to check if the activities of the organisation are being carried out according to the documented procedure. This audit can be performed either internally or externally. A system audit is evaluate the ability of a potential supplier to provide the required quality of products.

Process Audit

The process audit is used to check the manufacturing or processing activity. This audit verifies that the manufacturing and testing operation are being carried out according to the required standards . It involves auditing processes such as welding, soldering, heat treatment, painting etc. This audit may be carried out internally or externally.

Product Audit

The product audit is conducted to measure the level of conformity of the product to a specified standard of workmanship or quality. This audit involves checking of the accuracy of the equipment and also the calibration processes.

The product audit may be conducted internally before delivering the product to the customer, or it may be conducted with the customer. It is conducted at the final stage of processing to see that the outgoing products meet the specified requirements. The complete assembly is evaluated to verify that it meets the requirements of the customer.

Adequacy Audit

This audit is undertaken with a view to check whether the quality specification which the company is following is adequate for meeting the needs of the customers. This is an exercise where each requirement is compared with the provisions made in the documented system to check whether the documented system reflects the criteria requirements.

Compliance Audit

The following procedure should be followed by the auditors while conducting an audit in a specific organisation.

i. Auditors should meet at the organisation to b e audited at the appointed time.
ii. The auditors should be given access to all the documents such as the quality manual, work procedures, documentation of previous audits, records etc.
iii. The documents are reviewed and an opening meeting is conducted.
iv. During the opening meeting, the auditor and the auditee sit together and discuss on the process to be audited the type of audit to be carried out, the time schedule, and to set the ground rules for the audit. A senior member of the organisation usually opens the meeting. The duration of the meeting should not exceed 20 to 30 minutes.
v. The audit teams must then visit the sections of the organisation and determine the size and the layout of operations.

The team leader of the auditing team should then assign particular sections of the organisation to each person to carry out the audit. He should also given the extent of the audit to be carried out and the time schedule that each person must take.

If the auditors are new to the site they must be escorted to the departments which they have to the departments which they have to audit and also be introduced to the interface personnel for that department.

The information received before and during the audit must be kept confidential. This is explained during the opening meeting and the extent of cooperation of the organisation is also determined.

Auditing is usually carried out on a sample basis. The limitations which can occur due to sampling are briefed to the management during the opening meeting. The samples which are taken for the should be representative of the entire population of the product. This selection of the sample is of utmost importance.

The observations must be recorded as follows.

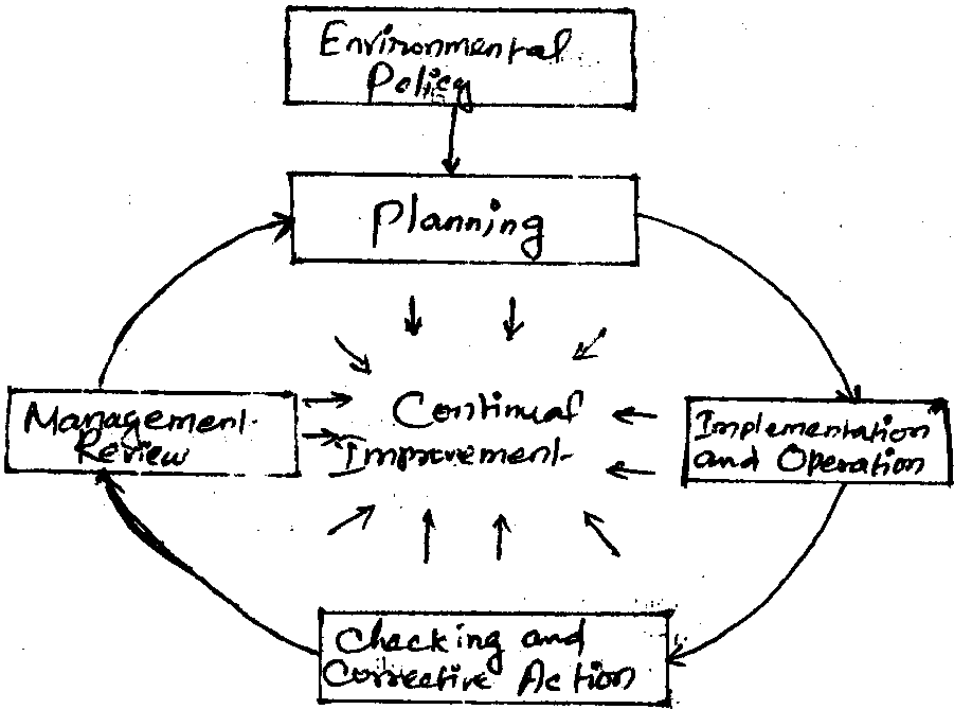
- The recording of observations should always be with reference to the documents examined bath numbers items involved, job titles etc. the recording should be understandable and made in such way that it is easy to retrieve them in the later part of the audit. These observations can be used for checking for non conformities in the products.
- The auditors can get information by asking the auditee personnel for information. The

auditors should b e objective to obtain the essential facts.

- The auditors should witness the processes and verify the facts obtained. This provides tangible proof form which inferences can be taken. The auditor should see how the processes and verify the facts obtained. This provides tangible proof form which inferences can be taken, The auditor should see how the process is performed and check whether the documentation and the process being done comply with each other.
- After the information has been collected, a closing meeting Is held by the auditors to consolidate their findings. The processes are checked for adequacy or non compliance and the findings are reported to the management. The management then must take the required steps to see that the non conformities are rectified.

16. Explain briefly about ISO 14000 environmental management system.

The ISO 14000 standard gives the company background on which to base its Environmental Management System (EMS). This system can be joined with other Quality Standards and can be implemented together to achieve the organisations environmental targets. It gives the requirements for the registration of the organisation's Environmental Management System . By registering this system it will assure the other parties that the particular organisation has an EMS in place and it is being monitored. The ISO 14000 is applicable to all types of organisations whatever maybe their size type geographical location or any other applicable condition. The requirements of the standard are based on the bettering of the process and its continual improvement.



Environmental Management systems can be basically divided into Environmental policy, Planning, implementation and operation, checking and corrective action, and management review. The above events form the sequence of a cycle in order to provide continuous improvement. The overall aim of the system is to provide protection to the environment and to prevent pollution.

To properly understand the standards involved in the environmental system a few terms have to be defined.

Environment is defined as the surroundings in which the organisation operates which includes the air, water, land, plant and animal life, humans and the interaction of the all the above.

Environmental impact is any change that occurs in the environment whether bad or good wholly or partially, resulting from the organisation's activities, products or service. E.g, soil erosion, impact on habitat.

Environmental aspect is defined as the element of the organisations activities that can interact with the environment e.g. wastewater discharge, air emissions.

Environmental objective is the overall environmental goal, arising from the policy statement which the organisation has set and which is quantified when practical. They define how the policy will be achieved.

Environmental Target is the conditions that are to be met in order to achieve the objective. E.g. air particulate emissions must be within a particular range.

ISO 14000 Series or Standards

The ISO 14000 series of Standards is used by organisations to incorporate in Environmental Management system into their organisation . The standard can be divided into two areas the organisation Evaluation Standard and the product Evaluation Standard.

The Standards that come under each of the above areas are given in the table below.

Organisation Evaluation Standard

Category	Standard	Title	Explanation
Environmental Management system	ISO 14001	Specifications with guidance for use	This standard givens the elements that the organisation must conform to if they want the system registered.
	ISO 14004	Guidelines on principles Systems	This standard provides supplementary material for the above standard and should not be

		and supporting techniques	followed for registration.
Environmental Auditing	ISO 14010	General principle for Environmental Audition	Gives information on External and Internal auditing
	ISO 14011	Auditing Procedures Auditing or Environmental Management System	Shows how to plan and conduct the audit. Also shows how to document the audit
	ISO 14012	Qualification Criteria for Environmental Auditors Performing EMS audits	Gives information on Auditor Performance Training Attributes and skills
Environmental Performance Evaluation	ISO 14031	Guidelines on Environmental Performance Evaluation	Gives information on how to record the information to track Performance and check performance requirements

Performance Evaluation Standards

Category	Standard	Title	Explanation
EAPS Guide	Guide 64	Environmental Aspect in product standards	This standard helps the developers of the standard for the organisation.
Environmental Labeling	ISO 14020	Basic principles for all Environmental Labeling	Gives the goals and the principles that must be used in a labeling program
	ISO 14041	Goals and Definition /Scope and Inventory Analysis	Provides guidelines for the preparation conduct and critical review of the life cycle Analysis
	ISO 140442	Impact Assessment	Used the results of the inventory analysis to evaluate the significance of potential environmental impact
	ISO 24043	Improvement Assessment	Provides information to improve the total environmental performance of a product system

The implementation of the organizational Evaluation Standards are easy because the focus of these standards are not on the product but on the process like ISO 9000. On the other hand, the product Evaluation Standards will be difficult to put into practice because at present there is a lack of scientific knowledge on life cycle assessment

17. Describe briefly the requirements of ISO 14001.

The standard is divided into six parts or clauses and has a total of 18 requirements. The numbering system used is identical to the standard.

General Requirements

The organisation shall establish and maintain an environmental management system that includes policy, planning, implementation and operation, checking and corrective action, and management review. These requirements are given in the rest of the standard.

Because the document is available to the public and other stakeholders, the organisation may with to include in this narrative a brief description of the company . In addition this clause is a good place to include manual control and distribution.

In developing the EMS keep it as simple as possible. It will work better when it is easy to follow and easy to understand. It can always be expanded at a later time making certain that the registrar is informed of the change . It is not necessary to start over use existing procedures such as ISO 9000 where applicable. Existing information may need to be reformatted, but this action is easier than starting from scratch.

Environmental policy

The organisation's policy statement should be based on its mission and values. It should show management commitment, leadership, and direction for the environmental activities. Management will ensure that the policy is implemented and carried out. An initial environmental review is suggested which includes the following.

- Identification of legislative and regulatory requirements.
- Identification of environmental aspects of its activities, products or services that can have significant impact and liabilities.
- Identification of existing activities with suppliers.
- Identification of existing management policies and procedures.
- Evaluation of past performance with regard to the above
- Feedback from investigation of previous incidents of noncompliance
- Identification of opportunities for competitive advantage
- Having this information will help the organisation develop its environmental policy.

The policy must b e relevant to the organisation's committed to continual improvement impact of its activities, products, and services.

The policy must ensure that management is committed to continual improvement and prevention of pollution. Management's commitment must be apparent to all the employees because employees tend to do what is important to management.

The policy includes a commitment to comply with relevant legislation and regulations and with any other requirements applicable to the organisation, industry, and locality. Other requirements may include items such as permits, licenses, and voluntary program activities.

The policy provides a framework for setting and reviewing environmental objectives and targets. Their setting should aim to comply with legislative and regulatory requirements. Provision must be made for periodic review of progress in meeting the objectives and targets.

The policy must be documented, implemented, and maintained; it also must be communicated to all employees. Documenting the policy means that it must be in writing or in electronic format. Implementing it means that it must be put into practice by everyone involved in the EMS. Maintaining it means that the policy is dynamic and provision for updating must be provided. Communicating the policy to the employees is a never ending job it requires repetition and the use of different forms of media.

The policy must be available to the public seldom do organisations make internal policies available to the public however where the environment is concerned, the public is a major stakeholder. Suggested approaches are to distribute the policy to libraries, chambers of commerce, environmental organisations, or other public access organisations. Of course copies should be made available in the organisation's reception area and to anyone that asks for one. Each year UAE publishes its average amount of emissions of carbon dioxide nitrogen oxides and sulfur dioxide as well as the amount of nuclear waste.

Planning

This area contains four elements environmental aspects, legal and other requirements, objectives and targets, and environmental management programs

ENVIRONMENTAL ASPECTS

The relationship among the environmental aspects environmental impacts and the standard is necessary for successful implementation of the standard. It requires that environmental aspects of an organisation's activates, products, and services that it can control and influence be identified in order to determine the environmental impact.

Consideration should be given to abnormal and emergency situations, startup and shutdown, and normal operations. It is worth nothing that there is a cause and effect relationship between the environmental aspect and its impact.

Those aspects that relate to significant impacts shall be considered in setting objectives. It is not necessary for every aspect to have an objective only that it be considered. This information must be kept current.

LEGAL AND OTHER REQUIREMENTS

The standard requires the organisation to have a procedure to identify and have access to all legal and other requirements are those attributed to governmental legislative and regulatory action. Other requirements usually include industry codes of practice, contracts agreements with public authorities and nonregulatory guidelines. Even if some of these requirements are voluntary, the organisation is accountable to those with which it agreed to comply.

The issues to be considered in the procedure should include how the organisation.

- Accesses and identifies legal and other requirements
- Keeps track of legal and other requirements.
- Keeps track of changes of legal and other requirements.
- Communicates relevant information about legal and other requirements to employees.

The number and complexity of legal and other requirements throughout the world can make the procedure quite complex however the organisation need only identify those requirements that are applicable to the environmental aspects of its activities, products, and services. Examples of laws that might apply are clan Air act U.S , public Health Act U.K and chemical Products Act Sweden.

OBJECTIVES AND TRAGETS

The organisation shall establish and maintain these objectives and targets that reach relevant function and level. They shall be consistent with the policy statement, especially in regard to the prevention of pollution. An objective for a paper manufacturer would be “Reduce tree cutting” and some targets would be “Increase chipper yield to 80% by 2005 and “Increase recycled material to 30% by 2009.

In addition to the environmental aspects, and the legal and other requirements which were previously discussed this clause also requires that the organisation consider.

The best technological option to mitigate an aspect.

- Economic viability of the option
- Cost effectiveness of the option
- Appropriateness of the option to the situation.
- Affordability of the option, given the organisation's financial, operational, and business situation.

Views of interested parties such as employees regulatory agencies, and any other stakeholders.

Objectives may apply to one person group function or to the entire organisation, They should be developed by those who are involved in their attainment. ISO 14004 lists different forms of objectives such as

Reduce waste and the depletion of resources.
Reduce or eliminate the release of pollutants in the environment.

Design products to minimize their environmental impact in production use and disposal.

Control the environmental impacts of sources of raw material.

Minimize any significant adverse environmental impact of new developments.

Promote environmental awareness among employees and the community.

ENVIRONMENTALMANAGEMENTPROGRAMS

The organisation shall establish and maintain a programs for achieving the objectives and targets. It shall include designation of the responsible function, team or individual and a timeframe for achievement.

i. State the objective target
ii. State the purpose how the objective target will support the policy
iii. Describe how the objective target will be achieved.
iv. State the program team leader.
v. Designate departments and individuals responsible for specific tasks
vi. Establish the schedule for completion of the tasks.
vii. Establish the program review which will include format, content, and review schedule.

18. Explain briefly about implementation and operation of EMS?

Implementation and operation

This area contains seven elements.

- Structure and responsibility
- Training, awareness and competency
- Communication
- EMS documentation
- Document control
- Operational control and
- Emergency preparedness and response

STRUCTURE AND RESPONSIBILITY

Roles responsibilities and authorities shall be defined, documented and communicated for all personnel affecting the EMS. They must be given the freedom and authority to take the necessary actions. An organisation chart is one method to show the flow of authority. A management representative must be appointed and given the authority to ensure that this standard is being met and to periodically report to senior management the status of EMS with the aim of improvement. This appointment must not be viewed by top management as a way to avoid their involvement in the EMS. The management representative can only be as effective as management's involvement.

Senior management must provide the resources in terms of people technology and money to implement and maintain an effective system that achieves its objectives.

TRAINING AWARENESS AND COMPETENCY

Training needs should be evaluated on a regular basis usually annually to ensure their effectiveness. There are two types of training general awareness and job competency. General awareness includes the importance of conformance to the EMS the relationship of significant environmental impacts to the employee's work activities employee roles and responsibilities and potential consequences of failing to follow specific operating procedures. Personnel performing tasks that can cause significant environmental impacts shall be competent based on education, training, or experience. Records must be maintained to document that the training requirements have been met.

- At a minimum this training should include.
- Record of training needs assessments.
- Task competency requirements
- Training procedures
- Training plans
- Records of training delivered to specific employees

Registrar's audits will require these documented records, and they will be valuable for internal operations and litigation defense if needed.

COMMUNICATION: A key aspect of any management program is communication with all stakeholders. The standard requires that procedures shall be established and maintained for internal communication among all employees.

Effective communication up down and laterally should ensure that questions are answered and that understanding is complete and accurate. Internal environmental communication procedures should address reporting on environmental activities to

Demonstrate management's commitment to the environment and EMS
Handle concerns and questions about environment aspects of the organisation's activities, products, and services.
Inform appropriate employees of all legal and regulatory changes and all changes to the EMS.
Raise awareness of the organisation's environmental activities.
Ensure that all employees are aware of objectives, targets, programs, and achievements.
Publish results of internal and external audits as well as management reviews.
Maintain a high level of employee focus on environmental issues.

In addition procedures shall be established for receiving documenting, and responding to relevant external communication from interested parties. It is up to the organisation to decide what is relevant or not relevant. However from a practical matte, it is best to respond to all external inquiries.

Furthermore the organisation shall consider processes for external communication of its environmental aspects and record its decision to implement or not to implement those processes. Many organisations take a proactive approach and externally communicate their environmental aspects. Organisations that do not take a proactive approach should record the fact and present reasons for their actions.

ENVIRONMENTAL MANAGEMENTS SYSTEM DOCUMENTATION:

The organisation shall establish and maintain information in paper or electronic form to describe the core elements of the system and their interaction and provide direction to applicable documents. ISO 14000 requires a documentation system very similar to ISO 9000 which makes integration of the two system very easy. The organisation must show that it is actually practicing what the documentation states.

DOCUMENT CONTROL

This element requires that procedures be established and maintained to control all EMS documents. Examples are blueprints, test procedures, work instructions, and of course, the EMS manual. Provisions must be made for the review and approval of documents for adequacy before they are issued and after any changes. The purpose of document control is to ensure that appropriate and current issues of documents are in place at all locations. Obsolete documents must be removed and destroyed or stored in a safe place if retention for legal purpose is necessary. Documents shall be legible dated, readily identifiable, and easily located.

The best document control system is the simplest one that meets the needs of the organisation and ISO 14000. if the organisation has an existing system such as ISP 9000 it can be used as a model.

ISO documentation can be viewed as four levels. Level 1 the policy level is the EMS manual that includes the environmental policy responding to each clause. Organisational charts and other forms of documentation can be used to clearly define core elements of the system and how they relate of level 2 procedures. The organisation may wish to list environmental aspects; objectives; targets; and legal, regulatory, and other requirements at this level.

Level 2 the procedure level. Describes what the organisation does to meet level 1 policies. There are 17 procedures and while only three are explicitly required to be documented it is best from an effectiveness standpoint to document all 17.
Level 3 the practice level. Describes the work instructions by which operating personnel perform their tasks. They are step by step instructions dealing with activities required by the standard. Organisations involved with TQM or ISO 9000 will already have these activities documented.
Level 4 the proof level is the location of all forms records, drawing and so forth that represent the objective evidence or proof of the performance of the EMS.

It is important to note that the system should be an efficient one and not a bureaucratic one keep it simple. In addition, the documentation must show the interaction of the elements and provide direction to related documents such as flow charts check sheets and drawings.

OPERATIONAL CONTROL:

This element aligns operations and activities with the identified significant environmental aspects environmental policy, and environmental objectives and targets. The organisations shall plan these activities to ensure that the procedures.

Cover situations where their absence could lead to deviations from. The policy and the objectives and targets.

Stipulate operating criteria which are the details and instructions that would normally be included in any process procedure, or step by step work instruction. They include equipment to be used materials required process settings, maintenance program, and so forth.

Cover the identification of environmental aspects of goods and services and communicate relevant procedures and requirements to suppliers and contractors. Ford Motor Co.. which has registered all 140 facilities in 26 countries requires its suppliers to be certified to ISO 14001

EMERGENCY PREPAREDNESS AND RESPONSE

Procedures are required to identify and respond to potential accidents and emergency situations. In addition, the procedure should prevent or mitigate the environmental impact of these accidents and emergency situations. If plans and procedures are required by law, they will usually suffice for the standard. Emergency plans should include.

i. Emergency organisation and responsibilities of key personnel.
ii. Details of emergency services such as fire department and spill cleanup services.
iii. Internal and external communication plans.
iv. Actions to be taken for the different types of emergencies.
v. Information on hazardous materials and their impact including information about equipment and protective clothing.
vi. Training plans and testing for effectiveness.

These procedures shall be reviewed and revised if necessary especially after an emergency.

19. List out briefly about benefits of environmental management system?

The benefits of having an ISO 14000 certification can be divided into two categories organizational benefits and Global Benefits.

Organisational benefits

Having ISO 1400 certification would benefit the organisation in the following ways Assuring customers that the organisation is committed to environmental management

- The products from the company can be assured of quality
- Obtaining Insurance at reasonable cost
- Maintaining a good public community relations image
- Improving defense posture in litigation
- Conserving input materials and energy
- Satisfying investor criteria and improving relations to capital
- Competitive advantages results by having an increased share value
- Improving industry government relations.
- Making it easier to obtain permits and authorization
- Becoming cost effective by reduction of wastes
- Becoming more active in improving workplace and external environment

Global Benefits

There are three main global benefits that can be seen after the implementation of a ISO 14000 certification.

- The performance of planet earth is improve
- Build consensus that there is a need for environmental management
- Facilitate trade and remove barriers

The ISO 14000 plays a major role in the process of environmental improvement worldwide. As it can be seen how the ISO 9000 has helped industries improve their quality it can be expected from the ISO 14000 that it will help to improve the environment.

The formation of national and regional standards has led to confusion and trade barriers. This international standard will help to join all countries in their approach to environmental management and life cycle assessment. This approach will also remove trade barriers and make trading between countries easier. The ISO 14000 has such a framework that once it is implemented within countries. It will lead to a progress that will reassure the worldwide community.

20. Difference between ISo 9000 and TQM Approach.

ISO 9000 is a Quality Management System in which the emphasis is on the writing of formal procedures and work instruction to guide employees. It is expected

21. Difference between ISO 9000 and TQM Approach.

ISO 9000 is a Quality Management System in which the emphasis is on the writing of formal procedures and work instructions to guide employees. It is expected that all employees will comply with the procedures in order to ensure that the work is done properly. Internal and external audits are carried out in order to identify whether or not employees are complying with the requirements and whether corrective actions are taken to remedy the deficiency. The focus is, therefore, on technical system. On the other hand, TQM talks about integration of technical system with social system – the people 'in' and 'outside' the organization. TQM is a management philosophy which involves integration of people, system and management philosophies like vision, commitment, leadership and continuous quality improvement. Companies which are only certificated to BS-5750/ISO 9000/IS-14000 may not be always strategically focused on identifying and satisfying the customer needs, neither may they be necessarily focused on the involvement and empowerment of employees in pursuit of continuous improvement. For this, they need a TQM-approach across the organization. So, while TQM is a (never-ending) journey, ISO 9000 is just a milestone. Key differences are tabulated in Table. TQM is like a 'three-legged' stool as described by Pike and Barnes and absence of any leg would destabilize the stool, as is clear from figure.

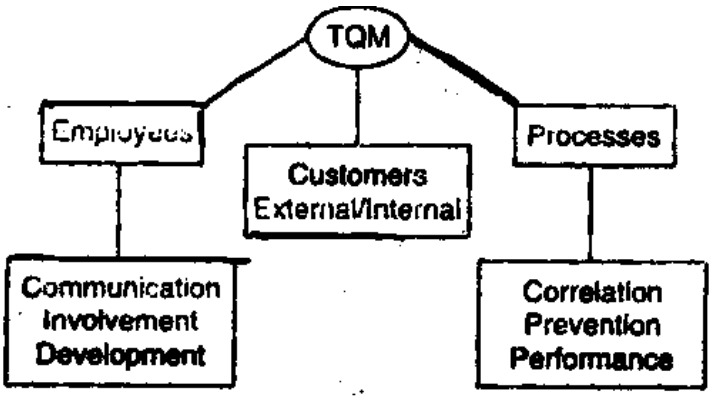


Fig. Key issues in TQM implementation strategy (Pike & Barnes, 1994)

The differences could be summarized as follows in the Table.

Table: Nature of ISO 9000 and TQM APPROACH

ISO 9000 Approach	TQM Approach
A technical system of TQM.	A total management philosophy.
Not always integrated with corporate strategy.	Always integrated to company strategy, mission and vision.
Technical system and procedures focused.	Philosophy, concepts, tools and techniques focused.
All employees involvement not necessary.	Emphasis on Total Employee Involvement (TEI) and empowerment.

Can be departmentally focussed. More responsibility to quality department.	Organization-wide. Every department and everyone responsible, at every level.
May not require organizational transformation and development.	Involves process and culture change and requires organization development process.
Mostly organization based.	Extends even outside the organization.

22. Explain the Elements of Quality System.

The following are the elements of a quality system:

i. Management responsibility
ii. Quality system
iii. Contract review
iv. Design control
v. Document control
vi. Purchasing
vii. Purchaser supplied products
viii. Product identification and traceability
ix. Process control
x. Inspection and testing
xi. Inspection, measuring and test equipment
xii. Inspection and test status
xiii. Control of non-conforming product
xiv. Corrective action
xv. Handling, storage, packaging and delivery
xvi. Quality records
xvii. Internal quality audits
xviii. Training
xix. Servicing
xx. Statistical techniques.

23. Explain the Salient Features of ISO 9001 (2000)

Salient Features of ISO 9001 (2000)

In this standard, the term 'organization' replaces the term 'supplier' and 'supplier' replaces the term 'sub-contractor'.

(i) General Requirements

(a) Identification of processes, needed for QMS and their application throughout the organization;
(b) Determination of sequence and structure of these processes;
(c) Ensure availability of resources and information necessary to support the operation and monitoring of these processes;
(d) Monitor, measure and analyze these processes; and
(e) Implement actions, necessary to achieve planned results and continuous improvement of these processes.

When an organization chooses to outsource any process, control of such outsourced processes shall also be identified for QMS.

(ii) The Documentation Requirements

The QMS documentation should include a quality policy, quality manual and quality objectives. The Quality manual should include scope of the QMS and also the documented procedures, which means that each procedure is established, documented, implemented and maintained. Such records should remain legible, identifiable and retrievable. It is also important to establish means for identification, storage, protection, retrieval, retention and disposition of records.

(iii) Management Responsibility

Top management should provide evidence of its commitment by communicating to organization the importance of meeting customer-needs and regulatory-requirements. As a part of their responsibility, they should establish quality policy and objectives. They must also conduct reviews and ensure availability of resources. The quality objectives should be measurable and consistent with quality policy which must be understood within the organization and reviewed for continuing suitability.

Top management shall ensure that responsibilities and authorities are defined and communicated within the organization and shall also appoint a member of management who would report to top management on QMS and also liaison with external parties. An appropriate internal communication system also needs to be established for discharging management responsibility for QMS.

The management should also carry out reviews, the input to which would include information on:

i. Results of audits,
ii. Customer feedback,
iii. Process performance and products conformity, and
iv. Status of preventive and corrective actions.

The review output would be, obviously, related to decisions and actions related to improvements in effectiveness of QMS, processes and product related to customer requirements and the need for resource.

***(iv)* Resource Management**

It is inevitable for the organization to provide resources for QMS, continually improve its effectiveness and to enhance customer satisfaction by meeting customer requirements. The organization should provide for development of adequate competence and awareness and training for development of human resources.

Infrastructural resources are also to be provided, say:

(a) Workspace and utilities,
(b) Process Equipments, and
(c) Supporting services (transport and communication)

The organization should also manage the work environment, needed to achieve, conformity to product requirements.

(v) Product Realization

(a) *Planning:* The organization should plan and develop the processes, needed for product realization, monitoring, inspection and test activities and provide resources, specific to the product.
(b) *Customer related processes:* The organization should also determine requirements specified by the customer (both explicit and implicit), including the requirements for delivery and post-delivery activities. The review of product-related requirements, including statutory and regulatory requirements, should be done even before committing to supply product to customer, e.g. submission of tender, acceptance of contracts/orders, etc.

In sales through internet, formal review can be replaced by review of catalogues or advertising material.

Communication with customers: ISO 9001 provides for effective arrangements for communicating with customers in relation to product information and enquiries, order handling, customer feedback, including complaints.

(c) *Design and development:* Primarily the organization should manage the interfaces between different (cross-functional) groups involved in design and development of product. The inputs to design should include:

- Functional and performance requirements,
- Statutory and regulatory requirements as applicable,
- Feedback from previous similar designs, and
- Other new requirements

The outputs from such exercise should:

- Provide information for purchasing, production and service provision.
- Contain product acceptance criteria and
- Specify characteristics of the product for its safe and proper use.

Design and Development should be reviewed to identify any problems and propose necessary actions. Design and development has to be rectified and validated to ensure that resulting product is meeting the requirements for specified application or intended use and such validation should be completed, prior to delivery of product. Any changes carried out in design and development should be identified and records maintained. These changes should be reviewed, time to time, for control purposes.

(d) *Purchasing:* The organization should ensure the adequacy of purchasing information in terms of requirements for approval of product, processes and equipment prior to communication to the supplier. The organization should evaluate and select suppliers based on their ability to supply product in accordance with organization's requirements. The organization should also arrange for verification of purchased product and if need be, at supplier's premises.

(e) *Production and services provision*

– *Controlled conditions:* The organization should carry out production and service provision under controlled conditions. Controlled conditions should include:

* Availability of information describing the characteristics of the product,
* Availability of work instructions,

* Use of suitable equipment,
* Availability and use of monitoring and measuring devices and
* Implementation of release, delivery and post delivery activities.

- *Validation of processes:* The organization should validate any process where the resulting output cannot be verified by subsequent monitoring or measurement.

- This includes any process where deficiencies become apparent only after product is in use/service has been delivered. The arrangements established should include:

  * Defined criteria for review and approval of processes.
  * Approval of equipment and qualification of personnel
  * Use of specific methods and procedures.
  * Requirements for records and revalidation.

- *Identification and traceability:* The organization staff should be able to identify the product by suitable means throughout product realization and should control and record unique identification of product.

- *Customer property:* The organization shall identify, verify, protect and safeguard customer property provided for use or incorporation into the product.

- *Preservation of product:* The organization should preserve the conformity of product during internal processing and during intended destination. It should include identification, handling, packaging storage and protection.

(f) *Monitoring and measuring devices:* The organization should establish processes to ensure that monitoring and measurement provide evidence of conformity of product to determine requirements.

Measuring equipment should be:

- Calibrated or verified at specified intervals or prior to use against international/national standards.

- Adjusted/re-adjusted, as necessary, but should be safeguarded from adjustments that would invalidate the measurement result.

- Be protected from damage and deterioration during handling, maintenance and storage.

The records of calibration and verification should be maintained and, whenever possible, the ability of computer software to satisfy intended application should be confirmed.

(VI) Measurement, Analysis and Improvement

The organization should plan and implement processes needed to;

(a) demonstrate conformity of the product
(b) demonstrate conformity of QMS

It may also include application of statistical methods:

(a) *Customer satisfaction:* The organization should monitor information related to customer perception as to whether the organization has met customer requirements. The methods for obtaining and using this information should also be determined.

(b) *Internal audits:* The organization should conduct internal audits at planned intervals to determine whether QMS conforms to the planned arrangements and to the requirements of ISO, say, ISO 10011-1, 2 and 3 related to quality audits. The audit criteria, scope, frequency and methods should be clearly defined and selection of auditors and conduct of audits should ensure objectivity and impartiality of the audit process. The management of the function being audited should ensure that actions are taken without undue delay to eliminate detected non-conformities and their causes.

(c) *Monitoring and measurement:* The organization should monitor and measure the characteristics of the product at different stages of product realization process. Evidence of conformity with acceptance criteria should be maintained. Product release and service delivery should not be allowed unless conformity is established.

(d) *Control of non-conforming (NC) product:* Product, which does not conform to product requirements, is identified and controlled to prevent its unintended use/delivery. This should be defined in a documented procedure. The organization should deal with NC product by:

- Taking action to eliminate the detected NC product.
- Authorizing its use, release or acceptance under concession by a relevant authority or by customer. Records of nature of NC and action taken including concessions obtained, should be maintained. When NC product is detected after use/delivery, the organization should take action, appropriate to the effects of NC.

(e) *Analysis of data:* Analysis of data is must for continual improvement of the processes. The data generated mainly comes from monitoring, measurement, customers and suppliers. The analysis should provide information related to:

- Customer satisfaction;
- Conformity to product requirements;
- Trends in processes and products, including opportunities for preventive action; and
- Supplier.

(f) *Improvement:* As pointed out, the organization should continuously improve the effectiveness of QMS through reviews of quality policies, objectives, audit results, analysis of data and corrective and preventive actions.
Corrective actions are taken to eliminate the cause of NC's in order to prevent recurrence. A documented procedure should be established for:

- Review of NC's, including customer complaints;
- Delimitation of causes of NC:
- Evaluating preventive actions to eliminate recurrence;
- Determination, implementation and recording of action taken; and
- Review of corrective action taken.

In addition, preventive actions to eliminate potential NC's is also to be determined. All preventive actions for potential NC's are recorded and reviewed.

Matt Seaver (2001) has outlined practical aspects related to QMS in service and manufacturing operations as per ISO 9000 : 2000 particularly with regard to:

- Documentation;
- Records to be kept; and
- Activities to perform.

24. Explain the ISO 14000 Environmental Management System (EMS) Standards.

ISO 14000: ENVIRONMENTAL MANAGEMENT SYSTEM (EMS) STANDARDS

The ISO 14000 standards are a set of norms for Environmental Management System (EMS) either at organization and process level or product level. The major standards are as follows:

ISO 14001 specifies requirements for Third Party registration and specification standards.
ISO 14004 gives guidelines for design and implementation of EMS.

ISO 14010 to 15 are concerned with environmental auditing.
ISO 14020 to 24 are concerned with environmental labeling.
ISO 14040 to 48 are concerned with life cycle assessment.
ISO Guide 64 is concerned with environmental aspects in product standards.

Under these standards, management structure has to address organizational needs to respond to the effect of products, processes and services on environment. The environment auditors evaluate processes, not outcomes.

Life Cycle Assessment (LCA) deals with measurements of environmental consequences of product during various stages of its life. LCA guidelines are used to develop labeling standards and used for environmental rating of products and marketing.

ISO 14000 is not a product or performance standard. These focus on management processes and not on performance goals. These also exclude occupational health and safety for which ISO 20000 draft is being prepared. Also, EMS is based on PDCA (Plan, Do Check and Act) cycle.

Major Elements of EMS Standards

Following are the major components of an EMS:

i. Environmental policy
ii. Legal aspects
iii. Planning
iv. Objectives and goals
v. Environmental Management Programme
vi. Management and employee commitment
vii. Environment planning
viii. Emergency preparedness and response
ix. Operational control & maintenance programme
x. Environment system procedure and documentation
xi. Environment audit
xii. Commendation

Installation of HCCA (Hazards and Control of Critical-point Analysis) programme is a must in implementation of EMS.

The Environmental Policy (EP): It must address the following issues:

i. Management commitment to continual improvement, i.e. core values and beliefs in making environment policy;

ii. Prevention of pollution;
iii. Compliance with environment laws and regulation, co-operation with public authorities.
iv. Creating a framework for setting objectives;
v. Communication requirement with shareholders; and
vi. Education and training for environment.

Gap analysis is to be carried out in each area and data is collected through questionnaires, examination of records and benchmarking. Environment aspects, related to product/service/activities, could be its spilling/discharges/emission/noise, etc. The EP must have a system of reporting and advice to customers about handling and disposal of products. EP must also list action-plans to reduce pollution and ensuring equivalent EMS at contractor's site. Continual improvement of environmental performance should be the central part of EP.

Under EMS, it is imperative that performance criteria be developed for:

i. Emission,
ii. Environmental accidents,
iii. Risk reduction in terms of spills, hazards, noise, etc.,
iv. Reduction of waste,
v. Reduction in impact of packaging materials,
vi. Product/process redesigns,
vii. Energy savings,
viii. Environmental performance of contractors and suppliers, and
ix. Degree of ensuring equivalent EMS of contractors.

Focus points of EMS: The EMS must essentially focus on:

i. Roles, responsibilities and authorities of environment personnel;
ii. Employee awareness, education and training about EMS;
iii. Maintenance of records (register) of significant environmental effects;
iv. Documentation system: records of compliance and audits and their retention;
v. Operational and control procedures of activities, that effect environment;
vi. Procuring and contracting procedures;
vii. Work-procedures for employees for EMS;
viii. Measurement and control of process characteristics;
ix. Examination of preventive mechanisms;
x. Investigation and rectification of non-compliance;
xi. Records of compliance and environmental audits;
xii. Verification of EMS by external auditors;

xiii. Publication of environmental statement; and
xiv. Registration

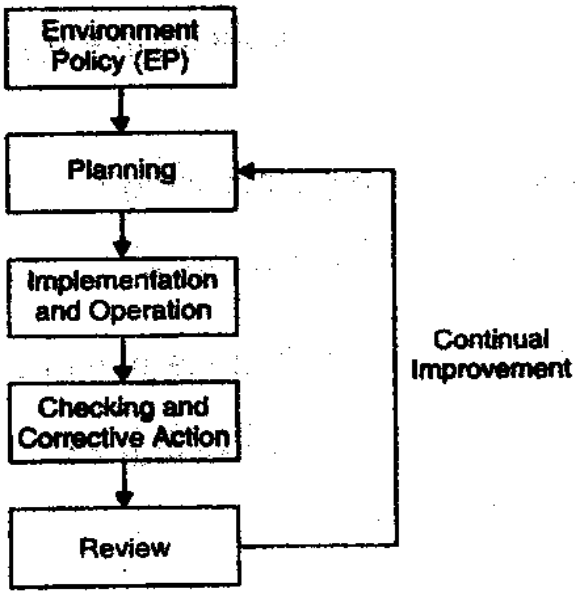


Fig. The EMS model as per ISO 14001

Environment labeling:- It refers to communicating environment attributes of a product on a label. The label must be factual and relevant. The claims must be based on experimentation and criteria for claims should be publicly available and developed by consensus. Evaluation must be based on environmental impact during different stages, i.e. life cycle assessment (LCA). The labeling should not create trade barriers and should not discourage innovation.

NOVEMBER / DECEMBER 2006.

(COMMON TO ALL BRANCHES)

GE 1406 – TOTAL QUALITY MANAGEMENT

PART – A

1. What are the basic concepts required for TQM?
2. Why is it difficult to change organizational culture?
3. Write short notes on Maslow's Hierarchy of needs.
4. What are the required condition to create empowered environment?
5. What is the structure of a control chart?
6. What are the control charts for attributes?
7. What are the reasons to benchmark?
8. When is quality function deployment (QFD) used?
9. What are the concepts of ISO 14000?
10. What is an environmental objective?

PART – B

11. a) i) What should a leader know and understand in order to be effective?

    ii) What are the duties of quality council? Explain in detail?

    Or

    b) i) What are the seven steps to strategic planning?

    ii) How are the quality costs categorized? Explain in detail.

12. a) i) What are the important factors that influence purchases?

    ii) How can the organizations use customer feedback to their benefits? Give examples.

    Or

b) i) What are the major benefits of 5S implementation? Explain how are they achieved?

ii) What are the principles of customer / supplier relations?

13. a) i) How is Pareto analysis done? Explain with an example/

ii) How is a cause and effect diagram constructed? Discuss in detail with a case study.

Or

b) i) Discuss the properties of normal curve.

ii) Discuss the applications of a new seven management tools with examples.

14. a) i) What are the steps that contain the core technique of bench marking?

ii) How is the house of quality constructed? Explain with an example.

Or

b) i) What are the six major loss areas need to be measured for implementing TPM?

ii) Explain the step by step procedure to perform design FMEA with computer mouse as an example.

15. a) i) What are the objectives of ISO 9000?

ii) Discuss in detail the elements of ISO 9000.

Or

b) i) What is the registration process of ISO 9000? What questions will the auditors might ask?

ii) Explain in detail different types of quality audits.

B.E. / B.Tech DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007

THIRD SEMESTER

CIVIL ENGINEERING

GE 406 – TOTAL QUALITY MANAGEMENT

PART – A

1. What do you mean by total cost of quality?
2. Name any two popular awards for quality?
3. What is the use of performance appraisal?
4. What are the benefits of 5s?
5. Distinguish between defect and defective?
6. Define the term process capability?
7. What are the objectives of QFD?
8. Why TPM is required?
9. What is the need for documentation?
10. What are the main elements of ISO 14000?

PART – B

11. Explain the fourteen the fourteen steps of Deming's philosophy for improving quality, productivity and competitiveness

12. (a) (i) What are the customer perceptions of quality? Explain
    (ii) Explain the service quality with its characteristics and expectations

(Or)

(b) (i) Explain the basic techniques used for measuring performance?
    (ii) If the Deming wheel rotates, improvement is assured. Explain Deming wheel.

13. (a) (i) Explain the tree diagram and arrow diagram?

(ii) Explain the stages of six sigma in process improvement?

(Or)

(b) In the manufacture of connecting rod assembly, the number of defectives found in the inspection of 15 samples of 50 items in each sample are given in the following table.

Sample No.	:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of defective	:	8	7	5	4	8	7	9	21	12	10	9	8	16	15	17

(i) Determine the trial control limits, construct the up chart and state whether the process is in control

(ii) If any point goes outside the control limits, determine the revised control limits eliminating that point.

14. (a) Explain Quality Function Deployment (QFD) with a suitable example.

(Or)

(b) Write short notes on:

(i) Benchmarking process.

(ii) FMEA

15. (a) Explain the steps to be followed in implementing Quality System ISO 9001:2000.

(Or)

(b) (i) Contrast between internal audit and external audit.

(ii) What are the requirements of ISO 14000? Explain them briefly.

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