PRODUCTION AND OPERATIONS MANAGEMENT

Unit I

OVERVIEW

Production and Operation Management deals with the creation of goods and services through the application of the business concept. They are also vital in both service and manufacturing firms. It has a primary objective, which is to employ the company's resources to produce goods and services fit for the market. The goal of the production function is to add value. Be it product or services; the idea is to create something that will strengthen the relationship between the organization and customers. But this cannot only be made possible by the production department. The marketing people also have a huge role to play in this. They are the ones that will distribute the product to potential buyers and should have the capacity to inform the production department of what customers or consumers would prefer.

Production management is relevant to the firm's success in many ways. Used efficiently, it can lead to numerous accomplishments which will take the business to a great height. Following are the importance of production management:

- Helps the Firm to Accomplish its Objectives
- Boost Business Reputation and Goodwill
- Reduces the Cost of Production

The goal of customer satisfaction is an important part of effective production and operations. In the past, the manufacturing function in most companies was inwardly focused. Manufacturing had little contact with customers and didn't always understand their needs and desires. In the 1980s, many U.S. industries, such as automotive, steel, and electronics, lost customers to foreign competitors because their production systems could not provide the quality customers demanded. As a result, today most American companies, both large and small, consider a focus on quality to be a central component of effective operations management.

Meaning of "Production"

Production implies the creation of goods and services to satisfy human needs. It involves conversion of inputs (resources) into outputs (products). It is a process by which, raw materials and other inputs are converted into finished products. Earlier the word "manufacturing" was used synonymously with the word "production", but nowadays, we use the term "manufacturing" to refer to the process of producing only tangible goods whereas the word "production" (or operation) is used to refer to the process of creating both goods (which are tangibles) as well as services (which are intangibles). Any process which involves the conversion of raw materials and bought-out components into finished products for sale is known as production. Such conversion of inputs adds to the value or utility of the products produced by the conversion or transformation process. The utility or added value is the difference between the value of outputs and the value of inputs. The value addition to inputs is brought about by alteration, transportation, storage or preservation and quality assurance.

Meaning of "Operations"

The term “operations” refers to a function or system that transforms inputs into outputs of greater value. Operations are often defined as a transformation or conversion process wherein inputs such as materials, machines, labour and capital are transformed into outputs (goods and services). In a productive system, if the outputs are strictly tangible goods, such a system is referred to as a “production system” and the transformation process is referred to as “production”. Nowadays, the service system in which the output is predominantly a service or even a pure service, is also treated as a productive system and often referred to as an “operating system” instead of a “production system”.

Production/Operations as a System

This view is also known as "systems concept of production". A system is defined as the collection of interrelated entities. The systems approach views any organisation or entity as an arrangement of interrelated parts that interact in ways that can be specified and to some extent predicted. Production is viewed as a system which converts a set of inputs into a set of desired outputs. A production system has the following elements or parts : (i) Inputs, (ii) Conversion process or transformation process, (iii) Outputs (iv) Transportation subsystem, (v) Communication subsystem and (vi) Control or decision making subsystem.

Production/Operations as a Conversion/Transformation Process

The conversion or transformation sub-system is the core of a production system because it consists of processes or activities wherein workers, materials, machines and equipment are used to convert inputs into outputs. The conversion process may include manufacturing processes such as cutting, drilling, machining, welding, painting, etc., and other processes such as packing, selling, etc. Any conversion process consists of several small activities referred to as "operations" which are some steps in the overall process of producing a product or service that leads to the final output.

Importance of Production Function

The production is the core function of any business organisation. Production function creates goods and services and organisations exist primarily to create goods and/or to provide services. Without production function, there would be no need for any other function such as marketing, finance or human resource function. Also, more than 50 per cent of employees in a business organisation have jobs in the area of production. Moreover the production function is responsible for a major portion of assets in most organisations. Consumption of goods and services is an integral part of any society and production function facilitates creation of goods and services for the benefit of people in the society.

Objectives of Production/Operations Management

Some of the important objectives of production/operations management are :
(i) Maximum customer satisfaction through quality, reliability, cost and delivery time.
(ii) Minimum scrap/rework resulting in better product quality.
(iii) Minimum possible inventory levels (i.e.,optimum inventory levels).
(iv) Maximum utilisation of all kinds of resources needed.
(v) Minimum cash outflow.

(vi) Maximum employee satisfaction.
(vii) Maximum possible production (i.e., outputs).
(viii) Higher operating efficiency.
(ix) Minimum production cycle time.
(x) Maximum possible profit or return on investment.
(xi) Concern for protection of environment.
(xii) Maximum possible productivity.

Responsibilities of Production/Operations Managers

The following are the major responsibilities of production/operations managers :
(i) Meeting requirements of quality demanded by customers.
(ii) Establishing realistic delivery or completion dates.
(iii) Producing the required volume of products to meet the demand.
(iv) Selection and application of most economic methods or processes.
(v) Controlling the cost of inputs and conversion process and thereby keeping the cost of outputs within the desired limits.

DECISION MAKING IN PRODUCTION/OPERATIONS MANAGEMENT

The production/operations managers manage all activities of the production/operations systems which convert inputs into the desired outputs (goods and services). The production/operations managers have the ultimate responsibility for the creation of goods or provision of services. Even though the kind of jobs that production/operations managers oversee vary from organisation to organisation, (because of the different products or services involved) their job is essentially managerial. They must co-ordinate the use of resources through the managerial process of planning, organising, staffing, directing (or influencing) and controlling.

The decisions which production/operations managers make may be classified into three general categories:
(i) **Strategic Decisions**: Decisions about products, processes and facilities. These decisions are strategically important and have long-term significance for the organisation.
(ii) **Operating Decisions**: Decisions about planning production to meet demand. These decisions must help to resolve the issues concerned with planning production to meet customers' demands for products and services and to achieve customer satisfaction at reasonable costs.
(iii) **Control Decisions**: Decisions about controlling operations concerned with day-to-day activities of the workers, quality of products and services, production costs, overhead costs and maintenance of plant and equipment.

PROBLEMS OF PRODUCTION/OPERATIONS MANAGEMENT

The problems involved in production management require two major types of decisions relating to :
(i) Design of the production system and
(ii) Operation and control of the production system. Decisions related to the design of production system are long-run decisions whereas, decisions related to operations and control of the production system are short-run decisions. The problems involve the relative balance of the emphasis on such factors as cost, service and reliability of both functional and time performance, which depends on the basic purposes of the total enterprise

and on the general nature of goods and services produced. In general, manufacturing organisations emphasise more on cost, consistent with quality and delivery commitments whereas, service organisations may emphasise reliability and service, consistent with cost objectives (for example, hospitals).

Long-Run Decisions

Long-run decisions related to the design of the production system are:

(i) **Selection and Design of Products**: Product selections and designs with productive capability (i.e., producibility of products) are interdependent.

(ii) **Selection of Equipment and Processes**: Selection of the most economic equipment and processes among the various alternatives considered, the firm's capability to invest in capital assets and its basic approach to production (i.e., job, batch, mass or continuous production) must be considered.

(iii) **Production Design of Parts Processed**: Production design aims at selection of equipment, processes, and tools for economic production which set limits on the cost of outputs.

(iv) Job Design: It involves basic organisation of work as well as matching workers to their jobs in order to reduce fatigue and improve productivity.

(v) **Location of the System**: It is a trade-off decision since there is no one best location for a productive system to be located. The balance of cost factors determined by various considerations is critical.

(vi) **Facility Layout**: This involves decisions related to design capacity, basic modes of production, shifts of working, use of overtime and subcontracting. In addition, operations and equipment must be located in relation to each other such that the overall material handling cost is minimised. Other factors involved are heating, lighting and other utility requirements, the allocation of storage space, washing space and the design of the building to house the layout.

Short-Run Decisions

Short-run decisions related to the operations and control of the system are :

(i) **Inventory and Production Control**: Decisions made are concerned with allocation of productive capacity consistent with demand and inventory policy. Feasible schedules must be worked out and the load on machines and labour and the flow of production must be controlled.

(ii) **Maintenance and Reliability of the System**: Decisions must be made regarding the maintenance effort, maintenance policy and practice recognising the fact that machine down time may lead to idling of labour and production stoppage resulting in lost sales.

(iii) **Quality Control**: Decisions must be made to set permissible levels of risk that bad parts are produced and shipped or the risk that good parts are scrapped due to sampling inspection. Inspection costs must be balanced with the probable losses due to passing defective materials or products. Decisions regarding controlling the quality of on-going processes must be taken.

(iv) **Labour Control**: Labour is the major cost element in most products and services. Hence, work measurement and wage incentive systems must be developed to control labour costs and to increase labour productivity.

(v) **Cost Control and Improvement**: Day-to-day decisions which involve the balance of labour, material and overhead costs must be made by production supervisors.

THE SCOPE OF OPERATIONS MANAGEMENT

Operations management has been gaining increased recognition in recent years because of the following reasons:

(i) The application of operations management concepts in service operations.

(ii) The growing importance of quality.

(iii) The introduction of operation management concepts to other areas such as marketing and human resources and

(iv) The realization that the operations management function can add value to the end product.

FACILITY PLANNING

Facility planning exercise determines how an activity's tangible fixed assets best support achieving the activity's objectives. In developing a layout for a system producing goods or services, we seek the optimum allocation of space to the components of the system.

More specifically we try to determine the best arrangement of facilities and equipment capable of satisfying anticipated demand (quantity, quality and timing) at lowest cost. This is the phase when all the elements of the process are integrated and therefore special care should be taken to create an environment conductive to high productivity and the satisfaction of social and psychological needs of all the people at work. Facility Planning is also known under other names such as Lay out Planning, Plant Layout, Facilities Design, Facilities Planning etc.

Objectives of Facility planning

i) Support organisation's mission through improved material handling_ materials control and good housekeeping.

ii) Effectively utilise people, equipment, space and energy.

iii) Minimise capital investment.

iv) Be flexible and promote ease of maintenance.

v) Provide for employee safety and job satisfaction.

These objectives can be restated as characteristics of good layout.

Stages in New Product development Process: -

-To minimize risk of new product failure, new product development follows a structured process.

- Stages in new product development are:

 Idea Generation.

 Idea Screening.

 Concept Development & Testing.

 Marketing Strategy Development.

 Business Analysis.

 Product Development.

 Market Testing.

 Commercialization.

Idea Generation:

- New product development process starts with search for ideas.

- Sources of new product ideas could be

Customers:

• Market research could be done with recent customer/lead users (customer who make advance use of product & recognize improvement needs).

• Market research determines product improvement required.

R & D / Employees:

• Employees could be encouraged to give new product ideas & rewarded suitably.

Competition:

• Through study/analysis of competitive products.

Marketing Channel & Their Staff:

• Dealers, distributors, employees of distributors & dealers.

Senior/Top Management:

• Product innovators could be senior management.

Idea Screening:

- Ideas generated need to be screened for action.
- To start with, ideas are sorted into

Promising ideas.

Marginal ideas.

Rejects.

- Promising ideas are evaluated by a committee.
- Surviving promising ideas are screened through a process.

Concept Development & Testing:

- Attractive ideas should be refined into list able product concepts.

Product Ideas:

• Possible product that company may offer to the market.

Product Concept:

• Elaborated version of the idea expressed in meaningful consumer terms.

Product Image:

• Picture that consumer acquire of an actual/potential product.

Marketing Strategy Development:

- After concept testing, for concepts that qualify a preliminary marketing strategy is created to introduce new product into market.
- Marketing strategy may be refined in later stages.

Business Analysis:

- After product concept/marketing strategy is developed, company can evaluate proposal's business attractiveness.
- For this,

Sales.

 Cost.
 Profits.
• Are projected for 5 years period.
- These are matched with company's objectives. If there is a match, the new product concept moves to product development stage.

Product Development:
- If a product concept passes the business analysis test, it is taken forward to the product development stage.
- So far, the concept exists on paper.
- In product development, concept is provided in detail to R & D to make physical product.
- Stages in product development could be:
    - o Prototype development.
    - o Prototype Lab Testing.
        - Test for Functionality.
        - Test for Psychological aspects such as color.
        - Test for Looks/Styles.
        - Test for Price Fitment.
    - o Functional Testing.
        - Test for Safety/Effectiveness.
    - o Consumer Testing.
        - Test samples with consumers in lab.
- Once management is satisfied with new product, functional/psychological performance, product is ready for market.

Market Testing:
- At this stage, new product is ready for:
    - Brand Name.
    - Packaging.
    - Preliminary Marketing Program.
- Objective of market testing could be:
    - Test product in actual market setting.
    - Learn about actual market size.
    - Learn about how consumers/dealers handle, use, repurchase new product.

Commercialisation:
- After successful market testing, new product moves to commercialisation stage.
- During this stage, production of new product on a commercial basis is rapidly built up.
- New product is formally launched. For this, decision to be taken could be:
    - o When to Launch:
    - o Where to Launch:
    - o To Whom:
    - o How to Launch:

The Phases of Product Design

To design is to formulate a plan for the satisfaction of human need.

A. ***Recognition of need:*** The designing process begins with recognition of need and deception to do something about it. Recognition of the need and phrasing the need often constitute a highly creative act, because the need may be only an age of discontents, a feeling of uneasiness, or a sensing that something is not right. For example the need to do something about a food packaging machine may be indicated by noise label, by the variation in package weight, and by slight but perceptible variations in the quality of the packaging or wrap.

B. ***Definition of the problem:*** It must include all the specifications for the product that is to be designed. Specifications are the inputs and output quantities, the characteristics and the dimensions, and all the limitations on these quantities. The specification defines the cost, the number to be manufactured, the expected life, the range, and the reliability. Anything, which limits the designer's freedom of choice, is specification. Firms that are constantly evolving new designs make extensive use of computer-assisted design (CAD) techniques during this phase. These approaches enable designers to develop and test a multitude of goods or service configurations that could not otherwise be explored.

C. ***Synthesis:*** After the problem is defined and a set of written and implied specification has been obtained, the next step in design is the synthesis of the optimum solution.

D. ***Analysis and optimization:*** Synthesis cannot take place without both analysis and optimization, because the product under design must be analyzed to determine whether the performance complies with the specification. The analysis may reveal that the product is not an optimum one. If the design fails either or both of these tests, the synthesis procedure must begin again.

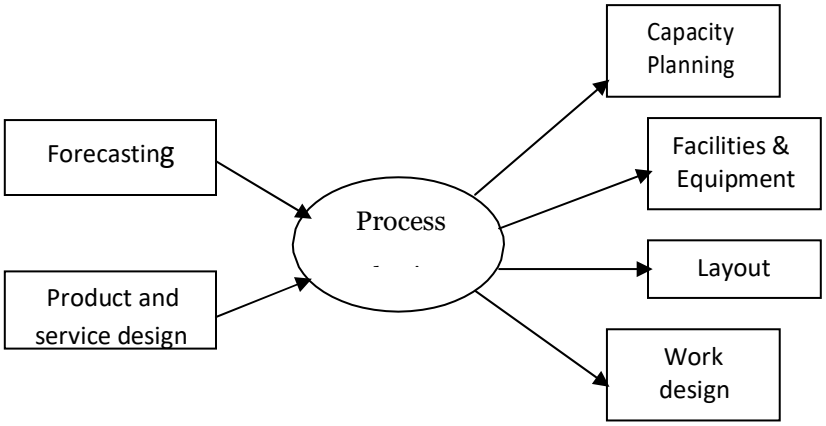
E. ***Evaluation:*** It is a significant phase of the total design process. Evaluation is the final proof of a successful design. Here the designer wishes to discover:

- If the design really satisfy the need or needs?
- Will it compete successfully with similar products?
- Is it economical to manufacture and to use?
- Is it easily maintained and adjusted?
- Can a profit be made from its sale and use? etc.

F. ***Presentation:*** The designer has also to sale the new idea. The designer should not be afraid of possibilities of not succeeding in a presentation. In fact, occasional failure should be accepted, because failure or criticism seems to accompany every really creative idea. Those willing to risk defeat obtain the greatest gains. In final analysis, the real failure would lie in deciding not to make the presentation at all.

Process Selection

In the manufacturing the product, the process selection refers to the way an organization chooses to produce its goods. Essentially it involves choice of technology and related issues. And it has major implications for capacity planning, layout of facilities, equipment, and design of work systems. Process selection occurs when new products or services are being planned. However it also occurs periodically due to technological changes in equipment.



In the processing system the continuous and intermittent processing have some key differences which affect-how these systems are managed. The following sections highlight the key differences between the processing systems.

Continuous and Semi-continuous Processing

High volumes of standardized output are produced by continuous processing systems. The ultimate continuous processing systems produce a simple product such as flour or sugar. Generally, these products are measured on a continuous basis rather than counted as discrete units. Industries that use continuous processing are sometimes referred to as process industries. Products of process industries include plastics, chemicals, petroleum, grain, and steel. Other examples include liquid and powder detergents, and water treatment. The output of the system is highly standardized. Semi continuous processing produces outputs that allow for some variety; products are highly similar but not identical. Example includes automobiles, television, computers, calculators, cameras and video equipments. This form of processing is often referred to as repetitive manufacturing.

Intermittent Processing

When systems handle a variety of processing requirements, intermittent processing is used. Volume is much lower than in continuous system. Intermittent systems are characterized by general-purpose equipments that can satisfy a variety of processing requirements, semiskilled or skilled workers who operate the equipment, a narrow work span of supervision than for most continuous systems. One form of intermittent processing occurs when batches, or lots, of similar items are processed in the same manner (e.g., food processing). A canning factory might process a variety of vegetables; one run may be sliced carrots, the next green beans, and the next corn beets. All might need similar process of washing, sorting, slicing, cooking, and packing, but the equipment needs to be cleaned and adjusted between runs.

Another form of intermittent processing is done by a job shop which is designed to handle a great variety of job requirements than batch processing .Lot sizes vary from large to small, even a single unit. What distinguishes the job shop operation from batch processing is that the job requirements often vary considerably from job to job. Examples of intermittent processing are textbook publication, bakeries, health care systems, and educational systems. In some cases the outputs are made for inventory (clothing, automobile tires); in others,

they are destined to meet customer needs (health care) or specifications (special tools, parts, or equipment).

Types of Process

Process technologies are broadly of five types according to its unique operating characteristics, problems, and challenge. These five types are Job shop, Batch, Assembly line and Continuous and Project.

i. **Job shop**: Job shop technology is a process technology suitable for a variety of custom–designed products in small volumes. Job shop technology is appropriate for manufactures of small batches of many different products. It is also considered as intermittent processing systems because small quantities are produced.

ii. **Batch**: Batch technology is a process technology suitable for a variety of products in varying volumes. Batch technology is a step up from job shop technology in terms of products standardization, but it is not as standardized as assembly line technology. Within the wide range of products in the batch facility, several are demanded repeatedly and in large volumes. These few dominant products differentiate batch facilities from job shops. The system must be flexible for the low-volume/high-variety products, because it is meant for those many jobs which are performed with frequent shifting from one job to another. This system has a high to moderate variety range. Many food items are produced by batch system.

iii. **Assembly Line**: Assembly line technology is a process technology suitable for a narrow range of standardized products in high volumes. Assembly line (or simply line) technology is for facilities that produce a narrow range standardized products. Laundry appliances are a representative example. Since the product designs are relatively stable, specialized equipment, human skill and management systems can be developed and dedicated to the limited range of products and volumes. Beyond this range, the system is inflexible. Automobiles, for example are produced in Assembly Line system.

iv. **Continuous**: Continuous process is suitable for producing a continuous flow of products. Chemical plants and oil refineries exemplify users of continuous flow technology. Materials and products are produced in continuous, endless flows rather than in batches or discrete units. The product is highly standardized, as are all of the manufacturing procedures, the sequence of product buildup, materials and equipment. Continuous flow technology affords high-volume, around- the-clock operation with the capital-intensive, specialized automation. It produces large volumes of one highly standardized item. There is no processing variety. Sugar is produced by a continuous processing system.

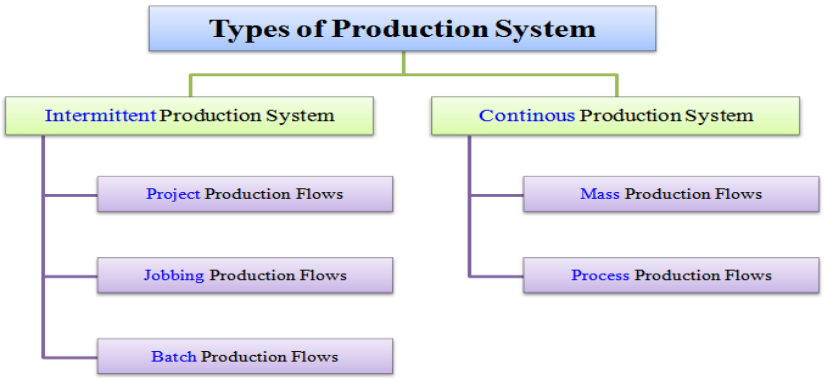
v. **Project**: Project technology is suitable for producing *one-of-a-kind* products. Project technology deals with products that are tailored to the unique requirement of each customer. A construction company, with its many kinds and sizes of projects, is an example. Since the products cannot be standardized, the conversion process must be flexible in its equipment capabilities, human skills and procedures. The conversion process features problem solving, teamwork, and coordinated design and production of unique products. It is suitable for handling complex jobs consisting of unique sets of activities that must be completed in a limited time span. Examples include large or unusual construction projects, new product development or promotion, space mission, and disaster relief efforts.

TYPES OF PRODUCTION SYSTEM

❖ Basic 2 types of production system -

1. Intermittent production system
2. Continuous production

And they are further divided into sub types as –

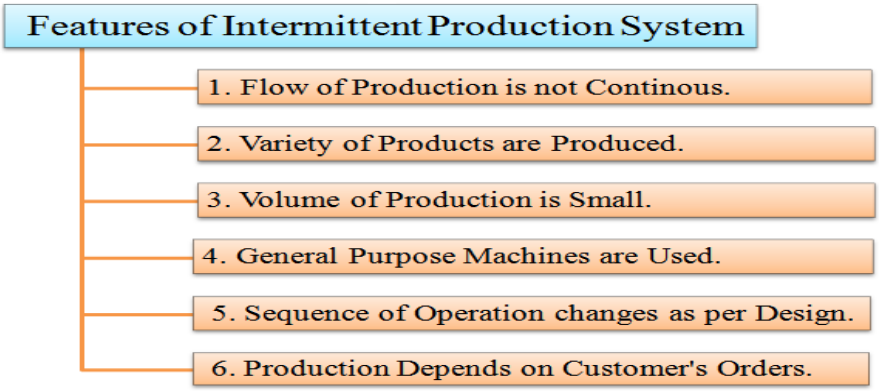


A. INTERMITTENT PRODUCTION SYSTEM: -

- Intermittent means something that starts (initiates) and stops (halts) at irregular (unfixed) intervals (time gaps).
- In the intermittent production system, goods are produced based on customer's orders.
- These goods are produced on a small scale.
- The flow of production is not continuous.
- In this system, large varieties of products are produced. These products are of different sizes.
- The design of these products goes on changing according to the design and size of the product. Therefore, this system is very flexible

➢ **Examples of the intermittent production system:-**

The work of a goldsmith and a tailor's is based exclusively on the frequency of customer orders. Here, ornaments or clothes are not made continuously.



THE TYPES OF INTERMITTENT PRODUCTION SYSTEM -:

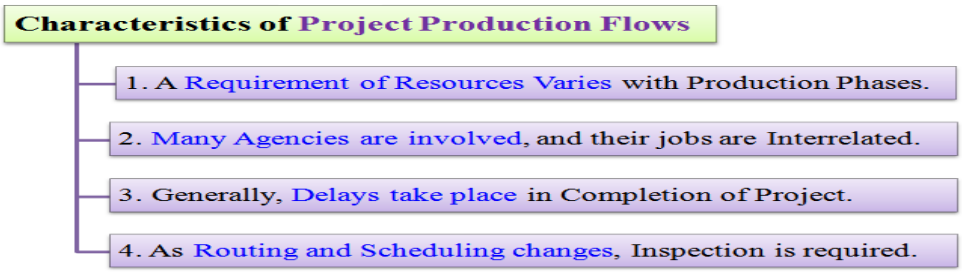
Ai) Project production

Aii) Job shop production and

Aiii) Batch production flows.

Ai) PROJECT PRODUCTION:

- The company accepts a single complex order or contract.
- The order must be completed within a certain period of time and at an estimated cost.
- Consider manufacturing of ships, or flyovers or bridges or highways etc.
- Such products are never manufactured in large quantities.
- Labour, facilities and other resources focus on these products.
- Therefore, each product can be treated as a project, which requires the sequencing of certain activities, either in series or simultaneously.
- Examples - construction of airports, roads, buildings, shipbuilding, dams, etc.



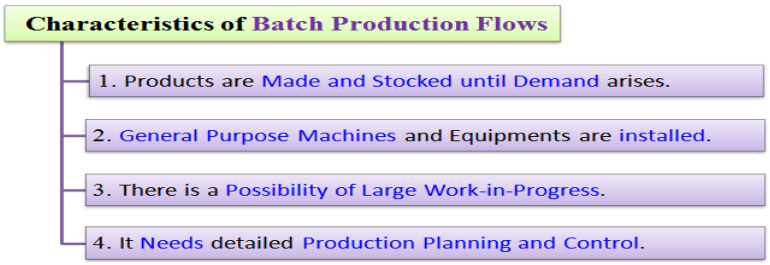
Aii) JOB SHOP PRODUCTION:

- In the job production flows, the company accepts a contract to produce one or a few units of a product strictly according to the specifications given by the customer.
- The product is produced within a certain period and at a fixed cost. This cost is fixed at the time of signing the contract.
- Examples -services provided by clothing workshops, repair shops, manufacturers of special machine tools, etc.

Aiii) BATCH PRODUCTION FLOWS:

- In batch production flows, the production schedule is decided according to specific orders or is based on demand forecasts.

- Here, the production of items takes place in lots or lots.
- A product is divided into different jobs.
- All jobs in a production batch must be completed before starting the next production batch.
- Example - manufacturing of drugs and pharmaceuticals, medium and heavy machinery, etc.



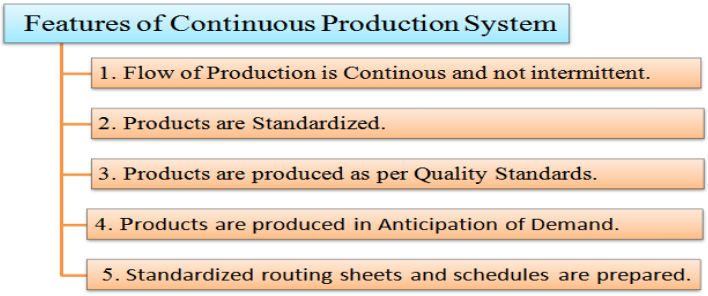
B. CONTINUOUS PRODUCTION SYSTEM:

- Continuous means something that operates constantly without irregularities or frequent stops.
- Goods are constantly produced according to the demand forecast. The goods are produced on a large scale for storage and sale.
- They are not produced at the customer's request.
- Here, the inputs and outputs are standardized together with the production process and the sequence.
- Examples -

(i) Food industry is based solely on the demand forecast. Here a large-scale food production takes place. It is also a continuous production.

- (ii) Fuel industry is also based solely on the demand forecast. Crude oil and other raw sources are continuously processed on a large scale to obtain a usable form of fuel and

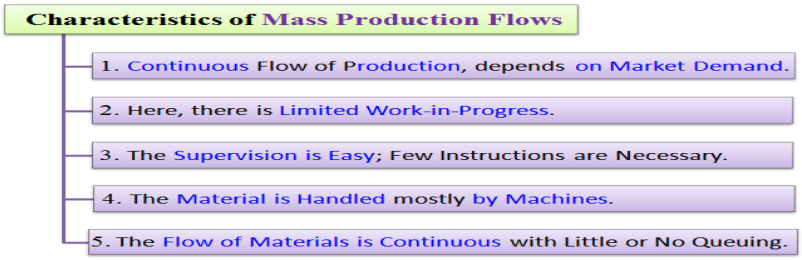
offset global energy demand.



SUB TYPES OF CONTINUOUS PRODUCTION SYSTEMS -:

1. MASS PRODUCTION FLOWS:

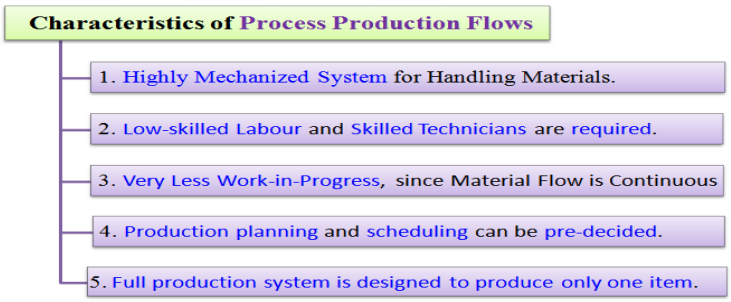
Here, the company produces different types of large-scale products and stores them in warehouses until they are demanded in the market.



B –ii) PROCESS PRODUCTION PROCESSES:

- Here, a single product is produced and stored in warehouses until it is demanded in the market.
- The flexibility of these plants is almost nil because only one product can be produced.

Examples -Production system at steel, cement, paper, sugar, plant etc.



Unit II

FACILITY LOCATION AND LAYOUT PLANNING

Facility Location is the right location for the manufacturing facility, it will have sufficient access to the customers, workers, transportation, etc. A manufacturing unit is the place where all inputs such as raw material, equipment, skilled labors, etc. come together and manufacture products for customers. Facility locations involve numerous aspects, such as the location of manufacturing plants, assembly locations as well as distribution centres. Facility location refers to establishment of the physical unit of production process. The physical unit means "plant" where man, material, money, equipment, machinery etc are brought together for manufacturing of product. The need of facility location, factory location or plant location is important for both new enterprises and existing enterprises.

NEED OF FACILITY LOCATION (FACTORY LOCATION, PLANT LOCATION)

Decision of facility location (generally, facility refer to service organization and factory or plant refers to manufacturing organization) is important to any organization whether it is manufacturing or service. Facility location has a significant impact on firm's operation as well as cost structure. Once the location is decided and plant is installed, it is highly expensive to alter the location if it is later known that the location decision was not correct.

Location decision is a ***long-term commitment***.

An established company might need the factory location planning for following reason:

- The availability and cost of resources like labor, raw materials and other supporting resources may change.
- The geography of demand may shift. It may be desirable to change facility location to provide before service to the customer.
- As the new market is opened, the added capacity should be located so that the market is served effectively.
- Development of new technologies.
- Socio–Political situations, economic conditions or government policy may change.

Facility location planning is more important for **new enterprises**. The success of organization is also dependent on the location decision. Wrong location decision may doom the business and its existence forever. However, it is very difficult to find ideal and perfect location for any business. So, there is need to analyze the various factors affecting the plant location and take help of mathematical modeling technique to determine the best location decision.

The plant location involves three major activities.

- First to select a proper geographical region.
- Select specific site with this region.
- Find the actual site.

FACTORS AFFECTING PLANT LOCATION

The production function is associated with conversion of input to desired output by using the appropriate technology i.e. conversion process. The inputs are fed to conversion process, while

outputs are marketed. Here, the important factors are **input**, **conversion process** and **market** and these are the **primary factors** affecting location decision. However other minor factors too are important for location decision.

- **Nature of the input (raw material):**

In some cases, it is beneficial to locate the factory (plant) near to raw material. If the cost of transportation of raw material is very high comparison to the transportation of finished goods, it is suitable to establish the factory near to input resources. For example cement factory is established near the sources of lime because major input is lime which is very bulky. Similarly, sugar factory is established nearer to sugar cane farm. Other examples are oil refineries, steel industries, and paper industries which are established nearer to source of raw material.

- **Nature of output (product or service):**

In some cases it is beneficial to locate the facility nearer to market or potential customer. Service produced by hotels, golf course, church, temples, schools, hospitals, are usually located near the market or the recipients because these services cannot be transported or keep in stock. These facilities should be located within the reach of consumers.

In manufacturing organization, when the product are potential of being damaged or spoiled in course of transportation it is beneficial to establish plant nearer to market. Furthermore, a plant being nearer to the market can catch a big share of the market and can render quick service to the customer. In some cases the transportation of final product to market may be costly compared to transportation of raw material to industry and transportation cost has significant effect, in such case it is beneficial to establish plant nearer to market. For examples soft drink companies like Coca Cola and Pepsi are established nearer to market.

- **Nature of technology employed:**

Conversion process and the technology employed also determine the facility location decisions. The conversion process, which produces unfriendly conditions to the people and environment, are usually located in remote areas i.e. far from consumer and the final product and service are transported to the market. The nuclear plant and airport are the good examples.

Other minor factors affecting the location decisions are:

- **Availability of labors and their skill**

Stable labor forces of right kind, adequate size (number), and reasonable rates with proper attitude towards works are a few factors which govern the plant location to a major extent. The purpose of management is to face less boycotts, strikes or lockouts and to achieve lower labor cost per unit of production.

- **Transport facilities:**

Good transportation facility is an important factor of determination of location. Basic mode of transportation like air, road, rail, water, pipelines are preferred based on the nature of raw material and finished goods. A lot of money is spend on transporting the raw material and finished goods. The location should minimize the cost of transportation.

- **Availability of services:**

Services like gas, electricity, water, drainage, waste disposal, communication and other external amenities like shop, community services, communication system etc. are also important

- **Suitability of land and climate:**

The topography (geography) of the land also affects plant location. Similarly the climatic conditions e.g. rain fall, humidity, average temperature are also critical factor while determining the location decisions.

- **Opportunity for expansion:**

The long range prospective of expansion opportunity must be considered while making location decision. The location should be flexible enough to cover the expansion program.

- **Political, cultural and economic situation and regional regulations:**

The political instability may jeopardize the business. Socio-cultural situation like women, foreign worker restriction of working should be considered. The economic condition of locality is important factor to be considered for business like gambling, casino, insurance companies or private educational institutions. Similarly, the study must be made of local regulations before determining the location decisions.

- **Special grants, regional tax and import (export) barriers:**

Some local authorities and central government offer special grants, low interest loan, low rental or taxes and other inducement in the hope of attracting certain industries to a particular location. Location of companies to foreign countries to avoid export difficulties are now commonly accepted practices.

After identify the several key location requirement management should find the alternative locations that are consistent with these requirement. These alternative locations are subjected to qualitative and quantitative analysis before determining the exact location decisions.

COMPETITIVE ADVANTAGE BETWEEN URBAN, RURAL & SUB URBAN PLANT LOCATIONS

The basis of plant location is first to locate the region and after that to locate the site with in that region. Each region may have the urban, rural & sub-urban site. Thus at the second stage the relative merit and demerit of these different types of locations must be assessed.

Urban sites (city)

The advantage and disadvantage of urban sites are listed below.

Advantage

- Better transportation system
- Larger market
- Right labor force is available
- Availability of services
- Greater easy to finance.

Disadvantage

- Low area of land available
- Cost of land and building construction are high
- Expansion generally hard
- Local taxes are high

- Labour salaries are high
- Union problems.

Rural sites (Plant sites in small towns)

The advantage and disadvantage of rural sites is as follows:

Advantage

- Plenty of land, low cost
- Unskilled labor available, low cost
- Less union problem
- No neighbor problem.
- Municipal, other regulations and taxes are seldom burdensome.
- Government gives inducements to develop underdeveloped areas.

Disadvantage

- Skilled labor are not available
- Transportation facility may in inadequate
- Power may be unavailable
- Far market
- Fewer services available.

An alternative between rural and urban is sub-urban sites which being a compromise between the two is probably the most suitable. It possesses the good points of both urban and rural.

General Procedure In Facility Location

The factory location includes the determination of alternatives site of various geographical regions. These alternative sites are subjected to various qualitative and quantitative analyses to find-out the adequate alternatives among them. The procedure in facility location include

- Preliminary screening
- Detailed analysis that includes qualitative and quantitative models.

Preliminary screening

The importance of various factors affecting the location depends on the types of products and service. Some time it is beneficial to locate proximate to marketing where as in other cases it is better to locate proximity to raw material. The factors like labour, transportation facilities, availability of resources, climatic condition, regional regulations, political, cultural and economic situation, has the various degree of effect on the plant location decision depending upon the types of product or service. Hence the preliminary screening is done to alternatives sites, with regard to these factors affecting the location decisions. The detailed information regarding these factors could be obtained from local chambers of commerce, local communities, trade publications etc.

Detailed analyses

Once the preliminary screening narrows alternative sites to just a few, more detailed analysis is

done. This detail analysis involves either ***qualitative techniques*** or ***quantitative techniques*** or both.

A. Qualitative techniques

Some factors affecting the location cannot be measure in terms of money. The subjective evaluations of sites, regarding these qualitative factors are carried out in qualitative models. These qualitative models are:

- Simple comparative chart analysis
- Factor ratings.

I. Simple comparative chart analysis

This method is widely used for analyzing intangible factors affecting the locations decision. The following steps should be followed

- Identify critical intangible factor affecting the location decision
- Compare all the alternative location on the basis of these factors like good / bad, favorable / unfavorable, important /not important etc.
- Select the best location for organization.

The simple comparative chart can be used when an organization does not feel to evaluate intangible factors in details as shown in table.

Intangible factors	**Location A**	**Location B**	**Location C**
Labor supply	Suitable	More suitable	Suitable
Business climate	Good	Very good	Not good
Attitude of community	Unfavorable	Favorable	More favorable
Union activities	Important	Less important	More important

From the above simple comparative chart analysis for intangible factors location 'B' is selected as good one.

II. Factor Rating Method

The factors affecting the facility location decision discussed earlier are all more or less important for any type of the organization i.e. the importance of each of these factors may vary for different types of plants. Hence operations managers can use weightings of these factors of the location with respect to the purposed plant or organization to make the location decision more objective. The factor-rating method is most widely used of the general location decision techniques because they provide a mechanism to combine diverse intangible factors in an easy to understand format. The step used in this method to reach to the selection of the location is as follows:

Step 1: Identify and note down all the relevant critical success factors to the purposed plant or organization.

Step 2: Assign a rate to each factor to reflect its relative importance in company's objectives. Generally these factor are rated from 1-5. A rating of 5 is given to the most important factor and 1 is given to the least important one. These are called factor ratings.

Step 3: Take the attractive location alternatives from preliminary screening. Assign the rate to the alternative for each factors according to the benefits a particular location option offers. Generally, these rates varies from 1 - 10. A rating of 10 is given to the most beneficial factor at that particular location. Similarly a rating of 1 is given to the least beneficial factor at that location. These rating are called the location rating. [Note: There is no specific benchmark for factor rate and location rate determination. This is depended on the analytical skill of decision maker.

Step 4: Factor rating calculated in step 3 and corresponding location rating calculated in step 4 are multiplied and the cumulative total rating for each alternative location is calculated.

Step 5: Select the location with highest total score.

Example 1: Location selection for a sugar factory base on the tabulated information

Factors	**Factor ratings (1-5)**	**Location A**		**Location B**		**Location C**	
		Location rate (1 - 10)	**Scores**	**Location rate (1 - 10)**	**Scores**	**Location rate (1 - 10)**	**Scores**
1. Availability of sugar cane	5	8	40	10	50	6	30
2. Transportation	4	10	40	4	16	10	40
3. Labour costs	3	3	9	8	24	6	18
4. Proximity to market	5	7	35	5	25	10	50
5. Power supply	3	8	24	1	3	8	24
6. Governmental/ local rules & regulations	4	9	36	10	40	8	32
7. Environmental rules	3	8	24	9	27	7	21
8. QOL issues	2	10	20	5	10	10	20
9. Banking	1	9	9	2	2	10	10
Total cumulative score			237		197		245

Conclusion: Since total cumulative score for the location is highest i.e. 245 hence location C is selected for the purposed sugar factory.

B. Quantitative Techniques (Models)

Various quantitative models are used to determine the best locations of facilities. The widely used models for location decisions are

- Simple median model
- Linear programming
- Simulation

I. Simple median model

Simple median model is also called ***centre of gravity meth*od**. It is a quantitative method for

choosing an optimal facility location that minimize cost of transportation based on the median load.

II. Simulation Method

Different quantitative models are developed for location decision. These models have their own assumptions, specifications and conditions for application. However in real world (working situations) these specifications, limitations or assumptions may not be applicable or may not be met, reducing the usefulness of these models. Similarly there might be numerous constraints and variable which makes it difficult, handling with quantitative method. Hence to cope with this real complex problem, simulation method is developed. This method is based on the approximation technique.

Besides these three models ***other models*** are also used for location decision. They are

- Cost benefit analysis
- Locational Break even analysis (BEA)
- Analytical Delphi methods**.**

I. Cost Benefit Analysis

In this method, all the factors affecting the location decision are estimated as cost/unit & those locations is determining where the variable cost/unit is least. This method does not take account the intangible factor. So this method is unsuitable for that situation where in tangible factors e.g. attitude of labor, government regulation or others are major concern. Variable costs per unit of production for two location factor are as follows:

	Location A	Location B
Material	12	8
Labor	8	8
Power	4	3
Taxes	3	1
Insurance	1	2
Transportation	2	4
Total	30	26

Comparing the variable cost per unit of location B is less than Location A, so Location B is selected.

II. Locational Break-Even-Analysis (BEA)

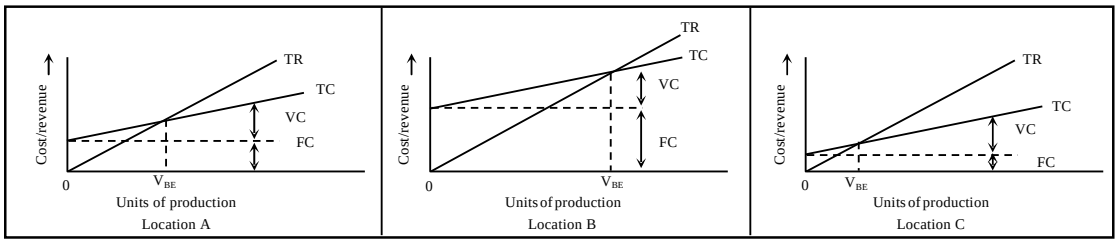
Break even analysis can help a operations manager to make an economic comparison of location alternatives by making the cost-volume analysis. The transformation process from inputs to outputs involves two types of costs, namely, the ***fixed cost*** and ***variable cost*****.**

Fixed costs are the capital expenditures which are long-term investments in fixed assets like purchase of the land, construction of building purchase of machines and equipment. These costs remain constant irrespective of the volume of production.

An organization always prefers to have a low break-even volume so that its investments can be completely recovered soon. In facility location planning, a location at which the break-even

volume is lower is preferred. The fixed cost and the variable cost may be different at different location options, and hence, these options may have different values of V_{BE}. In the following BEP analysis of three alternatives A, B and C, the alternative location C is best because it has lower V_{BE}.

Comparative study of location A,B,C.



Factory Layout Concept

Plant layout means the disposition of the various facilities (equipments, materials, human resources) and utilities of the plant within the area of the site (location decision) selected previously. Plant layout begins with the ***design*** of the factory building and goes up to the location and movement of individual work table. All the facilities like equipments, raw materials, machinery, tools, fixtures, workers etc. are given a proper place so that the objective of lay out will meet.

There are various layout principles; however considerable arts & skill are required in designing a good plant layout. The research work is being continued in order to develop a scientific approach for solving plant layout problems.

Objectives Of Layout

In a good plant layout, the following objectives are met.

- Handling & transportation of material is minimized.
- Bottlenecks and points of congestions are eliminated (by **line balancing**) so that the raw material and semi-finished goods movement is faster.
- Workstations are designed suitably & properly.
- Suitable spaces are allocated to production and service centre.
- The movements made by workers are minimized.
- Waiting time of the semi-finished goods is minimized.
- Working conditions are safer, better & improved.
- There is an increased flexibility for changes in product design and for future expansion.
- There is a utilization of cubic space (length / width / height)
- There are improved work methods and reduced production cycle times.
- Plant maintenance is simpler.
- There is increased productivity and better product quality with reduced capital cost.

Principles Of Plant Layout

The few principles for sound plant layouts are:

- Integration
- Minimum movement & material handling

- Smooth & continuous flow
- Cubic space utilization
- Safe & improved environment
- Flexibility

Integration: It means, integration of production centers facilities like workers, machinery, raw material etc in a logical & balance manner.

Minimum movement and material handling: The number of movements of workers & material should be minimized. It is better to transport material in optimum bulk rather than in small amounts.

Smooth and continuous flow: Bottlenecks, congestion points & back tracking should be removed by proper line balancing technique.

Cubic space utilization: Besides using the floor space of a room, if the ceiling height is also utilized, more materials can be accommodated in the same room. Boxes or bags containing raw material or goods can be stocked one above the other to store more items in the same room. Overhead material handling equipments save a lot of valuable floor space.

Safe and improved environments: Working places should be safe, well ventilated and free from dust, noise, fumes, odor and other hazardous conditions. This will increase the operating efficiency of the workers and also improve their morale. All these lead to satisfaction amongst the workers & thus better employer- employee relationship.

Flexibility: In automotive and other industries, where models of product change after some time, it is better to permit it all possible flexibility in the layout. The machinery is arranged in such a way that the changes of the production process can be achieved in the least cost or disturbance.

Factors Influencing Plant Layout

The objectives of layout are affected by various factors.

1. **The material factor:** This includes design, variety, quantity, necessary operation and sequence of various material (Raw material, work in progress goods, finished goods) used in production system.
2. **The machinery factor:** This includes the producing equipment, tools & their utilization.
3. **The man factor:** This includes human resources employed in production system for supervision, service, direct and indirect direct workers.
4. **The movement factor:** This includes inter-intra departmental movement of man and material factors for transport and handling and inspection at the various operations of production function.
5. **The waiting factor:** This includes permanent & temporary storage of finished goods, semi finished goods or raw materials are delayed for dispatch or processing.
6. **The service factor:** This includes maintenance, inspection, waste, scheduling & dispatching.
7. **The building factor:** This includes outside and inside building features, utility distribution and

equipment.

8. **The change factor:** This includes versatility, flexibility & expansion.

Types Of Layout

It is quite difficult to distinguish the lay out type because, the production lay out are now made more flexible to achieve the versatility of service and goods as per customer requirement. However in broad aspects, lay out are classified as follows:

- Process layout (Functional layout)
- Product layout (Assembly line)
- Combination layout
- Fixed position layout

Process Layout

Process layout is characterized by keeping similar machines or similar operation at one location (place). This is also called ***functional lay out*** because machine are arranged according to their function. Taking an example of a work shop, all lathes will be at one place, all milling machines at another and so on. This type of layout is generally employed for industries engaged in job order production and non repetitive kind of manufacturing or maintenance activities. In the figure, it is seen that all lathe works are done on lathe section which consists of one or more lathe machine as required. Similarly, all the milling works are carried out on milling section where milling machines are placed and so on. For example a machine shaft has to be made which consist of shaping, drilling, milling and lathe operation. For that the component is issued from the store, it is that carried to shaper section where shaping is done, then to drilling section where drilling is done on the shaped component. Similarly, it is carried to milling and lathe operation. The final component are inspected on inspection department and finally issued to store.

Process layout

<table>
<tr><td rowspan="2">Store room</td><td>Inspection department</td><td>Broaching section</td><td>Milling section</td></tr>
<tr><td rowspan="2">Lathe Section</td><td colspan="3" rowspan="2">Shaper section</td></tr>
<tr><td colspan="2">Drill section</td><td>Stock Room</td></tr>
</table>

Advantages:

- Wide flexibility exists as regards allotment of work to equipments and workers
- Better utilization of the available equipments.
- Comparatively less number of machines is needed, thus involving reduced capital investment.
- Better product quality because, supervisors and worker attend to one type of machines and operations.
- Varieties of jobs make the work more interesting for the workers.

- Workers in one section are not affected by the nature of the operation carried out in another section. For example, a lathe operator is not affected by the rays of the welding, as the two sections are quite separate.

Disadvantages (compared to product layout):

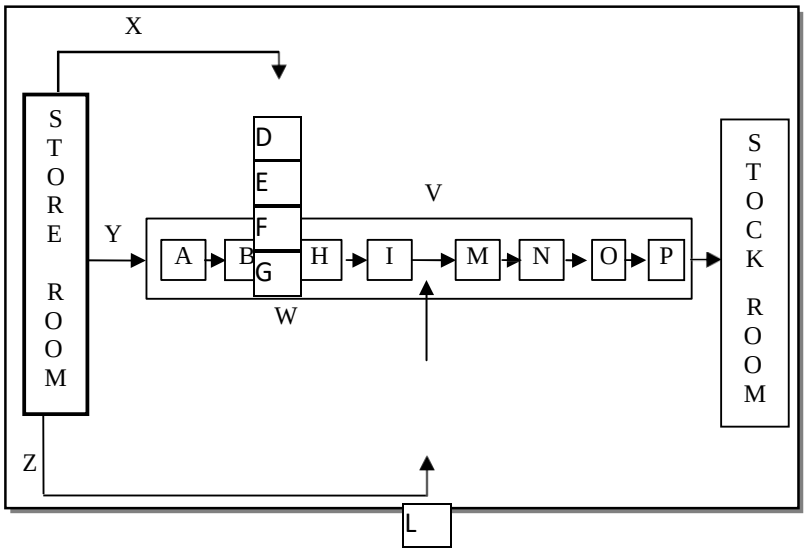
- For the same amount of production, process layout needs more space.
- Automatic material handling is more difficult.
- More material in process remain in queue for further operation
- Completion of same product takes more time.
- Work-in-process inventory is quite large.
- Production control becomes difficult and also needs skilled manpower to carry out variety of job in single machine.
- Raw material has to travel larger distance for being processed to finished goods. This increases the material handling and associated costs.
- It needs more inspections & efficient co-ordinations.

Some example of functional (process) lay out are: nursing homes, hospitals, universities, office building, work shop, tailor shop, printing process etc.

Product Layout

It is also known as ***line layout***. It implies that various operations on the raw material are performed on sequence and the machines are placed along the product flow line. It means, machines are arranged in sequence in which the raw material will be operated upon. This type of layout is preferred for continuous production which involves continuous flow of in-process material towards the finished product stage. Some examples are textile, sugar, instant noodles, paper mills etc. From these examples it is seen that product layout are suitable for high volume production system, producing very limited or single variety products. As we know, in sugar only sugar related products could be produced. This layout is specialised for high volume unique products making highly inflexible.

Product Layout



K
G

Raw material from the store is fed to three lines X, Y, and Z. Material in X lines gets processed on machine D, E, F & G and meets material of Y line after it has been processed on the main assembly line machine A & B. Products of X and Y lines are assembled at W and get processed on the machine H and I till another parts comes from Z line and assembles with main product at V. After that the total assembly gets worked on machine M, N, O and P and final products are send to stock room.

Assumptions for product layout

1. Volume is adequate for high equipment utilization.
2. Product demand is stable enough to justify high investment in specialized equipment.
3. Product is standardized or approaching a phase of its life cycle that justifies investment in specialized equipment.
4. Supplies of raw materials and components are adequate and uniform quality (adequately standardized) to ensure that they will work with the specialized equipment.

Advantages (compared to process lay out)

- Less space requirements for the same volume of products compared to process lay out.
- Automatic material handling, lesser material handling movements, times and cost.
- Less in process inventory.
- Product completes in lesser time.
- Better co-ordination and simple production planning & control
- Smooth & continuous workflow.
- Less skilled workers may serve the purpose.

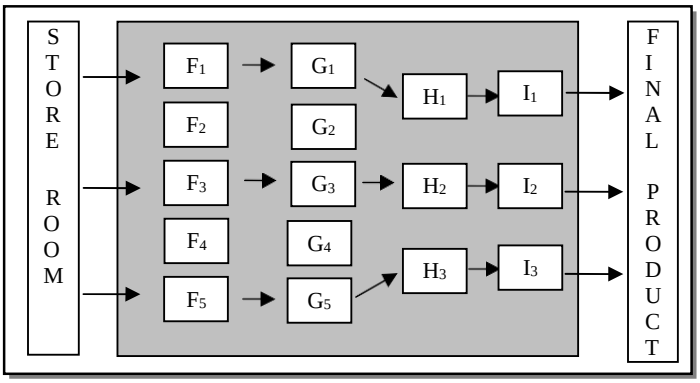
Disadvantages

- The layout is inflexible.
- The pace or rate of working depends upon the output rate of the slowest machine. This involves excessive idle time for other machines if the production line is not adequately balanced.
- Machine being scattered along the line, more machine of each type are required for keeping them stand by, because if any machine in the line fails, it may lead to shut sown of the complete production line. This is how product layout involves higher capital investment.
- Though it involved less supervision as compared to process layout, sometimes it (inspection) becomes difficult when one inspector has to look after many (say all welding) machines in two or more production lines.
- It is difficult to increase production beyond the capacities of production line.

Combination Layout

Combinations of process and product layout are usually used to acquire the advantage of both layouts. More ever, in these days' pure product or process layout are rare. A combination layout is possible where items are being made in different type and sizes. In such cases, machinery is arranged in a process layout but process grouping (a group of number of similar machine) is than arranged in a sequence to manufacture various types and size of products. The point to be noted is that, no matter the product varies in size and type, the sequence of operation remains same or similar in combination layout. In the following figure of Combination layout, F, G, H, I represent different machine and 1, 2, 3, 4, 5 represent the similar type of machine. Here same machine are arranged in process lay out, however different machines are arranged as product lay out.

A combination layout is also useful when numbers of items are produced in same sequence in fewer amounts (i.e. not on bulk) and it is not advantageous to have single production line for each product. For example refrigerator & TV manufacturers use a combination layout. First of all, they use process layout for manufacture of parts and components. However they use product layout for final assembling of products. To sum up, in combination layout, fabrications are normally handled with a process layout, where as assembly operations are carried out by product layout.



Combination Layout

Fixed Position Layout

In other types of layout discussed earlier, the product moves past stationary production equipment, where as in this case the reverse applies; men and equipment are moved to the material, which remain at one place and product is completed at that place where the material is fixed. Layout by fixed position of the product is inherent in ship building, aircraft manufacture and big pressure vessels fabrications.

Advantages:

- It is possible to assign one or more skilled workers to a project from start to finish in order ensuring continuity of work.
- It involves least movement of materials.
- There is maximum flexibility for all sorts of changes in product and process.
- A number of quite different projects can be takes with the same layout.

Disadvantages:

- It usually involves a low content of work-in-process.

- There appears to be low utilization of labor and equipments.
- It involves high equipment handling costs.

Application:

Layout by fixed position of product is limited to large items made singly or in very small lots.

Comparison Of Basic Layout

The fundamentals differences between product oriented, process oriented and fixed layout are discussed

Difference between three types of layout

Basis	Product oriented	Process oriented	Fixed position
Product	Standardized product, large volume, stable rate of output	Diversified product, varying volume, varying rate of output.	Made to order, low volume.
Work-flow	Straight line, same sequence of operation for each unit.	Variable flow, different sequence of operation	Little or no flow of material but human come to site.
Human skill	Highly specialized, routine & repetitive task	Primarily skilled performed with less supervision	Greater flexibility, work & location vary
Material handling	Flow, predictable, systematized, can be automated.	Variable flow	Variable flow, general purpose handling equipment needed.
Inventory	High turnover of raw material and WIP inventory.	High raw material inventory, low turnover of raw material and WIP inventory	Variable inventories, frequent tie-up as production cycle is long
Capital requirement	Large investment in specialized equipments and process	General purpose flexible equipments and process	General purpose, mobile equipment and processes.
Product cost	Relatively high fixed cost, low unit cost for direct labor and materials	Relatively low fixed cost, high unit cost for direct labor, material & material handling.	Relatively low fixed cost, high unit labor & material cost.
Space utilization	Efficient utilization, large output per unit space.	Large WIP space requirement, small output per unit space.	Small output per unit space if conversion is on site.

Product Versus Process Layout

Relative Advantages of Product Layout

i) Lower total material handling cost
ii) Lower total production time
iii) Less work-in-process
iv) Greater incentive for groups of workers to raise level of performance and greater possibility of group incentive pay plans with broader coverage.
v) Less floor area required per unit of production.
vi) Simpler production control; fewer controls & records needed, lower accounting cost.

Relative Advantages of Process Layout

i) Less duplication of equipment and hence lower total investment in equipment.
ii) Greater flexibility of production. Flexibility with respect to accommodating
- design changes,
- production volume changes, and
- new products and new machines.

iii) Capability to handle breakdown of equipment by transferring the work to other machines.
iv) Better and more efficient supervision possible through specialisation.
v) Greater incentive to efficient individual workers.

When to use Product and Process Layouts?

Product Layout

i) One or few standard products.
ii) Large volume of production of each item over a considerable period of time.
iii) Possibility of carrying out effective motion and time studies and setting accurate standards.
iv) When there is a scope for getting good labour & equipment balance.
v) Minimum of inspection required during processing.
vi) Minimum of very heavy equipment or equipment requiring special features (isolation from general production areas etc.)
vii) Little or no occasion to use some machines for more than one operation.

Process Layout

i) Many types cir styles of products, or emphasis on special orders.
ii) Relatively Ion Column o production of individual items.
iii) Adequate motion and time studies difficult or impossible to make.,
iv) Difficult to achieve good labour and equipment balance.
v) Many inspections required during a sequence of operations.

Methods Of Plant And Factory Layouts

A layout furnishes details of the building to accommodate various facilities (like workers, materials, machinery etc). In addition, it integrates various aspects of the design of production system. The information required for plant lying out includes, dimensions of work places, sequence of operations, flow pattern of materials, storage space for raw material, in process inventory and finished goods, offices, toilets etc. There is no single universal technique leading to

best layout. Various techniques independently or in conjunction with other techniques may be employed at different stages involved in plant or factory layout. The word plant or factory can be taken more or less as synonyms.

The following methods may be used while developing a layout in sequential order.

- Process flow chart
- Material movement pattern
- Layout analogues
  - Templates
  - Three dimensional models
- The correlation chart
- Travel chart
- Load path matrix

The initial stage of the development is process flow chart. They show how different component parts assemble in sequence of operation to form sub-assemblies, which in turn lead to assemblies (finished products). Secondly, the flow pattern of material in process is traced and layout is built around it. Once the material movement patterns are determined, layout analogues are developed. These analogues are:

1. Templates
2. Three-dimensional models.

Templates (Cut outs)

They are used to develop plant layout. They are two-dimensional or block templates made up of cardboard, colored paper or celluloid. They are made to scale (***e.g. 1: 50***) and are placed on the scaled outline plan of the building. Templates or cut outs show the plan of the various facilities and the buildings. They show the actual flow floor space utilization. These templates have flexibility in use and can be moved on the graph paper from place to place in order to evaluate various feasible positions for different machines.

Models

They are the scale models of a facility and more clear to the real situation as besides length and width they show the height of a facility also. Models are used mainly to develop floor plans and elevations. Models can be made for production machine, workers, material handling equipment or any other facility. Models are much more effective and fast as compared to drawings or templates especially when multi storey plant layout is to be designed. Multi storey models can be made of a clear plastic.

The ***correlation chart, travel chart*** & ***load path matrix*** are the mathematical model to have the optimum layout which minimize the material handling, material flow of cost of transportation.

These help to determine the layout of one facility with relation to other department. These help to increase the efficiency of existing plant layout.

Layout Procedure

The ideal procedure for a plant layout is to build the layout around the productive process and then design the building around the layout. This may not be possible always, because the plant

building may already be existing or shape of plant may not permit the construction of a building to house the productive process, etc. Ultimately, one has to strike a balance between the two approaches. However, various procedural steps involved in plant layout have been listed and described below:

a. Accumulate basic data

The basic date includes:

- Volume and rate of production.
- Product specification and bill of materials.
- Process sheets indicating tools, equipments, the method and the product which will be manufactured.
- Flow process charts.
- Standard time to complete each operation, etc.

b. Analyze and coordinate basic data

The basic data are analyzed and coordinated in order to find

- The workforce and size and type.
- Number of work stations required
- Type of equipment required
- Storage and other space requirements.
- Assembly chart and operation process chart help coordinating data.

c. Decide the equipment and machinery required

Number of equipments required to meet a particular production target can be calculated by knowing the following parameters.

- Number of articles to be produced
- Capacity of each equipment
- Time in which the order is to be completed, etc.

d. Select the material handling system.

The material handling system is selected for moving raw material, semi-finished goods and final products. The type of material handling equipment to be selected depends upon:

- Material/product to be moved
- Container in which it will be moved
- Length of movement
- Frequency of movement
- Speed of movement, etc.

e. Sketch plan of the plot for making factory building

Sketch plan for the plot to mark building outline, roads, storage and service areas, etc.

The plan orientation should utilize maximum, the natural heat light and other weather conditions.

f. Determine a general flow pattern.

Machinery may be laid as per production p[process requirements and plant building be erected

about the same. The flow pattern of materials should be such that the distance involved is least between the store and the shipping department through the production centers .There should be minimum back tracking and bottlenecks. Flow patterns may be analyzed using operation process charts or travel charts in case of multiple flow patterns .Based upon the process or product requirements, one may adopt process layout, product layout, or a combination layout. Plant layout should be flexible so that it can accommodate changes in product or product diversification

g. Design the individual work station.

Each work station should be laid for achieving optimum performance of operations, materials and space utilization, safety and comfort of employees etc.

h. Assemble the individual layout into the total layout.

Once the individual work station is designed , the next step is to assemble the individual layout into the total layout in accordance with the general flow pattern and the building facilities.

i. Calculate storage space required.

The storage space can be calculated by knowing the volume of each store item, number of items to be kept in store, the time each item may be kept in store etc.

j. Make flow diagrams for work stations

The next step is to make flow diagrams for work stations and allocate them to areas on areas on plot plan.

k. Plan and locate service areas.

Service area like office, toilets, wash rooms, tool rooms, rest and launch room, cafeterias, dispensary, power generating areas and packing area etc are planned and allocated.

l. Make master layout

The next step is to built the master layout by using the templates and models

m. Check final layout

Once the master layout is prepared, it is checked as regard to following layout principle aspects:

- Integration
- Minimum movement & material handling
- Smooth & continuous flow
- Cubic space utilization
- Safe & improved environment
- Flexibility

n. Get official approval of the final layout.

After the final plant layout has been checked, it is got officially approved and signed by the team which checked the final layout. The final layout accompanies information like product drawings, bill of materials, assembly and operation process chart, manpower requirement, equipment requirement, estimated expenditure and revenues etc depending the layout type and scale of production.

o. Install the approved layout.

Once the official approval has been obtained, detailed plan for installing production , service and

other centers are made and carried out accordingly.

Flow Pattern of Materials:

Meaning and Types

Meaning of Flow Pattern:
"Flow Pattern" means the system to be adopted, for the movement of raw materials, from the beginning and up to the end of manufacturing. The overall-objective of the 'Flow Pattern' is to plan for the economical movement of the raw materials throughout the plant.

The Flow Pattern affects the following:
(i) Materials handling cost.
(ii) Amount of work-in-process.
(iii) Capital and space tied up by work-in-process.
(iv) Length of total production time.
(v) The rate of the performance and coordination of operations.
(vi) Amount of physical and mental strain on the operators.
(vii) Supervision and control mechanisms.
Quite often a plant layout design starts with the flow system around which services and other facilities are added and building design are modified accordingly but sometimes the flow must be adopted to suit existing buildings.

Factors Governing Flow Pattern:
(i) External transport facilities.
(ii) Number of products to be handled.
(iii) Number of operations on each product.
(iv) Number of units to be processed.
(v) Number of sub-assemblies made up ahead of assembly line.
(vi) Size and shape of available land.
(vii) Necessary flow between work areas.

Types of Flow Pattern:
The flow patterns can be classified into horizontal and vertical. The horizontal flow system is adopted on a shop floor while vertical flow is adopted where material has to move in a multi-storey building.

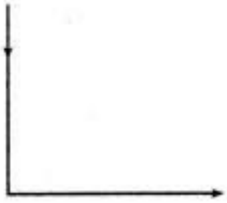
1. Horizontal Flow Lines:
There are five basic types of horizontal flow line:
(i) I-Flow or Line Flow.
(ii) L-Flow.
(iii) U-Flow.
(iv) S-Flow.
(v) O-Flow.

(i) I-Flow or Line Flow:

It is the simplest form of flow. In this, materials are fed at one end and components leave the line at the other end. This type is economical in space and convenient in I-shaped buildings. I-Flow is preferred for building automobile Industries.

(ii) L-Flow:

It is similar to the I-Flow and is used where I-line cannot be accommodated in the available space.

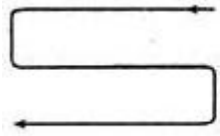


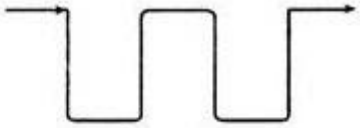
(iii) U-Flow:

In this, both feeding and output take place at the same end i.e., it allows both receiving and despatching of goods to be done on one side. In comparison to I or L-Flow, this method is easier for supervision. This type of flow can be adopted in the manufacture of Electric Motor Industry etc.

(iv) S-Flow:

If the production line is so long that zig-zagging on the plant floor is necessary, than S-Flow is adopted. This type provides efficient utilization of space and is compact enough to allow effective supervision.

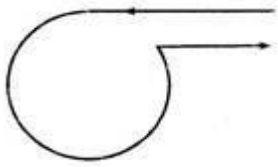




(v) O-Flow:

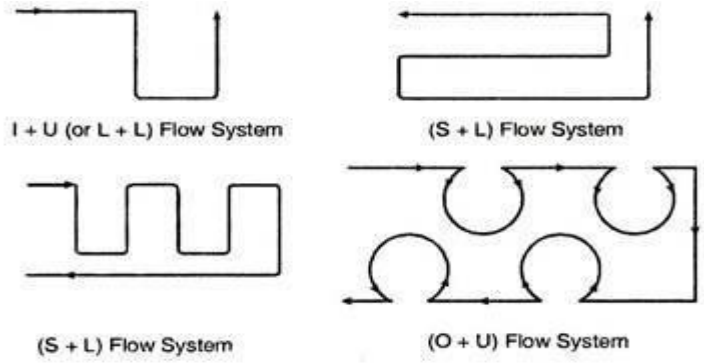
This type is used where processes or operations are performed on a rotary table or a rotary handling system. The components are moved from one working station to the other and when they leave the O-line, a complete set of processes or operations have been performed.

The components are inspected before they are moved on to a second line for an additional series of processes or operations or to an assembly line. O-Flow can be adopted by industries manufacturing electric bulbs.



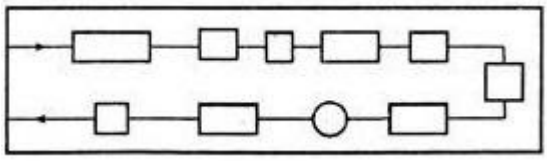
These above mentioned basic flow lines are mostly used by industries in various combinations. Examples of combinations of basic horizontal flow systems are shown below.

Unidirectional and Retractional Flow:



(a) Unidirectional Flow:

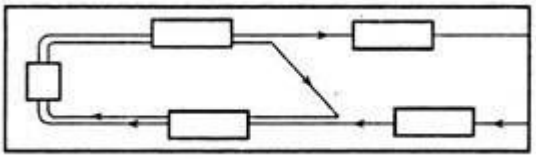
The flow is said to be unidirectional when the material is passed from one work station to another without having to pass along the same path. The flow methods explained above are all unidirectional type of flow.



(b) Retractional Flow:

In this, the flow is repeated i.e., two or more non-consecutive operations are performed on the same machine. The aspect of flow is decided by consideration of machine utilization.

In this flow, the available machine time is fully utilized but schedules have to allow for repeated machine setting and for the fact that intermittent localized halts occur in the production line i.e., each time a machine is switched over from one operation setting to another. This flow is also known as Repeated flow.



2. Vertical Flow Lines:

This type of flow is for multi-storey buildings. In order to have the materials handling systems and control mechanisms to operate effectively, following six basic aspects of vertical flow systems are in use.

(i) Processing downward or upward.
(ii) Centralized or Decentalized elevation.
(iii) Unidirectional or Retractional flow.
(iv) Vertical or Inclined flow.
(v) Single or Multi-flow.
(vi) Flow between buildings.

(i) Processing Downwards or Upwards:

In downward processing, the materials are fed from the top floor and in upward processing the materials are fed from the bottom floor while the finished product is received at the top floor.
In processing downward much gravity handling system such as roller lines, chutes, pipes, buckets, hand operated lifts etc. can be used. These are economical in installation, operation, maintenance etc.

(ii) Centralized or Decentralized Elevation:

In a centralized elevation all the material handling devices are installed at one central place of the building. Therefore, this system is economical in supervision and maintenance. It sometimes reduces installation cost also. This method is usually employed when the flow on each floor is a U-flow.
A decentralized elevation method is more costly in installation, maintenance and space, but by this method handling on each floor can be greatly reduced and more flexibility in design of the flow lines is possible.

(iii) Unidirectional or Retractional Flow:

In retractional type of flow, material has to come back on the floor which had already passed previously. This is done purposely to achieve better utilisation of available space and machines.

(iv) Vertical or Inclined Flow:

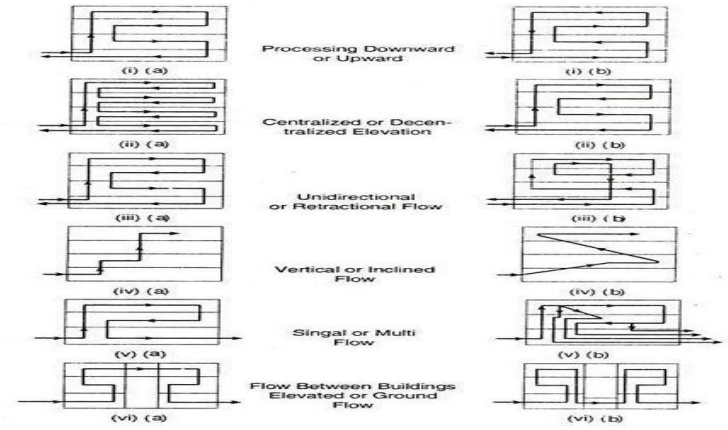
This type of flow is more economical and carried on with material handling devices such as elevators, chutes, buckets etc. In addition, inclined flow may also be carried out by conveyor belts as used in coal handling plants and chain system to move boiler grates etc. and similar other tasks.

(v) Single or Multi-flow:

In a single flow, there is only one flow line of materials while in multi-flow, there will be several flow lines and all these feed one assembly line.

(vi) Flow between Buildings:

When one production line is executed in several adjacent buildings, the flow of goods may be achieved either on an elevated floor or a ground floor. Ground floor is cheaper but requires more handling than an elevated floor. Elevated flow frees the ground for traffic and storage purposes.



Capacity Planning

Capacity planning is the process of determining the production capacity needed by an organization to meet changing demands for its products. In the context of capacity planning, design capacity is the maximum amount of work that an organization is capable of completing in a given period.

Design capacity refers to the maximum designed service capacity or output rate and the effective capacity is the design capacity minus personal and other allowances. These two functions of capacity can be used to find the efficiency and utilization.

Capacity planning helps businesses with budgeting and scaling so they can identify their optimal levels of operations. Capacity planning helps to determine how services are offered, the appropriate time frames and staff required to meet current demand and cover all operational costs.

Steps in Capacity Planning

Here are five critical steps that every capacity planning process should include.

STEP 1: CHECK ON THE CURRENT SLA LEVELS

Before you look toward your future needs, you need to understand the current capacity and Service Level Agreements of your IT systems. This may involve reviewing SLA documents and signed partnership agreements with service providers, as it's important to know whether or not your vendors are keeping up their end of the SLA and how much room you have for growth.

STEP 2: ANALYZE YOUR EXISTING CAPACITY

Next, analyze your current capacity. During this step, you also want to consider how well your systems stand up to current needs. For instance, if your users frequently complain about slow performance or other issues, it could be a sign that you're lacking proper capacity to support user activity.

STEP 3: DETERMINE YOUR FUTURE NEEDS

Once you have an idea of your current capacity, it's time to map out future capacity requirements.

"If you are looking only at the company's future growth, what you are really looking at is how well the existing infrastructure, servers, and applications will hold up to an increased number of users". "Future needs are different, though, and have more to do with the way the company's business may change." It's important to think about growth like specialized client needs, including requirements for running new applications, or updating other hardware and software elements.

STEP 4: IDENTIFY ANY OPPORTUNITIES FOR CONSOLIDATION

Capacity planning is also an ideal time to consolidate your workloads or potentially eliminate under provisioned servers. Not every workload will be well-suited for consolidation, and it's imperative that consolidation doesn't come at the cost of necessary redundancy.

STEP 5: MAKE YOUR CAPACITY RECOMMENDATIONS AND TAKE ACTION

Remember, your capacity plan should be just that: a plan outlining the actionable steps you should take to support your users and infrastructure now and into the future. Using the data and insights about your current capacity and where your needs will take you in the future, you can formulate recommendations about how to best support these requirements.

Following your plan, your team can prepare your infrastructure capacity for the future. Keep in mind, though, that this is an ongoing initiative — you should regularly check into your existing capacity and compare it to your future requirements to ensure you're on track. Capacity planning is especially important when prepping your infrastructure to handle high-capacity projects. In

addition, if you undergo a merger or acquisition, you'll need to ensure that you have the right capacity in place to account for new users.

Capacity planning is a critical pursuit for you and your team, and it can go a lot smoother with the right tools and technology in place.

Unit III

Work and Job Design

Work/job design/ task design is used to assess how tasks or the entire job is organised within the work environment, and then ensure these are well-matched to the attributes of the employee. Job design is a core function of human resource management and it is related to the specification of contents, methods and relationship of jobs in order to satisfy technological and organizational requirements as well as the social and personal requirements of the job. It is the allocation of specific work tasks to individuals and groups. Allocating jobs and tasks means specifying the contents, method and relationships of jobs to satisfy technological and organizational requirements, as well as the personal needs of jobholders.

If the work design is good, or safety in design, it considers hazards and risks as early as possible in the planning and design process. It aims to eliminate or minimise the possibility of workplace injury or illness throughout the life of the product or process.

Job design makes the work more interesting and challenging, which motivates the employees for higher level of performance. The challenging and interesting job provides better pay for the employees which inspires them for better job performance.

Objectives of Work Design

1. The first objective of job design is to meet the requirements of the organisation, such as high productivity, technical efficiency and quality of work.
2. The second objective is to satisfy the needs of the individual employees such as job satisfaction in terms of interest, challenge and achievement.
3. The next objective is to integrate the needs of the individual with the requirements of the organisation.

Work Study

Work study is a means of enhancing the production efficiency (productivity) of the firm by elimination of waste and unnecessary operations. It is a technique to identify non-value adding operations by investigation of all the factors affecting the job. Work study is a combination of two groups of techniques, method study and work measurement, which are used to examine people's work and indicate the factors which affect efficiency. Measure the amount of work involved in the method used and calculate a “standard time” for doing it.

Role of Work Study

1. To standardise the method of doing a work,
2. To minimise the unit cost of production,
3. To determine the standard time for doing a task,
4. To minimise the material movement, and operators movement,
5. To eliminate unnecessary human movements,
6. To utilise facilities such as man, machine and materials most effectively, and

7. To a systematic investigation of all factors.

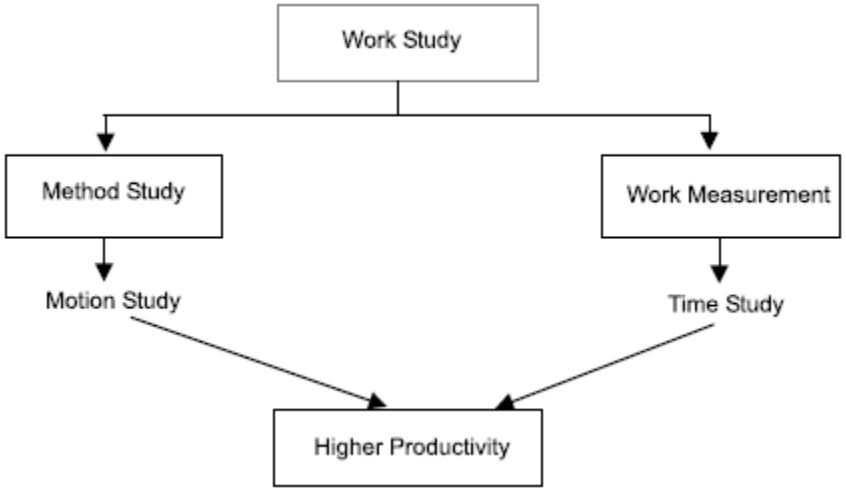
Objectives of Work Study:

1. Increased efficiency,
2. Better product quality,
3. To choose the fastest method to do a job,
4. To improve the working process,
5. Less fatigue to operators and workers,
6. Effective labour control,
7. Effective utilisation of resources,
8. To decide equipment requirements,
9. To pay fair wages,
10. To aid in calculating exact delivery,
11. To formulate realistic labour budgeting, and
12. To decide the required manpower to do a job.

Basic Procedure of Work-Study

- Select - The task to be studied.
- Record - By collecting data at source & by direct observation.
- Examine - By challenging the purpose, place, sequence & method of work.
- Develop - New methods, drawing on contribution of those concerned.
- Evaluate - Results of alternative solutions.
- Define.
- Install.
- Maintain.

Framework of work study



Method Study

Method study is the process of subjecting work to systematic, critical scrutiny to make it more effective

and/or more efficient. It is one of the keys to achieving productivity improvement. It is the technique of systematic recording and critical examination of existing and proposed ways of doing work and developing an easier and economical method. Method study is to simplify the job and develop more economical methods of doing it. It is systematic both in investigation of problem being considered and in the development of its solutions. It can be stated as one of most penetrating tools of investigation available to management.

Objectives of Method Study

1. Improvement of manufacturing processes and procedures.
2. Improvement of working conditions.
3. Improvement of plant layout and work place layout.
4. Reducing the human effort and fatigue.
5. Reducing material handling
6. Improvement of plant and equipment design.
7. Improvement in the utility of material, machines and manpower.
8. Standardisation of method.
9. Improvement in safety standard.

Basic Procedure For Method Study

The basic procedure for conducting method study is as follows:

1. Select the work to be studied.
2. Record all facts about the method by direct observation.
3. Examine the above facts critically.
4. Develop the most efficient and economic method.
5. Define the new method.
6. Install the new method
7. Maintain the new method by regular checking.

1. Select

While selecting a job for doing method study, the following factors are considered:

(a) Economical factors.
(b) Human factors.
(c) Technical factors.

(a) Economical Factors

The money saved as a result of method study should be sufficiently more. Then only the study will be worthwhile. Based on the economical factors, generally the following jobs are selected.

(a) Operations having bottlenecks (which holds up other production activities).
(b) Operations done repetitively.
(c) Operations having a great amount of manual work.
(d) Operations where materials are moved for a long distance.

(b) Human Factors

The method study will be successful only with the co-operation of all people concerned viz., workers, supervisor, trade unions etc.

Workers may resist method study due to

1. The fear of unemployment.
2. The fear of reduction in wages.
3. The fear of increased work load.

then if they do not accept method study, the study should be postponed.

(c) Technical Factors

To improve the method of work all the technical details about the job should be available. Every machine tool will have its own capacity. Beyond this, it cannot be improved.

For example, a work study man feels that speed of the machine tool may be increased and HSS tool may be used. But the capacity of the machine may not permit increased speed. In this case, the suggestion of the work study man cannot be implemented. These types of technical factors should be considered.

2. Record

All the details about the existing method are recorded. This is done by directly observing the work.

Symbols are used to represent the activities like operation, inspection, transport, storage and delay.

Different charts and diagrams are used in recording. They are:

1. Operation process chart: All the operations and inspections are recorded.
2. Flow process chart

(a) Man type All the activities of man are recorded

(b) Material type All the activities of the material are recorded

(c) Equipment type All the activities of equipment or machine are recorded.

3. Two-handed process chart: Motions of both lands of worker are Right hand-Left hand chart recorded independently.
4. Multiple activity chart: Activities of a group of workers doing a single job or the activities of a single worker operating a number of machines are recorded.
5. Flow diagram: This is drawn to suitable scale. Path of flow of material in the shop is recorded.
6. String diagram: The movements of workers are recorded using a string in a diagram drawn to scale.

3. Examine

Critical examination is done by questioning technique. This step comes after the method is recorded by suitable charts and diagrams.

The individual activity is examined by putting a number of questions.

The following factors are questioned

1. Purpose – To eliminate the activity, if possible.
2. Place – To combine or re-arrange the activities.
3. Sequence – -do-
4. Person – -do-
5. Means – To simplify the activity.

By doing this questioning

- Unwanted activities can be eliminated
- Number of activities can be combined or re-arranged
- Method can be simplified.

All these will reduce production time.

4. Develop

The answer to the questions given below will result in the development of a better method.

1. Purpose – What should be done?
2. Place – Where should it be done?
3. Sequence – When should it be done?
4. Person – Who should do it?
5. Means – How should it be done?

5. Define

Once a complete study of a job has been made and a new method is developed, it is necessary to obtain the approval of the management before installing it. The work study man should prepare a report giving details of the existing and proposed methods. He should give his reasons for the changes suggested. The report should show

(a) Brief description of the old method.

(b) Brief description of the new method.

(c) Reasons for change.

(d) Advantages and limitations of the new method.

(e) Savings expected in material, labour and overheads.

(f) Tools and equipment required for the new method.

(g) The cost of installing the new method including.

1. Cost of new tools and equipment.
2. Cost of re-layout of the shop.
3. Cost of training the workers in the new method.
4. Cost of improving the working conditions.

6. Install

This step is the most difficult stage in method study. Here the active support of both management and trade union is required. Here the work study man requires skill in getting along with other people and winning their trust. Instal stage consists of

(a) Gaining acceptance of the change by supervisor.

(b) Getting approval of management.

(c) Gaining the acceptance of change by workers and trade unions.

(d) Giving training to operators in the new method.

(e) To be in close contact with the progress of the job until it is satisfactorilyexecuted.

7. Maintain

The work study man must see that the new method introduced is followed. The workers after some time. may slip back to the old methods. This should not be allowed. The new method may have defects. There may be difficulties also. This should be rectified in time by the work study man. Periodical review

is made. The reactions and suggestions from workers and supervisors are noted. This may lead to further improvement. The differences between the new written standard practice and the actual practice are found out. Reasons for variations are analysed. Changes due to valid reasons are accepted. The instructions are suitably modified.

CHARTS AND DIAGRAMS USED IN METHOD STUDY (TOOLS AND TECHNIQUES)

As explained earlier, the following charts and diagrams are used in method study.

1. Operation process chart (or) Outline process chart.
2. Flow process chart.

(a) Material type

(b) Operator type

(c) Equipment type

3. Two-handed process chart. (or) Left hand-Right hand chart
4. Multiple activity chart.
5. Flow diagram.
6. String diagram.

Process Chart Symbols

The recording of the facts about the job in a process chart is done by using standard symbols.

Using of symbols in recording the activities is much easier than writing down the facts about the job. Symbols are very convenient and widely understood type of short hand. They save a lot of writing and indicate clearly what is happening.

1. Operation

A large circle indicates operation. An operation takes place when there is a change in physical or chemical characteristics of an object. An assembly or disassembly is also an operation.

When information is given or received or when planning or calculating takes place it is also called operation.

2. Inspection

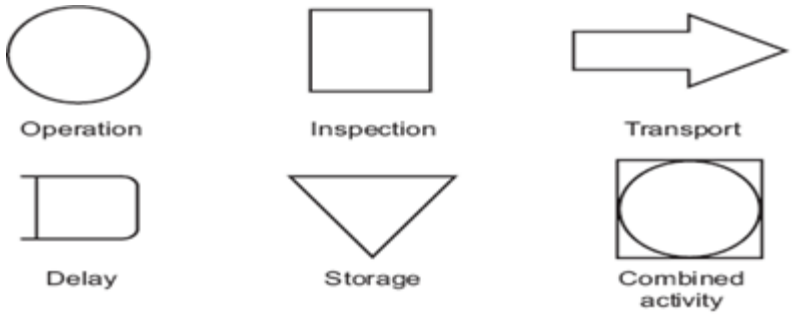
A square indicates inspection. Inspection is checking an object for its quality, quantity or identifications.

3. Transport

An arrow indicates transport. This refers to the movement of an object or operator or equipment from one place to another. When the movement takes place during an operation, it is not called transport.

4. Delay or temporary storage

A large capital letter D indicates delay. This is also called as temporary storage. Delay occurs when an object or operator is waiting for the next activity.



5. **Permanent storage**

An equilateral triangle standing on its vertex represents storage. Storage takes place when an object is stored and protected against unauthorized removal.

6. **Combined activity**

When two activities take place at the same time or done by the same operator or at the same place, the two symbols of activities are combined.

Operation Process Chart

An operation process chart is a graphic representation of the sequence of all operations and inspections taking place in a process. It is also known as outline process chart. It gives a bird's eye view of the overall activities. Entry points of all material are noted in the chart.

The conventions followed in preparing the chart are

1. Write title at the top of the chart.
2. Begin the chart from the right hand side top corner.
3. Represent the main component at the right extreme.
4. Represent the sequence of operations and inspections by their symbols. Connect them by vertical flow lines.
5. Record the brief description of the activity to the right side of the symbols.
6. Note down the time for each activity to the left of the symbol.
7. Number all operations in one serial order. Start from the right hand top (from number 1).
8. Similarly number all inspections in another serial order (starting from 1).
9. Continue numbering, till the entry of the second component.
10. Show the entry of purchased parts by horizontal lines.

Flow Process Chart

A flow process chart is a graphical representation of the sequence of all the activities (operation, inspection, transport, delay and storage) taking place in a process. Process chart symbols are used here to represent the activities. There are three types of flow process charts. They are

Man type flow process chart

This flow process chart records what the worker does.

Material type flow process chart

This flow process chart records how the material is handled or treated.

Equipment type flow process chart

This flow process chart records how the equipment or machine is used.

General guidelines for making a flow process chart

1. The details must be obtained by direct observation—charts must not be based on memory.
2. All the facts must be correctly recorded.
3. No assumptions should be made.
4. Make it easy for future reference.
5. All charts must have the following details:

(a) Name of the product, material or equipment that is observed.
(b) Starting point and ending point.
(c) The location where the activities take place.
(d) The chart reference number, sheet number and number of total sheets.
(e) Key to the symbols used must be stated.

Two-Handed Process Chart (or) Right Hand, Left Hand Chart

- It is the process chart in which the activities of two hands of the operator are recorded.
- It shows whether the two hands of the operator are idle or moving in relation to one another, in a timescale.
- It is generally used for repetitive operations.

Operation: Represents the activities grasp, position, use, release etc. of a tool, component or material.
Transport: Represents the movement of the hand or limb to or from the work or a tool or material.
Delay: Refers to the time when the hand or limb is idle.
Storage (Hold): The term ‗hold' is used here instead of storage. This refers to the time when the work is held by hand.
The activity ‗inspection' by hand is considered as an operation. Hence, the symbol for inspection is not used in this chart.
Two-handed process chart can be used for assembly, machining and clerical jobs.

General guidelines for preparing the chart

- Provide all information about the job in the chart.
- Study the operation cycle a few times before starting to record.
- Record one hand at a time.
- First record the activities of the hand which starts the work first.
- Do not combine the different activities like operations, transport etc.

Summary of the number of each activity can be tabulated at the bottom of the chart. The chart is first drawn for the existing method. This chart is analysed and if it is found that one hand is over loaded than the other, modification are done in the layout of the workplace or in the sequence of activities. Then a new chart is made for the proposed cycle.

Man-Machine Chart

A man-machine chart is a chart in which the activities of more than one worker or machine are recorded. Activities are recorded on a common time scale to show the inter-relationship. It is also known as multiple activity chart. It is used when a worker operates a number of machines at a time. It is also used when a number of workers jointly do a job. Activities of workers or machines are recorded in separate vertical columns (bars) with a horizontal time scale.

The chart shows the idle time of the worker or machine during the process. By carefully analyzing the chart, we can rearrange the activities. Work load is evenly distributed among the workers or machines by this the idle time of worker or machine is reduced. Multiple activity chart is very useful in planning team work in production or maintenance. Using the chart we can find out the correct number of machines that a worker can operate at a time. We can also find out the exact number of workers needed to do a job jointly.

To record the time, ordinary wrist watch or stop watch is used. High accuracy is not needed. Man-machine chart is a type of multiple activity chart. Here, the activities of a number of machines are recorded.

Flow Diagram

In any production shop, repair shop or any other department, there are movements of men and material from one place to another. Process charts indicate the sequence of activities. They do not show the frequent movements of men and material. If these movement are minimized, a lot of savings can be achieved in cost and effort. If the path of movement of material is not frequent and simple, a flow diagram is used for recording the movement.

A flow diagram is a diagram which is drawn to scale. The relative position of machineries, gang ways, material handling equipment etc. are drawn first. Then the path followed by men or material is marked on the diagram. Different movements can be marked in different colours. Process symbols are added to the diagram to identify the different activities at different work centres.

The flow diagram are used for the following purposes:

- To remove unwanted material movement.
- To remove back tracking.
- To avoid traffic congestion.
- To improve the plant layout.

Conventions adopted are

1. Heading and description of the process should be given at the top of the diagram.
2. Other information like location, name of the shop, name of the person drawing the diagram are also given.
3. The path followed by the material is shown by a flow line.
4. Direction of movement is shown by small arrows along the flow lines.
5. The different activities are represented by the symbols on the flow lines. (Same symbols used in flow process chart are used here).
6. If more than one product is to be shown in the diagram different colours are used for each path.

String Diagram

We make use of flow diagram for recording the movement of men or material when the movement is simple and the path is almost fixed. But when the paths are many and are repetitive, it may not be possible to record them in a flow diagram. Here a string diagram is used.

String diagram is a scaled plan of the shop. Location of machines and various facilities are drawn to scale in a drawing sheet. Pins are fixed at the various work centres in the drawing sheet. A continuous coloured thread or string is taken round the pins where the material or worker moves during the process.

Constructions

- Draw the layout of the shop to scale in a drawing sheet.
- Mark the various work centres like machines, stores, work bench etc. in the diagram.
- Hold the drawing sheet on a soft board and fix pins at the work centres.
- Tie one end of a coloured string to the work centre from which the movement starts.
- Follow the path of the worker to different work centre and accordingly take the thread to different points on the drawing board.
- At the end of the session note down the number of movements from one work centre to another.
- Remove the string and measure the total length of the string. Multiply by the scale and get the actual distance of movement.

Applications

1. It is used for recording the complex movements of material or men.
2. Back tracking, congestion, bottlenecks, under-utilized paths are easily found out.
3. It is used to check whether the work station is correctly located.
4. Used to record irregular movements.
5. Used to find out the most economical route.

WORK MEASUREMENT

Work measurement/Time study is a structured process of directly observing and measuring human work using a timing device to establish the time required for completion of the work by a qualified worker when working at a defined level of performance.

Role of time study

(i) It is useful in determining the standard time for various operations, which helps in fixing wages and incentives.

(ii) It is useful to estimate the cost of a product accurately.

(iii) It helps in production control.

(v) Using the time study techniques, it can be found that how much machines an operator can run.

Objectives of work measurement

- To reduce or eliminate non-productive time.
- To fix the standard time for doing a job.
- To develop standard data for future reference.
- To improve methods.

Uses of work measurements

1. To compare the efficiency of alternate methods. When two or more methods are available for doing the same job, the time for each method is found out by work measurement. The method which takes minimum time is selected.
2. Standard time is used as a basis for wage incentive schemes.
3. It helps for the estimation of cost. Knowing the time standards, it is possible to work out the cost of the product. This helps to quote rates for tenders.
4. It helps to plan the workload of man and machine.
5. It helps to determine the requirement of men and machine. When we know the time to produce one piece and also the quantity to be produced, it is easy to calculate the total requirement of men and machines.
6. It helps in better production control. Time standards help accurate scheduling. So the production control can be done efficiently.
7. It helps to control the cost of production. With the help of time standards, the cost of production can be worked out. This cost is used as a basis for control.
8. It helps to fix the delivery date to the customer. By knowing the standard time we will be able to calculate the time required for manufacturing the required quantity of products.

Techniques Of Work Measurement

The different techniques used in work measurement are

- Stop watch time study.
- Production study.
- Work sampling or Ratio delay study.
- Synthesis from standard data.
- Analytical estimating.
- Predetermined motion time system.

Stop Watch Time Study

Stop watch time study is one of the techniques of work measurement commonly used.
Here we make use of a stop watch for measuring the time.

Procedure for conducting stop watch time study

The following procedure is followed in conducting stop watch time study:

1. Selecting the job.

2. Recording the specifications.
3. Breaking operation into elements.
4. Examining each element.
5. Measuring using stop watch.
6. Assessing the rating factor.
7. Calculating the basic time.
8. Determining the allowances.
9. Compiling the standard time.

1. Selection of job

Time study is always done after method study. Under the following situations, a job is selected for time study:

1. A new job, new component or a new operation.
2. When new time standard is required.
3. To check the correctness of the existing time standard.
4. When the cost of operation is found to be high.
5. Before introducing an incentive scheme.
6. When two methods are to be compared.

2. Record

The following informations are recorded

1. About the product-name, product-number, specification.
2. About the machine, equipment and tools.
3. About the working condition-temperature-humidity-lighting etc. These informations are used when deciding about the allowances.
4. About the operator name-experience-age etc. This is needed for rating the operator.

3. Break down operation into elements

Each operation is divided into a number of elements. This is done for easy observation and accurate measurement. The elements are grouped as constant element, variable element, occasional element, man element, machine element etc.

4. Examine each element

The elements are examined to find out whether they are effective or wasteful. Elements are also examined whether they are done in the correct method.

5. Measure using a stop watch

The time taken for each element is measured using a stop watch. There are two methods of measuring. viz., Fly back method and Cumulative method. Cumulative method is preferable.

The time measured from the stop watch is known as observed time. Time for various groups of elements should be recorded separately. This measurement has to be done for a number of times. The number of observations depend upon the type of operation, the accuracy required and time for one cycle.

6. Assess the rating factor

Rating is the measure of efficiency of a worker. The operator‘s rating is found out by comparing

his speed of work with standard performance. The rating of an operator is decided by the work study man in consultation with the supervisor. The standard rating is taken as 100. If the operator is found to be slow, his rating is less than 100 say 90. If the operator is above average, his rating is more than 100, say 120.

7. Calculate the basic time

Basic time is calculated as follows by applying rating factor

$$\text{Basic time} = \text{Observed time} \times \frac{\text{Operator rating}}{\text{Standard rating}}$$

$$BT = OT \times \frac{OR}{SR}$$

8. Determine the allowance

A worker cannot work all the day continuously. He will require time for rest going for toilet, drinking water etc. Unavoidable delays may occur because of tool breakage etc. So some extra time is added to the basic time. The extra time is known as allowance.

9. Compile the standard time

The standard time is the sum of basic time and allowances. The standard time is also known as allowed time.

Breaking a Job into Elements

It is necessary to break down a task (job) into elements for the following reasons:

1. To separate productive time and unproductive time.
2. To assess the rating of the worker more accurately.
3. To identify the different types of elements and to measure their timings separately.
4. To determine the fatigue allowance accurately.
5. To prepare a detailed work specification.
6. To fix standard time for repetitive elements (such as switch on or switch off of machine).

Classification of elements

1. Repetitive elements

It is an element which occurs in every work cycle of the job.

2. Constant element

It is an element for which the basic time remains constant whenever it is performed.

3. Variable element

It is an element for which the basic time varies depending on the characteristics of the product, equipment or process.

4. Occasional element

It is an element which does not occur in every work cycle of the job. It may occur at regular or irregular intervals.

5. Foreign element

It is an element which is not a part of the job.

6. Manual element

It is an element performed by the worker.

7. Machine element

It is the element automatically performed by a power driven machine.

General rules to be followed in breaking down a task into elements

1. Element should have a definite beginning and ending.
2. An element should be as short as possible so that it can be conveniently timed. The shortest element that can be timed using a stop watch is 0.04 mt.
3. Manual elements and machine elements should be separately timed.
4. Constant element should be separated from variable elements.
5. Occasional and foreign elements should be timed separately.

Measuring Time with a Stop Watch

There are two methods of timing using a stop watch. They are

- Fly back or Snap back method.
- Continuous or Cumulative method.

1. Fly back method

Here the stop watch is started at the beginning of the first element. At the end of the element the reading is noted in the study sheet (in the WR column). At the same time, the stop watch hand is snapped back to zero. This is done by pressing down the knob, immediately the knob is released. The hand starts moving from zero for timing the next element. In this way the timing for each element is found out. This is called observed time (O.T.) .

2. Continuous method

Here the stop watch is started at the beginning of the first element. The watch runs continuously throughout the study. At the end of each element the watch readings are recorded on the study sheet. The time for each element is calculated by successive subtraction. The final reading of the stop watch gives the total time. This is the observed time (O.T.).

Production Study

Production study is a technique of work measurement to check accuracy of the original time study. This study is done to find the time delay due to occasional elements. These elements may occur at irregular intervals. Example: Tool grinding, setting tools etc. There are chances of missing these elements in the stop watch time study. Production study is conducted for a longer period—at least for half a day or one shift.

Ratio Delay Study

This study is also known as work sampling or activity sampling. Here the ratio of the delay time and working time to the total time of an activity is found out. This is done by random (irregular) observations. This study is applied to

- Long cycle operations.
- Activities where time study is not possible.

Synthesis From Standard Data

Synthesis is a work measurement technique to work out standard time for a job by totaling the elemental times already obtained from previous time studies. Many operators in an industry have several common elements. Example: starting the machine, stopping the machine etc. Whenever these activities occur, they take the same duration of time. These elements are called constant elements. Time for some elements vary proportionately with the speed, feed, length of cut etc. in machining operation. These elements are known as variable elements. Time for all these constant elements and variable elements are collected from the time studies previously made. These are stored in a file. This is called time standard data bank. Data bank contains data in the form of

- Tabulated standard time for constant elements.
- Charts and graphs.
- Formulae etc.

Analytical Estimating

Setting the time standards for long and non-repetitive operations by stop watch method are uneconomical. Analytical estimating technique determines the time values for such jobs either by using the synthetic data or on the basic of the past experience of the estimator when no synthetic or standard data is available. In order to produce accurate results the estimator must have sufficient experience of estimating, motion study, time study and the use of synthesized time standards.

Predetermined Motion Time System (Pmts)

Definition: PMTS is a work measurement technique where by times, established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

A predetermined motion time system (PMTS) may be defined as a procedure that analyzes any manual activity in terms of basic or fundamental motions required to performing it. Each of these motions is assigned a previously established standard time value in such a way that the timings for the individual motions can be synthesized to obtain the total time for the performance of the activity.

The main use of PMTS lies in the estimation of time for the performance of a task before it is performed. The procedure is particularly useful to some organizations because it does not require troublesome rating with each study.

Applications of PMTS are for

(i) Determination of job time standards.

(ii) Comparing the times for alternative proposed methods so as to find the economics of the proposals prior to production run.

(iii) Estimation of manpower, equipment and space requirements prior to setting up the facilities and start of production.

(iv) Developing tentative work layouts for assembly line prior to their working.

(v) Checking direct time study results. A number of PMTS are in use, some of which have been developed by individual organizations for their own use, while other organizations have publicized for

universal applications.

Cycle graph and Chrono cycle graph

These techniques of analyzing the paths of motion made by an operator were developed by the Gilbreths. To make a cycle graph, a small electric bulb is attached to the finger, hand, or any other part of the body whose motion is to be recorded. By using still Photography, the path of light of bulb (in other words, that of the body member) as it moves through space for one complete cycle is photographed by keeping the working area relatively less illuminated. More than one camera may be used in different planes to get more details. The resulting picture (cycle graph) shows a permanent record of the motion pattern employed in the form of a closed loop of white continuous line with the working area in the background. A cycle graph does not indicate the direction or speed of motion. It can be used for improving the motion pattern and Training purposes in that two cycle graphs may be shown with one indicating a better motion pattern than the other.

The Chrono cycle graph is similar to the cycle graph, but the power supply to the bulb is interrupted regularly by using an electric circuit. The bulb is thus made to flash. The procedure for taking photograph remains the same. The resulting picture (Chrono cycle graph), instead of showing continuous line of motion pattern, shows short dashes of line spaced in proportion to the speed of the body member photographed. Wide spacing would represent fast moves while close spacing would represent slow moves. The jumbling of dots at one point would indicate fumbling or hesitation of the body member. A chrono cycle graph can thus be used to study the motion pattern as well as to compute velocity, acceleration and retardation experienced by the body member at different locations. The world of sports has used this analysis tool, updated to video, for extensively the purpose of training in the development of from and skill.

Advantages of cycle graph and Chrono cycle graph:

1. They can record all sorts of fast, complex and unrestricted movements which are not possible to trace otherwise.
2. They are useful for method improvement by motion analysis.
3. They are very useful in training and evaluating the workers.
4. Provides an aid in describing a motion pattern used in performing a task.
5. They can be used for comparing the two methods or motion patterns.

Limitations of cycle graph and Chrono cycle graph:

1. Light source (along with electric wires) tied to the hands of the worker may cause inconvenience to the worker.
2. It needs sufficient photographic practice to achieve good results

Memo motion Study

Memo motion or spaced-shot photography is a tool of time and **motion study** that analyzes long operations by using a camera. It was developed 1946 by Marvin E. Mundel at Purdue University, who was first to save film material while planning **studies** on kitchen work.

It is a special form of micromotion study in which the motion pictures or videotape are taken at slow speeds. Sixty and one hundred frames per minutes are most common.
This study has been used to study the flow and handling of materials, crew activities, multiperson and machine relationships, stockroom activities, department store clerks and a variety of other jobs. It is particularly valuable on long-cycle jobs or jobs involving many interrelationships. In addition to having all of the advantages of micromotion study, it can be used at relatively low film or tape cost (about 6% of the cost at normal camera speeds) and permits rapid visual review of long sequence of activities.

Just-In-Time (JIT)

Just-in-time manufacturing, also known as just-in-time production or the Toyota Production System, is a methodology aimed primarily at reducing times within the production system as well as response times from suppliers and to customers. JIT approach has the capacity, when adequately applied to the organisation, to improve the competitiveness of the organisation in the market significantly by minimizing wastes and improving production efficiency and the product quality.
Just In Time method prevents a company from using excessive inventory and smoothens production operations if a specific task takes longer than expected or a defective part is discovered in the system. This is also one of the main reason why the companies (which are opted for JIT) invest in preventive maintenance; when a part/equipment breaks down, the entire production process stops.

Objective of JIT

1. To be more responsive to customers,
2. To have better communication among departments and suppliers,
3. To be more flexible,
4. To achieve better quality,
5. To reduce product cost.

Elements involved in JIT

Continuous improvement:

- Attacking fundamental problems and anything that does not add value to the product.
- Devising systems to identify production and allied problems.
- **Simplicity:** Simple systems are simple & easy to understand, easily manageable and the chances of going wrong are very low.
- **A product:** oriented layout for less time spent on materials and parts movement.
- Quality control at source to ensure every worker is solely responsible for the quality of their own produced output.

Eliminating waste: There are seven types of waste:

1. Waste from product defects.
2. Waste of time.
3. Transportation waste.
4. Inventory waste.
5. Waste from overproduction.

6. Processing waste.

Waste minimization is one of the primary objectives of Just In Time system. This needs effective inventory management throughout the whole supply chain. Initially, a manufacturing entity will seek to reduce inventory and enhance operations within its own organization. In an attempt to reduce waste attributed to ineffective inventory management, SIX principles in relation to JIT have been stated by Schniededans and they are:

1. Reduce buffer inventory.
2. Try for zero inventory.
3. Search for reliable suppliers.
4. Reduce lot size and increase the frequency of orders.
5. Reduce purchasing cost.
6. Improve material handling.

Advantages of Adopting Just-In-Time include:

- Just-in-time approach keeps stock holding costs to a minimum level. The released capacity results in better utilization of space and bears a favourable impact on the insurance premiums and rent that would otherwise be needed to be made.
- The just-in-time approach helps to eliminate waste. Chances of expired or out of date products; do not arise at all.
- As under this management method, only essential stocks which are required for to manufacturing are obtained, thus less working capital is required. Under this approach, a minimum re-ordering level is set, and only when that level is reached, order for fresh stocks are made and thus this becomes a boon to inventory management too.
- Due to the abovementioned low level of stocks held, the ROI (Return On Investment? of the organizations be high in general.
- As this approach works on a demand-pull basis, all goods produced would be sold, and thus it includes changes in demand with unanticipated ease. This makes JIT appealing today, where the market demand is fickle and somewhat volatile.
- JIT emphasizes the 'right-first-time' concept, so that rework costs and the cost of inspection is minimized.
- By following JIT greater efficiency and High-quality products can be derived.
- Better relationships are fostered along the production chain under a JIT system.
- Higher customer satisfaction due to continuous communication with the customer.
- Just In Time adoption result in the elimination of overproduction.

Disadvantages of Adopting JIT Systems

- JIT approach states ZERO tolerance for mistakes, making re-work difficult in practice, as inventory is kept to a minimum level.
- A successful application of JIT requires a high reliance on suppliers, whose performance is outside the purview of the manufacturer.

- Due to no buffers in JIT, production line idling and downtime can occur which would have an unfavourable effect on the production process and also on the finances.
- Chances are quite high of not meeting an unexpected increase in orders as there will be no excess inventory of finished goods.
- Transaction costs would be comparatively high depending upon the frequency of transactions.
- JIT may have certain negative effects on the environment due to the frequent deliveries as the same would result in higher use and cost of transportation, which in turn would consume more fossil fuels.

Flexible Manufacturing System

A flexible manufacturing system (FMS) is a production method that is designed to easily adapt to changes in the type and quantity of the product being manufactured. Machines and computerized systems can be configured to manufacture a variety of parts and handle changing levels of production.
Flexible manufacturing systems are most often used when small (relative to mass production), customized batches of products are required. A "small" single manufacturing cell can consist of varying kinds of production, material handling, and computer control modules.
A flexible manufacturing system (FMS) can improve efficiency and thus lower a company's production cost. Flexible manufacturing also can be a key component of a make-to-order strategy that allows customers to customize the products they want.
Such flexibility can come with higher upfront costs. Purchasing and installing the specialized equipment that allows for such customization may be costly compared with more traditional systems.
A flexible manufacturing system (FMS) is a manufacturing system in which there is some amount of flexibility to react in the case of changes, whether predicted or unpredicted. This flexibility can be divided into two categories:

- **Machine flexibility**, covers the system's ability to be changed to produce new product types, and ability to change the order of operations executed on a part, and
- **Routing flexibility**, this consists of the ability to use multiple machines to perform the same operation on a part, as well as the system's ability to absorb large-scale changes, such as in volume, capacity, or capability.

Most FMS systems consist of three main systems.

- The work machines which are often using computerized machines,
- Material handling system to optimize parts flow, and
- The central control computer which controls material movements and machine flow.

Working of Flexible Manufacturing Systems

The concept of flexible manufacturing was developed by Jerome H. Lemelson (1923-97), an American industrial engineer and inventor. His original design was a robot-based system that could weld, rivet, convey, and inspect manufactured goods.
A flexible manufacturing system may include a configuration of interconnected processing workstations with computer terminals that process the end-to-end creation of a product, from loading/unloading functions to machining and assembly to storing to quality testing and data processing. The system can be programmed to run a batch of one set of products in a particular quantity and then automatically switch over to another set of products in another quantity.

A make-to-order production process that allows customers to customize their products would also be an example of flexible manufacturing.

Key Takeaways

- A flexible manufacturing system (FMS) is designed up front to be readily adapted to changes in the type and quantity of goods being produced.
- Production is largely automated, reducing overall labor costs.
- An FMS system is, however, more expensive to design and put in place and requires skilled technicians to keep it running.
- Flexible manufacturing can be a key component of a make-to-order strategy that allows customers to customize the products they want

Advantages

- Faster, lower- cost changes from one part to another which will improve capital utilization
- Lower direct labor cost, due to the reduction in number of workers
- Reduced inventory, due to the planning and programming precision
- Consistent and better quality, due to the automated control
- Lower cost/unit of output, due to the greater productivity using the same number of workers
- Savings from the indirect labor, from reduced errors, rework, repairs and rejects
- Enhancement of production efficiency
- Downtime is reduced because the production line does not have to be shut down to set up for a different product.

Disadvantages

- Limited ability to adapt to changes in product or product mix (ex. machines are of limited capacity and the tooling necessary for products, even of the same family, is not always feasible in a given FMS)
- Substantial pre-planning activity
- Expensive, costing millions of dollars
- Technological problems of exact component positioning and precise timing necessary to process a component
- Sophisticated manufacturing systems
- It include higher upfront costs and greater time required to design the system specifications for a variety of future needs.
- There also is a cost associated with the need for specialized technicians to run, monitor, and maintain the FMS.

Computer Integrated Manufacturing (CIM)

Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each part. CIM is a combination of different applications and technologies like CAD, CAM, computer-aided engineering, robotics, manufacturing resource planning and enterprise management solutions. The major components of CIM are as follows: Data storage, retrieval, manipulation and presentation mechanisms.

The sole objective of computer-integrated manufacturing is to streamline production processes, delivering the following benefits: Reduced costs – i.e. the cost of direct and indirect labour. Improved scheduling flexibility.

Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each other and initiate actions. It makes the use of computer-controlled machineries and automation systems in manufacturing products. CIM combines various technologies like CAD and CAM to provide an error-free manufacturing process that reduces manual labor and automates repetitive tasks.

The term "computer-integrated manufacturing" is both a method of manufacturing and the name of a computer-automated system in which individual engineering, production, marketing, and support functions of a manufacturing enterprise are organized.

In a CIM system functional areas such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with factory floor functions such as materials handling and management, providing direct control and monitoring of all the operations.

Processes Involved

The various processes involved in a CIM are listed as follows:

- Computer-aided design
- Prototype manufacture
- Determining the efficient method for manufacturing by calculating the costs and considering the production methods, volume of products, storage and distribution
- Ordering of the necessary materials needed for the manufacturing process
- Computer-aided manufacturing of the products with the help of computer numerical controllers
- Quality controls at each phase of the development.
- Product assembly with the help of robots
- Quality check and automated storage
- Automatic distribution of products from the storage areas to awaiting lorries/trucks
- Automatic updating of logs, financial data and bills in the computer system.

Advantages of CIM

1. Error Reduction

Elimination of human error in many assignment and reporting functions on factory floor operations drastically reduces the error rate.

2.Speed

CIM environments reduce the time it takes to perform manufacturing fabrication and assembly, allowing quicker flow of product to customers and increased capacity.

3. Flexibility

With CIM companies quickly react to market conditions and then return to previous settings when market conditions change.

4. Integration

CIM offers a degree of integration that enables the flexibility, speed and error reduction required to compete and lead markets. Integrating factory floor operations with enterprise software enables employees to do higher value functions for their companies.

Challenges of CIM

1. Integration of components from different suppliers:

When different machines, such as CNC, conveyors and robots, are using different communications protocols (In the case of AGVs, even differing lengths of time for charging the batteries) may cause problems.

2. Data Integrity

The higher the degree of automation, the more critical is the integrity of the data used to control the machines. While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the data signals that are used to control the machines.

3. Process Control

Computers may be used to *assist* the human operators of the manufacturing facility, but there must always be a competent engineer on hand to handle circumstances which could not be foreseen by the designers of the control software.

Master Production Schedule (MPS)

A master production schedule (MPS) is a plan for individual commodities to be produced in each time period such as production, staffing, inventory, etc. It is usually linked to manufacturing where the plan indicates when and how much of each product will be demanded.

The Master Production Schedule (MPS) is a plan for the production of individual final items. The MPS breaks down the production plan to show, in each period, the quantity to produce of each final article. Each final article is also called Stock Keeping Unit, usually using its acronym SKU. The Master Production Program, which is developed over a period of time, is called the planning horizon. The planning horizon generally extends between 3 and 18 months, depending on the manufacturing cycles of the item in question.

The master production schedule (also commonly referred to as the MPS) is effectively the plan that the company has developed for production, staffing, inventory, etc.

It has as input a variety of data, e.g. forecast demand, production costs, inventory costs, etc and as output a production plan detailing amounts to be produced, staffing levels, etc for each of a number of time periods.

This production plan:

- operates at an *aggregate* level (that is it does not usually go into great detail about parts to be used, etc - hence the name *aggregate planning*); and
- is *cost driven*, that is it attempts to meet the specified requirements at minimum cost.

The information or input data feeding the MPS is the following:

1. Aggregate production plan, in product units
2. The forecast of each final article, in product units
3. The current order portfolio
4. The stock inventory level
5. The available production capacity

the MPS helps to decide:

- What to produce
- What batch sizes
- When to produce
- What sequence to adopt

To successfully implement an MPS, it must be understood that its purpose is not to state the quantities and delivery times of the products. The MPS is in fact a solid contract between Sales and Production. The MPS defines what Production will produce, and it's not a forecast at all.

Importance of master schedule

The **Master** Production **Schedule**, MPS, is an indicator of what, when, and how many items to produce. Additionally, the information that it generates can be used as an indicator that shows how much we can commit to produce for the client.

Objectives of master production schedule

The two main **objectives** of the **master production scheduling** are: Securing material for final assembly, which is being carried out based on specific customer needs. To be able to perform specific order in time desired by the client semi-products and materials must be prepared according to MPS.

Functions of master production schedule

- To translate aggregate plans into specific end items: Aggregate **plan** determines level of operations that tentatively balances the market demands with the material, labor and equipment capabilities of the company.

Creating a master production schedule

- To **create** your **master production schedule**, you need to know how many outstanding orders you have, the forecasted demand for your products for the upcoming weeks, the capacity of your manufacturing team, how much inventory you have on hand, and your employee needs, such as vacation time in the coming weeks.

Benefits of working with the MPS

There are multiple benefits when a manufacturing business introduces an MPS. They are described below:

- It provides a solid base to build, improve and track the sales forecast.
- It provides a solid base to determine the desired inventory levels.
- It provides a solid base to calculate the quantities of parts, subcomponents or raw materials to buy or produce, as part of the MRP next stage.
- It provides a solid base for calculating the required amount of labor and shifts, as part of the MRP next stage.
- It allows optimizing the installed capacity and balancing the load of the plant.
- Manufacturing can estimate the production and maintenance costs associated with the work centers.

- The financial department of the company can get income and expenses, derived from the MPS and generate a forecast of the cash flow in the company. It will help to build other financial statements, such as the Balance sheets, Profit and Loss statements, and the investment plans.
- The Department of Human Resources can take advantage of the MPS to anticipate the requirements of hiring labor.

Lean Production

Definition

Lean production is a systematic manufacturing method used for eliminating waste within the manufacturing system. It takes into account the waste generated from uneven workloads and overburden and then reduces them in order to increase value and reduce costs. The word ”lean” in the term simply means no excess, so lean production can be translated simply into minimal waste manufacturing.

Lean production is an approach to management that focuses on cutting out waste, whilst ensuring quality. This approach can be applied to all aspects of a business – from design, through **production** to distribution. **Lean production** aims to cut costs by making the business more efficient and responsive to market needs.

The broad **purpose of lean manufacturing** is to increase the value of products delivered to the customer to solve the customer's problems. Achieving this aim helps improve your company's competitiveness by reducing your costs.

Lean manufacturing, or **lean production**, is a production method derived from Toyota's 1930 operating model "The Toyota Way" (Toyota Production System, TPS). The term "Lean" was coined in 1988 by John Krafcik, and defined in 1996 by James Womack and Daniel Jones.

Many of these concepts originate from Just-in-Time (JIT) and Toyota's **Production** System (TPS). Three **lean** concepts are: small lot sizes, flexible workforce, and preventative maintenance. **Lean** systems use lot sizes that are as small as possible.

Consider the following eight steps for applying lean manufacturing to your business operation:

1. **Start by eliminating waste.** This is one of the core principles of lean manufacturing. Typically, you may use a value stream analysis to identify wasteful activities occurring at the plant. At the same time, you can intensify efforts to find more efficient ways to add value to the company’s product line. (See right-hand box for examples of waste.)
2. **Reduce unnecessary inventory.** The cost of maintaining excess inventory generally outweighs the potential benefits you might realize. It can tie up resources, slow down response time and complicate quality-control issues. Overstocking may become particularly problematic if some of the inventory eventually becomes obsolete-which is often the case.
3. **Shorten production cycles.** What used to take days or even weeks to complete can now often be accomplished in a matter of hours. Utilize the technological capabilities currently at your disposal. Disciples of lean manufacturing preach the production of small batches where you can add “bells and whistles” to later product versions.
4. **Speed up response time.** For years, manufacturers emphasized the need for making accurate forecasts of market requirements. However, this is not always the optimal approach in a fast-paced

environment. Alternatively, it may be preferable to develop a system that can react swiftly so you can capitalize on market changes.

5. **Ensure that all product components have been quality-tested.** Develop testing procedures and controls at several check-points in the process to detect problems at the earliest possible stage. Fine-tune the system to identify problems, make the necessary corrections or improvements and move forward.
6. **Extend employee autonomy.** Give more employees authority to make decisions and provide them with the tools and methodology for doing so. You can take this step even further by establishing teams to measure work progress and improve techniques. Frequently, companies find that viable solutions may be presented by employees below the management level. Plus, this kind of involvement can improve morale and performance.
7. **Solicit customer feedback.** After developing core product features, use a systematic approach for obtaining input from customers. The system should be designed to adapt to changes over its lifespan. Taking this step can enable you to satisfy customer needs within your basic framework
8. **Reach out to suppliers.** When it is appropriate, make suppliers "partners" in the lean manufacturing process. By combining cooperation from suppliers with implementation of lean manufacturing principles, benefits can be realized by all parties. This also helps strengthen existing relationships vital to your manufacturing operation.

The Five Lean Principles

1. Define Value

To better understand the first principle of defining customer value, it is important to understand what value is. Value is what the customer is willing to pay for. It is paramount to discover the actual or latent needs of the customer. Sometimes customers may not know what they want or are unable to articulate it. This is especially common when it comes to novel products or technologies. There are many techniques such as interviews, surveys, demographic information, and web analytics that can help you decipher and discover what customers find valuable. By using these qualitative and quantitative techniques you can uncover what customers want, how they want the product or service to be delivered, and the price that they afford.

The Five Lean Principles

2. Map the Value Stream

The second Lean principle is identifying and mapping the value stream. In this step, the goal is to use the customer's value as a reference point and identify all the activities that contribute to these values.

Activities that do not add value to the end customer are considered waste. The waste can be broken into two categories: non-valued added but necessary and non-value & unnecessary. The later is pure waste and should be eliminated while the former should be reduced as much as possible. By reducing and eliminating unnecessary processes or steps, you can ensure that customers are getting exactly what they want while at the same time reducing the cost of producing that product or service.

3. Create Flow

After removing the wastes from the value stream, the following action is to ensure that the flow of the remaining steps run smoothly without interruptions or delays. Some strategies for ensuring that value-adding activities flow smoothly include: breaking down steps, reconfiguring the production steps, leveling out the workload, creating cross-functional departments, and training employees to be multi-skilled and adaptive.

4. Establish Pull

Inventory is considered one of the biggest wastes in any production system. The goal of a pull-based system is to limit inventory and work in process (WIP) items while ensuring that the requisite materials and information are available for a smooth flow of work. In other words, a pull-based system allows for Just-in-time delivery and manufacturing where products are created at the time that they are needed and in just the quantities needed. Pull-based systems are always created from the needs of the end customers. By following the value stream and working backwards through the production system, you can ensure that the products produced will be able to satisfy the needs of customers.

5. Pursue Perfection

Wastes are prevented through the achievement of the first four steps: 1) identifying value, 2) mapping value stream, 3) creating flow, and 4) adopting a pull system. However, the fifth step of pursuing perfection is the most important among them all. It makes Lean thinking and continuous process improvement a part of the organizational culture. Every employee should strive towards perfection while delivering products based on the customer needs. The company should be a learning organization and always find ways to get a little better each and every day.

Applying the Principles

The five Lean principles provide a framework for creating an efficient and effective organization. Lean allows managers to discover inefficiencies in their organization and deliver better value to customers. The principles encourage creating better flow in work processes and developing a continuous improvement culture. By practicing all 5 principles, an organization can remain competitive, increase the value delivered to the customers, decrease the cost of doing business, and increase their profitability.

Disadvantages of Lean Manufacturing

Equipment Failure - **Lean** has very little room for error. Equipment or labor failure can lead to major inconsistencies within **lean** and can make the entire operation fall behind. In other mass **production** facilities, employees could just move over to another machine if one went out.

Unit IV

Materials Management

Material management is a scientific technique, concerned with Planning, Organizing &Control of flow of materials, from their initial purchase to destination. Material Management is responsible for purchasing the highest quality equipment and products at the lowest possible cost for the organization. Material Management is also responsible for managing purchasing, inventory control functions, shipping and receiving, and also planning and administering department budgets.
In its process of managing , materials management has such sub fields as inventory management , value analysis, receiving, stores and management of obsolete , slow moving and non moving items. The various activities represent these four functions:

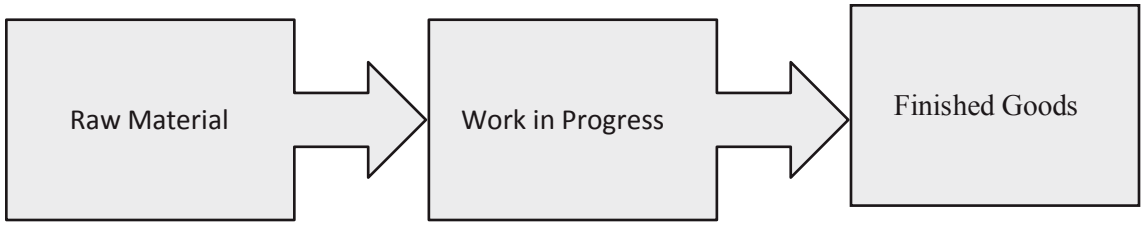
- Planning and control
- Purchasing
- Value analysis and
- Physical distribution

Classification of Inventory

The term material refers to all commodities which are consumed in the production process. The materials which can be consumed in the production process can be basically classified as:

- Direct Materials
- Indirect Materials

Material is generally called raw material. Inventory is a name collectively given to raw material; work in process and finished goods. Even though Material and Inventory are used as synonyms, material usually means raw material and inventory means raw material along with work in process plus finished goods.



Inventory classification

Raw Material is first subjected to a manufacturing process before it becomes finished goods. Raw material is also present with work in process and finished goods. It is a continuous process.

Inventory classification

Inventory includes idle resources that have future economic value. It indicates that it may be available in different forms depending upon the production cycle stage it is in. Classification of inventory is done on

this basis and thus, the different classifications of inventory are as follows:

- **Raw materials**: Raw materials are input goods intended for combination and/or conversion through the manufacturing process into semi-finished or finished goods. They change their form and become part of the finished product.
- **Components and parts**: Just as raw materials are converted to finished goods in a manufacturing operation, components and parts are assembled into finished goods in an assembly operation.
- **Maintenance, repair and operating inventories (MRO)**: These include parts, supplies and materials used in or consumed by routine maintenance and repair of operating equipment, or in support of operations.
- **Work-in-process goods**: These include goods in the process of manufacturing and only partially completed. They are usually measured for accounting purposes in between significant conversion phases. In-process inventories provide the flexibility necessary to deal with variations in demand between different phases of manufacturing.
- **Finished goods**: These represent the completed conversion of raw materials into the final product. They are goods ready for sale and shipment.
- **Resale goods**: These are goods acquired for resale. Such goods may be purchased by a wholesaler for resale to distributors, or by distributors for resale to consumers, etc.
- **Capital goods**: These are items (such as, equipment) that are not used or consumed during a single operating period, but have extended useful lives and must be utilised over multiple operating periods. Tax laws require that such an item be capitalised, and a predetermined percentage of its cost be recognised as an expense, each operating period, over a predetermined time frame, according to equipment classes.
- **Construction materials**: These are raw materials and components for construction projects such as a building, bridge, etc.
- **Hard goods/soft goods**: What one identifies as hard goods and soft goods will vary depending on the industry involved. For example, in data processing, hard goods include apparatus such as, computers and terminals, while soft goods include software, data storage media and the like.
- **Fuel and lubricants**: Fuel and lubricants are used for the oiling purpose for the equipment used in the process which again varies with the type of industry.
- **Stationery goods**: It includes writing material like, paper, pen, ink, etc., which are used by the people involved in the process.
- **Primary packing material**: Packing material like, plastic, paper, etc. are used to pack the finished goods for
sale.

Meaning of Material Management

Materials management can be defined as “an integrated management approach to planning, acquiring, processing and distributing production materials from the raw material state to the finished product state”. Materials management is a key business function that is responsible for the coordination of

planning, sourcing, purchasing, moving, storing and controlling materials in an optimum manner, so as to provide pre-determined service to the customer at a minimum cost.

Materials management has such sub-fields as:

- inventory management
- value analysis
- receiving
- stores and management of the obsolete
- slow moving and non moving materials

Materials management is the branch of logistics that deals with tangible components of a supply chain. It covers the acquisition of spare parts and replacements, quality control of purchasing and ordering such parts, and the standards involved in ordering, shipping, and warehousing the said parts. The physical arrangement of materials/spare parts is called materials management.

Planning and control of the functions supporting the complete cycle (flow) of materials, and the associated flow of information is called materials management. Materials management is concerned with the control of materials in such a manner which ensures maximum return on working capital. Materials management is concerned with the location and purchase of materials needed, their storage and movement. It also arranges to keep an account of them. It is also responsible for planning their movement through manufacturing processes, store rooms and distribution channels.

Materials management provides an integrated systems approach to the coordination of the materials activities and the control of total material costs. The materials management function ranges from receiving the material requisitions from user department to placement of purchase orders and then, on the other hand, receiving the materials from vendors and making it available to the users departments.

Objectives of Material Management

The fundamental objectives of the materials management function are acquisition of materials and services:

- of the right quality
- in the right quantity
- at the right time
- from the right source

The key objectives of material management are as follows:

- Buying at the lowest price, consistent with the desired quality and service
- Maintaining a high inventory turnover, by reducing excess storage, carrying costs and inventory losses occurring due to deteriorations, obsolescence and pilferage

- Maintaining continuity of supply, preventing interruption of the flow of materials and services to users
- Maintaining the specified material quality level and a consistency of quality. This permits efficient and effective operation
- Developing reliable alternate sources of supply to promote a competitive atmosphere in performance and pricing
- Minimising the overall cost of acquisition by improving the efficiency of operations and procedures
- Hiring, developing, motivating and training personnel and providing a reservoir of talent
- Developing and maintaining good supplier relationships in order to create a supplier attitude and desire furnish the organisation with new ideas, products, and better prices and service
- Achieving a high degree of cooperation and coordination with user departments
- Maintaining good records and controls that provides an audit trail and ensures efficiency and honesty
- Participating in 'Make or Buy' decisions

Scope of Material Management

The scope of material management includes the following aspects:

- Material planning
- Cataloguing or coding the materials
- Standardisation
- Scheduling
- Procurement
- Inspection
- Quality control
- Packaging
- Storage
- Inventory control
- Distribution
- Disposal

Material Planning

Material management involves the process of planning to get the materials. It is the starting point for the whole material management function. Material planning is a scientific way of determining the requirements starting with raw materials, consumables, spare parts and all other materials that are required to meet the given production plan for a certain period. Material planning is derived from overall organisational planning and hence, it is always a sub- plan of the broad organisational plan. What it does is forecast and initiate the procurement of materials.

Factors affecting material planning

The factors affecting material planning are:

- Macro factors: Global factors such as price trends, business cycles, government's import and export policies etc., are called macro factors. Credit policy of the government is a critical factor as banks follow these guidelines only while extending financial support to a business entity.
- Micro factors: These are essentially the factors existing within the organisation such as corporate policy on inventory holding, production plan, investments etc., For any organisation, factors such as lead time of procurement, acceptable inventory levels, working capital, seasonality, delegation of power are micro factors

Technique of Planning Materials

Materials Requirement Planning (MRP) considers the annual production plan of the manufacturing concern. Once a firm determines its annual production plan, the over all material requirement to meet the given production plan is worked out. It is a detailed analysis encompassing the materials and quantities available for use, materials with quantities not available and hence, needing procurement, the actual lead time of procurement, etc.

It is always possible to have a situation where some parts of an assembly are available and some others are not available. The Bill of Materials (BOM) is prepared. It quantifies all the materials (components) needed for various assemblies as per the production plan. BOM is thus a list displaying the code, nomenclature of an item, its unit and quantity, location of use and also the estimated price of each component. An explosion chart is a series of bills of materials grouped together in a matrix form so that combining the requirements for different components can be made. Once the BOM is ready, the same is handed over to the Purchasing wing which initiates the purchasing activities. MRP, thus, keeps in view the lead time also. Using computers, preparation of BOM through explosion of lists is quite easy and smooth.

Materials required for any operation are based on the sales forecasts and production plans. Planning and control is done for the materials taking into account the materials not available for the operation and those in hand or in the pipe line. This involves estimating the individual requirements of parts, preparing materials budget, forecasting the levels of inventories, scheduling the orders and monitoring the performance, in relation to production and sales.

Cataloguing or coding the materials

For easy procurement, storage, retrieval and the distribution of the inventories, it is essential to classify them into different categories. This classification can be done through codification or cataloguing. Codification or cataloguing is basically an identification system for each item of the inventory.

There are three broad approaches to developing a suitable identification system. These are:

- Arbitrary approach

- Symbolic approach
- Use of drawing numbers

Arbitrary approach

As and when an item is received by stores in its receiving bay, a running and unique serial number is assigned to it. This number becomes the code of the item for subsequent use at different stages. It does not help in the scientific management of inventory. Arbitrary approach is useful only where perhaps items are non-repetitive and the inventory management need not be scientific.

Symbolic approach

It assigns code in such a manner that the same item number is not allotted to two different materials. The code is designed such that it can be used to tell many things about an item of material.

The system uses either a numeric codification system or an alphanumeric system. Under the numeric system, a set of numeric code (length pre-decided) is assigned to each item where different parts of the code describe different aspects of an item: class, subclass, unique running number of that item, location of the storage suppliers' code, etc.

Use of drawing numbers

Many firms use drawing numbers as codes to identify an item. Since the drawing number for a firm remains unique, assigning a code on this basis assumes a unique code for that item and hence, confirms the requirement of a unique identification for the item.

Process of Codification

The process of codification is listed below:

- Decide if the firm wants to go for arbitrary system, symbolic system or engineering drawing system
- List the inventory items
- Define the class of items
- Define the sub class under each class
- Depending upon the number of classes, their subclasses and probable number of items under each sub class decide the length of codes which shall remain fixed for all the inventory items (10 digit, alphanumeric, etc.)
- Start assigning codes as per the detailed list of inventory

Codification is usually done by a team consisting of representatives drawn from stores, user department and industrial engineering department. The major responsibility lies with the stores department. Codification identifies an item. Also it acts as a communicating medium for an item among the different users of that item in whatever way such as stores, user department, planning department, finance, purchasing, etc. As soon as the item is received in the stores (if the item is a new one), it is codified. Once codified, the same code is used in the cycle of procurement, throughout and forever.

Standardisation

Standardisation means “formulation, publication and implementation of guidelines, rules and specifications for common and repeated use, aimed at achieving optimum degree of order or uniformity in a given context, discipline, or field”. Publication means communication of a message, statement, or text through any means such as audio, video, print, electronically as an e-book or on the web. Specification means exact statement of the particular needs to be satisfied or essential characteristics that a customer requires in goods, material, method, process, service, system, or work and which a vendor must deliver. Specifications are written usually in a manner that enables both parties (and/or an independent certifier) to measure the degree of conformity

Specifications are divided generally into two main categories:

- Performance specifications: Conform to known customer requirements such as keeping a room’s temperature within a specified range.
- Technical specifications: Express the level of performance of the individual units, and are subdivided into the

following:

- Individual unit specifications which state boundaries (parameters) of the unit’s performance consisting of a nominal (desired or mandated) value and tolerance (allowable departure from the nominal value)
- Acceptable quality level which states limits that are to be satisfied by most of the units, but a certain percentage of the units is allowed to exceed those limits, and
- Distribution specifications which define an acceptable statistical distribution (in terms of mean deviation

and standard deviation) for each unit, and are used by a producer to monitor its production processes

Scheduling

Scheduling means “assigning an appropriate number of workers to the jobs during each day of work and determining when an activity should start or end”. Schedule depends on the following:

- duration
- predecessor activity (or activities)
- predecessor relationships
- resource availability
- target completion date of the project

Procurement

Procurement means acquisition. It includes the complete process of obtaining goods and services from preparation and processing of a requisition to receipt and approval of the invoice for payment. It is also called sourcing.

Procurement involves the following activities:

- purchase planning
- standards determination
- specifications development
- supplier research and selection
- value analysis
- financing
- price negotiation
- making the purchase
- supply contract administration
- inventory control and stores, and
- disposals and other related functions

Purchasing

Basically, the job of a materials manager is to provide to the user departments, right material at the right time in right quantity of right quality at right price, from the right source. To meet these objectives, the activities undertaken include selection of sources of supply, finalisation of the terms of purchase, placement of purchase orders, follow up, maintenance of relations with vendors, approval of payments to vendors, evaluating, rating and developing vendors.

Before deciding the quantity to be purchased, the following factors should be taken into consideration:

- Quantity already ordered
- Quantity reserved - It may happen that a particular quantity, though in hand, might have been reserved for a particular job which is not available for other purposes. In such cases, this quantity is such, as if it is not in stock
- Funds availability - Amounts which are kept aside for drawing up purchase budget should be considered

Normally, the process of purchasing the materials involves the following stages:

- Requisitioning: At this stage, the purchasing officer should receive an accurate description of the goods or service required. The requisition form by which a member of staff notifies purchasing officer of a need for goods or services should be simple, but clear. The more accurate and detailed the requisition form is, the more are the chances that the purchase will meet the expectations.
- Financial approval: Here, the purchasing officer must be given the approval from a responsible person. It should be done before the purchasing commitment is made, and the purchasing system should ensure that this is done at the right time and by the right person.
- Market assessment: The purchasing officer receives an approved requisition and starts market research in this stage. He should check that the item is not already in stock, that there is a competitive

market for the item, if there is a list of “approved suppliers” for the item, if a lower price can be negotiated, and so on.

- Purchase decision: During purchase decision stage, after the purchasing officer completed the market assessment and determined the method of purchase, he decides on the supplier or suppliers. To avoid internal customer complaints or audit reproof, the decision must be well documented to provide clear reasons as to why a particular supplier has been chosen.
- Ordering: At the ordering stage, the main instrument purchasing officer works with is an order form. The order form is an official, numbered document which details the purchase requirements and authorises the supplier to deliver the goods or services to the company. Also, it can fulfil other important functions.
- Delivery: At the delivery stage, the purchasing officer controls the method, terms and time of delivery established while ordering. In case there is a competitive transport market, wise freighting decisions can lead to considerable cost savings.
- Receipting and accounting: At this stage, the purchasing officer should check whether the quality and quantity of delivered goods or services are relevant to ones in the purchase order. Usually, suppliers are not paid until the goods are checked however, this procedure should be taken up without unnecessary delays to ensure that payment terms are met.
- Payment: At the payment stage, the purchasing officer makes sure that the payments are made on the dates they are due, because maintaining good supplier relations is very important. Also, he should control the terms of payment in case, they include previously negotiated discounts, progress payments or postponement of payment during warranty period.

Inspection

Inspection involves critical appraisal involving examination, measurement, testing, gauging, and comparison of materials or items. An inspection determines if the material or item is in proper quantity and condition, and if it conforms to the applicable or specified requirements.

Inspection is generally divided into three categories:

- Receiving inspection
- In-process inspection and
- Final inspection

Quality Control

A subset of the quality assurance (QA) process, it comprises of activities employed in detection and measurement of the variability in the characteristics of output attributable to the production system, and includes corrective responses. In quality control the role of inspection is to verify and validate the variance data.

Packaging

Packaging includes processes (such as cleaning, drying, and preserving) and materials (such as glass, metal, paper or paperboard, plastic) employed to contain, handle, protect, and/or transport an article. The role of packaging is expanding and may include functions such as to attract attention, assist in promotion, provide machine identification (barcodes, etc.), impart essential or additional information, and help in utilisation.

Storage

Storage means non-transitory, semi-permanent containment, holding or placement of goods or materials, usually with the intention of retrieving them at a later time. It does not include the interim accumulation of a limited amount during processing, maintenance, or repair.

Inventory control

Inventory control covers aspects such as setting inventory levels, doing various analyses such as ABC, XYZ, etc, fixing economic order quantities (EOQ), setting safety stock levels, lead time analysis and reporting.

Distribution

Distribution means movement of goods and services from the source through the distribution channel, right up to the final customer, consumer, or user.

Disposal

Disposal means final placement or riddance of wastes, excess, scrap, etc., under proper process and authority with (unlike in storage) no intention to retrieve. Disposal may be accomplished by abandonment, destruction, internment, incineration, donation, sale, etc.

Functions of a Material Manager

The functions of a material manager are as under:

- materials planning and control
- purchasing
- management of stores
- inventory control
- use of information technology for efficient material management

Effects of Over Stocking and Under Stocking

The objective of material is to maintain optimum stock. The principle which should be kept in mind is that there should not be any over stocking or under stocking of materials, as both these situations involve costs.

Overstocking will result into the following consequences:

- blocking of working capital, resulting in escalating cost of capital investment
- risk of deterioration of quality and obsolescence resulting in the material being unfit for use
- more storage facilities, resulting in higher rental cost
- additional insurance cost
- more material handling and up-keeping
- risk of breakage/pilferage, etc.
- price of raw material may go down in future
- in a nut-shell, carrying cost goes up
- however, ordering cost goes down

Understocking will result into the following consequences:

- production hold-ups, resulting into disturbed delivery schedules
- frantic eleventh hour purchases which may result in unfavourable prices and quality
- payment for idle time to workers
- increase in the number of orders which will result in more transportation cost
- in nut shell ordering cost goes up
- however carrying cost goes down

Overstocking or understocking of materials results in losses, hence a manufacturer should go for optimum stock.

Maintenance Management

Maintenance activities are related with repair, replacement and service of components or some identifiable group of components in a manufacturing plant so that it may continue to operate at a specified 'availability' for a specified period.

Thus maintenance management is associated with the direction and organisation of various resources so as to control the availability and performance of the industrial unit to some specified level.

Thus maintenance management may be treated as a restorative function of production management which is entrusted with the task of keeping equipment/machines and plant services ever available in proper operating condition.

The minimization of machine breakdowns and down time has been the main objective of maintenance but the strategies adopted by maintenance management to achieve this aim have undergone great changes in the past.

Maintenance has been considered just to repair the faulty equipment and put them back in order in minimum possible time.

In view of the utilization of mostly general purpose/conventional machines with low production output, the demands on maintenance function were not very high. But with fast developments in the design,

development and mechanisms of control such as electronic, NC and CNC in machine tools the manufacturing scenario has changed a lot.

The stringent control of dimensional tolerances and surface finish of the product have increased the tendency to adopt standardization and interchange-ability of parts/components of machines.

In the current production setups even a minor down time leads to serious production problems both technological as well as economical. All this is due to tough competition in the industrial market. Under the present circumstances effective and objectively designed efforts to update maintenance management has become a necessity.

Importance of Maintenance Management:

Maintenance management is responsible for the smooth and efficient working of the industrial plant and helps in improving the productivity.

It also helps to keep the machines/equipment in their optimum operating conditions. Thus plant maintenance is an important and inevitable service function of an efficient production system.

It also helps in maintaining and improving the operational efficiency of the plant facilities and hence contributes towards revenue by decreasing the operating cost and improving the quality and quantity of the product being manufactured.

As a service function it is related with the incurrence of certain costs. The important component of such costs are — employment of maintenance staff, other minor administrative expenses, investment in maintenance equipment and inventory of repair components/ parts and maintenance materials.

Absence of plant maintenance may lead to frequent machine breakdown and failure of certain productive centres/services which in turn would result in stoppages of production activities, idle man and machine time, dislocation of the subsequent operations, poor quality of production, failure to meet delivery dates of product supply, industrial accidents endangering the life of workers/ operators and allied costs etc.

However, the importance of plant maintenance varies with the type of plant and its production but it plays a prominent role in production management because plant breakdown creates problems such as:

(i) Loss of production.

(ii) Rescheduling of production.

(iii) Materials wastage (due to sudden stoppage of process damages in process materials).

(iv) Need for overtimes,

(v) Need for work subcontracting.

(vi) For maximum manpower utilization workers may need alternative work due to temporary work shortages.

Hence, the absence of planned maintenance service proves costlier. So it should be provided in the light of cost benefit analysis. Since plant maintenance is a service function, it should be provided at the least possible cost but it is very important as discussed above.

Objectives of Maintenance Management:

The purpose of maintenance management is to optimize the performance of productive facilities of an organization by ensuring that these facilities function regularly and efficiently. This can be achieved by

preventing the failures or breakdowns if any, as far as possible and by minimizing the production loss due to failures.

The main objectives of maintenance management are as follows:

(1) Minimizing the loss of productive time because of equipment failure to maximize the availability of plant, equipment and machinery for productive utilization through planned maintenance.

(2) To extend the useful life of the plant, machinery and other facilities by minimizing their wear and tear.

(3) Minimizing the loss due to production stoppages.

(4) To ensure operational readiness of all equipment's needed for emergency purposes at all times such as fire-fighting equipment.

(5) Efficient use of maintenance equipment's and personnel.

(6) To ensure safety of personnel through regular inspection and maintenance of facilities such as boilers, compressors and material handling equipment etc.

(7) To maximize efficiency and economy in production through optimum utilization of available facilities.

(8) To improve the quality of products and to improve the productivity of the plant.

(9) To minimize the total maintenance cost which may consist of cost of repairs, cost of preventive maintenance and inventory costs associated with spare parts/materials required for maintenance.

(10) To improve reliability, availability and maintainability.

Functions of Maintenance Management:

The important functions of maintenance can be summarized as follows:

(1) To develop maintenance policies, procedures and standards for the plant maintenance system.

(2) To schedule the maintenance work after due consultation with the concerned production departments.

(3) To carry out repairs and rectify or overhaul planned equipment/facilities for achieving the required level of availability and optimum operational efficiency.

(4) To ensure scheduled inspection, lubrication oil checking, and adjustment of plant machinery and equipment.

(5) To document and maintain record of each maintenance activity (i.e., repairs, replacement, overhauls, modifications and lubrication etc.).

(6) To maintain and carry out repairs of buildings, utilities, material handling equipment's and other service facilities such as electrical installations, sewers, central stores and roadways etc.

(7) To carry out and facilitate periodic inspections of equipment and facilities to know their conditions related to their failure and stoppage of production.

(8) To prepare inventory list of spare parts and materials required for maintenance.

(9) To ensure cost effective maintenance.

(10) To forecast the maintenance expenditure and prepare a budget and to ensure that maintenance expenditure is as per planned budget.

(11) To recruit and train personnel to prepare the maintenance workforce for effective and efficient plant maintenance.

(12) To implement safety standards as required for the use of specific equipment or certain categories of equipment such as boilers, overhead cranes and chemical plants etc.
(13) To develop management information systems, to provide information to top management regarding the maintenance activities.
(14) To monitor the equipment condition at regular intervals.
(15) To ensure proper inventory control of spare parts and other materials required.

In terms of plants operations the functions of maintenance are:
(a) The plant must be available as and when required.
(b) The plant must not breakdown during actual operation state.
(c) The plant must operate in an efficient manner at required level of plant operation.
(d) The down time must not interfere with production runs.
(e) The down time due to breakdown should be a minimum.
To accomplish these conditions there must be complete cooperation and mutual understanding between maintenance and production departments. There must be an effective maintenance policy for planning, controlling and directing all maintenance activities.
The plant maintenance department must be well organized, adequately staffed sufficiently experienced and adequate in number to carry out corrective and timely maintenance with the efforts in minimizing breakdowns.

Types of Maintenance
Different maintenance pratices are adopted to suit the various types of production machineries and other devices.they are:-

- Breakdown maintenance
- Preventive maintenance
- Scheduled maintenance
- Productive maintenance

Breakdown maintenance
⦿ Machines are allowed to run without carrying out any maintenance.
⦿ Only when it becomes out of order(stop working) it is repaired
⦿ Next maintenance is done only when it breaks down.
⦿ Applicable to machines which are not important i.e; break down of these machines will not affect the production process

Causes of breakdown

- Failure to replace the wornout parts
- Non application of lubricants
- Neglected cooling system
- Carelessness towards minor repairs.

Preventive maintenance

⦿ aimed at avoiding or preventing breakdowns.
⦿ The principle of preventive maintenance is 'prevention is better than cure'
⦿ Here some components are identified as weak spots in all machineries and equipments.
⦿ These parts are inspected regularly.
⦿ Minors repairs are carried out immediately as soon as there is necessity avoiding unanticipated breakdowns.

Scheduled maintenance

- Maintenance done according to recommendation of the supplier of the equipment.
- Done at predetermined dates.
- Eg. Overhauling of machines, cleaning of tanks, annual shut down and maintenance of power plants
- In this, plant is shutdown and following are done:
    - inspection, repairing and replacing of worn out parts.

Productive maintenance

⦿ Type of preventive maintenance.
⦿ It is done only for critical machineries.
⦿ eg. In a chemical plant a small pump for circulating chemicals may be a critical equipment if the pump fails to function then the whole plant have to be stopped. So the pump is considered to be a critical equipment in the chemical plant. This pump which is identified as a critical equipment should be given preventive maintenance.

Advantages

⦿ Life of machinery and equipments are increased.
⦿ Production takes place as per the schedule.
⦿ Products are delivered to customers in time and hence high level of customer satisfaction can be expected.
⦿ Machines are in good condition. Hence quality of the products will be good.
⦿ No production loss.
⦿ Machinery is not damaged.
⦿ No idle time of men and machines. Hence their utility increases.

Disadvantages of poor maintenance

⦿ Machinery may be damaged. This is a loss.
⦿ Poorly maintained machines will produce poor quality products.
⦿ More wastage of materials.
⦿ Break down of machines makes both men and machine in idle position. So production time is wasted. This will increase cost of production.
⦿ Poor maintenance cause accidents.
Due to poor maintenance life of machine is reduced.

Purchasing

Purchasing function in a business environment is one of the most critical functions as it provides the input for the organisation to convert into output. Materials today are lifeblood of industry. They must be available at the proper time, in the proper quantity, at the proper place and the proper price. Company costs and company profits are greatly affected by them as normally, a manufacturing organisation spends nearly 50% of its revenue in purchasing.

Objectives of Material Management

The key objectives of material management are given below:

- to buy the materials at the lowest price
- consistent with desired quality and service
- to maintain continuity of supply of materials and services to users

Purchasing administration plays an important role in this regard. Every organisation establishes a purchase department to carry out different functions. Purchasing is responsible for spending nearly half of a company's income for buying the input materials. Obviously, any saving achieved by it results into direct saving for the company and all such savings are a company's profit. One percent saving achieved in purchasing results in 5% profit for any organisation.

Functions of Purchase Department

The job of a materials manager is to provide, to the user departments, the right material at the right time in right quantity of right quality at right price from the right source. To meet these objectives, the activities undertaken include selection of sources of supply, finalisation of terms of purchase, placement of purchase orders, follow up, maintenance of relations with vendors, approval of payments to vendors, evaluating, rating and developing vendors.

The functions of purchase department are to:

- support company operations with an uninterrupted flow of materials and services
- buy competitively and wisely
- help keep a minimum inventory
- develop reliable alternate sources of supply
- develop good vendor relationship and a good continuing supplier relationship
- achieve maximum integration with the other departments of the firm
- train and develop highly competent personnel who are motivated to make the firm as well as their department succeed
- develop policies and procedures which permit accomplishment of the preceding objectives at the lowest reasonable operating cost

Before deciding the quantity to be purchased, the following factors should be taken into consideration:

- Quantity already ordered
- Quantity reserved: It may happen that a particular quantity, though in hand, might have been reserved for a particular job which is not available for other purposes. In such cases, this quantity is treated as if it is not in stock.

• Funds availability: Amounts which are kept aside for drawing up purchase budget should be considered are used.

The following are the important activities of a purchase department:

• Buying activity: It addresses to a wide gamut of activities such as, reviewing requisitions, analysing specifications,
investigating vendors, interviewing sales people studying costs and prices and negotiating.

• Expediting: This is basically the order follow up activity involving various types of vendor relationship work. It involves reviewing order status, providing clarifications on transportation, writing and emailing vendors etc.

• Special projects (Non routine): In order to facilitate smooth purchasing in a highly competitive business environment, purchasing authorities have to keep building the capacity to do better by taking up as special projects activities such as vendor development, vendor registration, value analysis, market studies, system studies etc.

• Routine: Purchasing process or procedure involving routine or every day activities such as dealing specific purchase file, placing orders, maintaining records of commodities, vendors etc.

Objectives of Purchasing

The basic objective of purchasing is to derive the maximum value for each unit of money spent in buying. A purchaser has to find answers to the following questions:

- Are we buying at right cost?
- Supplier is producing it at right quantity or not?
- Whether supplier is producing the right product or not?
- Whether material will come at right time or not?
- Whether buyer is buying for the company or for personnel gain?

Purchase Procedure

A purchase department is usually engaged in purchasing a number of materials and services falling in different categories. The activities are performed regularly by purchase professionals with the objective of fulfilling organisation's materials and services needs. Therefore, depending upon the nature of procurement, environmental practices etc the purchasing systems and procedures may also vary substantially. However, purchase procedure can be seen to have a bit of standardisation across the globe.

A professional purchasing system does show following steps that eventually constitute a purchasing cycle:

- recognition and description of need
- transmission of need
- selection of source to satisfy the need
- contracting with the accepted source
- following up with the source

- receiving and inspecting material
- payment and closure of the case

Types of Purchasing

The following are the different types of purchasing:

- Forward buying
- Tender buying
- Systems contract
- Speculative buying
- Rate contracts
- Reciprocity in buying
- Zero stock buying
- Blanket orders

Forward Buying

Forward buying, as the name suggests, is the system under which buying is done with longer term in perspective. It is not meant for meeting the present consumption requirement. It is rather a commitment on part of both the buyer and the seller, normally for a period of one year. Depending upon the availability of the item, the financial policies, the economic order quantity, the quantitative discounts and the staggered delivery, the future commitment isdecided.

A few organisations do hedge, particularly in the commodity market by selling or buying contracts. Forward buying helps a firm in booking capacity of a supplier and thus often results into a safeguard against a competitor acquiring his capacity. It is usually done for raw materials but is not limited to it. Such an arrangement is a win-win situation for both, the buyer and the supplier

Tender Buying

Tender buying has always been considered the only way of buying materials/services in the government and quasi government procurements. Selecting a supply source (supplier) out of many sources available is called tender buying. Many applicants are invited to participate in the tendering process and then one or more than one tender is selected for order placement. Such tenders are also called the accepted tender's (A/Ts). The main focus through tender buying is on competition of price and quality. Usually, the best quality (T1 or Q1) is selected after assessment of the technical offers and then the lowest offered price (L1) tender is selected for order placement.

Process of tender buying

- A purchase function starts with the raising of a requisition (indent/material procurement requisition) for an item which is required for a stated purpose.
- This requisition is then converted into an enquiry form which is issued to the probable vendors who are asked to respond within a given date and time (called tender opening date) as mentioned in the enquiry issued to them.

- The interested vendors respond to the tender enquiry by giving their tenders.
- Tenders thus, received are opened on the tender opening date at the fixed time.
- The tenders are then subjected to evaluation with respect to a tenderer's capability, financial as well as technical,
and other criteria as laid down in the tender enquiry.
- This step also witnesses series of discussions, clarifications and negotiation with the tenderers.
- Some tenders can be rejected at this stage as they might not meet the requirement of the purchaser.
- Finally, the tenders that are found suitable are subjected to price comparison and usually the tenderer offering the lowest price (L1) is selected for placement of order.
- The process explained above shows a great deal of variations depending upon a company's procurement policy.
- In some places, the best quality offering tenders are accepted for subsequent price comparison whereas in some other place all the tenderer's who meet the minimum requirement are considered accepted for price comparison and order placement.
- Similarly, in some places the order is placed only on L1 (lowest offered price) whereas in some other places it may not be rigidly followed so.

Types of tenders

Since the tenders are sent to the probable vendors, knowledge of vendors for the item in question is a necessity. It's based on this concept that the types or mode of tendering is decided against a particular purchase requisition. Most commonly used types of tendering/tender buying are mentioned below:

- Global tender
  - A global tender is floated with a view to elicit offers/response from any vendor situated anywhere in the world.
  - The need for a global tender arises when the purchaser either does not know about the vendors for a particular item in question or when he thinks that a wider choice of vendor is possible through it, irrespective of his nation's boundaries.
- Open tender
  - An open tender too like a global tender tends to invite tender from any interested vendor.
  - The basic difference assumed between an open tender and a global tender enquiry is essentially the range of its applicability. While a global tender gets the worldwide publicity, an open tender is limited only within a country. Otherwise, the concept remains the same as it also seeks to elicit better or wider response.
  - Since the open tender enquiry is limited within the country itself, besides the internet mode, the enquiry is also printed in the national dailies, internal trade bulletins etc. for ensuring its wide publicity, within the country. Any vendor who meets the tender requirements can make an offer.
- Limited tender
  - When the issue of tender enquiry is limited only to a selected few vendors, it is called limited tender enquiry (LTE).

- LTE is issued when the capabilities of the vendors is well known to the purchaser.
- It is considered better than global and open tender modes as there is always an element of uncertainty in those two modes with respect to the capabilities of the vendors.
- For issuing LTE, a purchaser maintains a list of approved /registered vendors whose capabilities are checked periodically.

• Single tender enquiry

- An STE is issued only when either the item is proprietary in nature, that is only one supplier produces that item or where there may be more vendors but due to certain exigencies it is not possible to devote time on evaluating the vendors offers/one supplier can fulfil the needs.
- The mode to tender depends on many factors as well a company's procurement policy. For example, for a small value purchase, if the policy does not prohibit, single tender enquiry or limited tender enquiry is considered ideal.
- These are also ideal for high value and frequently bought items. On the other hand, for high value and non- frequently bought items/systems, open/global tenders are suited.
- In many government organisations, whose procurements are also called public procurements for the reason that they spend public money for the public cause, all the tenders are to be invited only through open/global tenders.

Systems Contract

Systems contract is a contract of system of buyer with that of the seller. It is a release system in which items, usually, commonly available off-the-shelf, are identified and pre-priced in anticipation of certain usage. Delivery releases are made against existing orders placed by purchase. This is a procedure intended to help the buyer and the seller to reduce administrative expenses and at the same time to ensure proper controls. The system authorises the designated persons of the buyer to place orders directly to the supplier with the specific materials during a given contract period. The contract is thus finalised only after it is ensured that an attempt has been made to integrate as many buyer-seller materials management functions as possible.

In this system the original indent, duly approved by competent authorities, is shipped back with the items and avoiding the usual documents like purchase orders, materials requisitions, expediting letters and acknowledgements, goods in transit report, etc. The contract is simple, covering only delivery period, price and invoicing procedure. System contracting is particularly useful for items with low unit price and high consumption profile and thus, relieves the buyers of the routine work.

While systems contract has certain features in common with other purchasing agreements, it is this integration of buyer-seller operations that clearly distinguishes it from other types of contracts. Obviously, the systems contracts are an excellent way of simultaneously cutting costs while building efficiencies through simplifications.

Speculative Buying

When purchasing is done purely from the point of view of taking advantage of a speculated rise in price

of the commodity it is called speculative buying. The intent is not to buy for the internal consumption but to resell the commodity at a later date when the prices have gone up and to make a profit by selling. The items may be those that are needed for internal consumption but the quantity shall be much more than the requirement so as to take advantage of the coming price rise.

Rate Contracts

Rate contracts are mutual agreements between the buyer and the seller to operate a set of chosen items, during a given period of time, for a fixed price or price variation. Under this system the rates are fixed and at times even the quantity of the selected items. As and when the need arises the buyer issues a purchase order directly on the basis of the rate chart available on the supplier who in turn supplies the items.

The system of rate contract is prevalent in public sector organisations and government departments. It is common for the suppliers to advertise that they are on rate contract with the DGS&D (Directorate General of Supply & Disposal), for the specific period for the given items. After negotiation, the seller and the buyer agree to the rates of items. Application of rate contract helps organisations cut down the internal administrative lead time as individual firms need not go through the central purchasing departments and can place orders directly with the suppliers.

However, suppliers always demand higher prices for prompt delivery, as rate contracts normally stipulate only the rate and not the schedule on which the item is needed. This difficulty has been avoided by ensuring the delivery of a minimum quantity at the agreed rates. This procedure of fixing a minimum quantity is called the running contract and is being practiced by the railways and the DGS&D.

As mentioned above, this system of buying helps an organisation reduce its internal as well as the external lead time, reduces administrative work load as the files don’t need to go up and down, helps in building buyer-supplier relationship as the contract period is usually one year and then there is always a chance of the same players doing the next contract.

The system works well normally in a situation where the selected items are routinely consumed. However, there is no compulsion that the demand be uniform over the period of time.

Reciprocity in Buying

In certain business situations a buyer may give preference to a supplier who also happens to be his customer. This relationship is known as reciprocity. It is something like 'I buy from you if you buy from me'.

One of the main questions for which this, otherwise simple way of buying, is always under the scanner of purchasing ethics is its undue ability to restrict competition and fair play. One of the major roles that any purchaser plays for his firm is in cost reduction arena which is attempted by generating competition among the suppliers. This principle gets a jolt through reciprocity in buying. However, when factors such

as quality, after sales service, price etc, are equal normally a buyer would like to buy from his customer, if for nothing then at least for having a good working relationship. However, the distinct disadvantages of reciprocal buying outweigh the limited and narrow advantage that a firm may derive out of it.

Some of the main disadvantages of reciprocity are not being able to follow the well laid criteria of quality, price and service. A purchasing executive should not indulge in reciprocity on his initiative when the terms and conditions are not equal with other suppliers. It is often found that less efficient manufacturers and distributors gain by reciprocity what they are unable to gain by price and quality. Since this tends to discourage competition and might lead to higher prices and fewer suppliers, reciprocity should be practiced on a selective basis.

Zero Stock Buying

Zero stock buying refers to buying in a manner that the system ensures that the material is delivered by the seller only when it is required and that no prior inventory of the item is maintained by the buyer. As the competition becomes more intense the need for a lean manufacturing system becomes more focussed. Keeping inventory thus is blocking huge money that is idle for the firm. Thus, zero stock buying is more of an inventory safeguard rather than the normal buying.

Normally, under this system the firms try to operate on the basis of zero stock and the supplier holds the stock for these firms. Usually, the firms of the buyer and seller are close to each other so that the raw material of one is the finished product of another. Alternatively, the system could work well if the seller holds the inventory and if the two parties work in close coordination. However, the price per item in this system is slightly higher as the supplier may include the inventory carrying cost in the price. In this system, the buyer need not lock up the capital and so the purchasing routine is reduced. This also significantly reduces obsolescence of inventory, lead time and clerical efforts in paper work. Thus, the seller can devote his marketing efforts to other customers and production scheduling becomes easy.

In practice, the buyer is called upon to pay to the supplier only when the material is delivered as per the need. For example, in India say the Indian Oil Limited maintains its petrol and diesel refilling stations inside the manufacturing premises of many companies. As and when petrol or diesel is required, say in a lorry, IOL fills that and a coupon is signed by the driver of the lorry. Buyer makes the payment to IOL against that coupon.

Zero stock is becoming popular with the concepts such as Just-in-time approach that is similar to it. However, in situations where the supplier has to transport material from one place to the other with a fair distance in between, this system needs careful handling as one never knows the road or weather conditions. Normally, the system caters to those items that are not very critical to manufacturing. It best suits the situations where the output of one firm is the input of the other firm with both the firms located nearby.

Blanket Orders

Under this system, an agreement is done between the buyer and the supplier to provide a required quantity

of specified items, over a period of time, usually for one year, at an agreed price. This system minimises the administrative expenses and is useful for 'C' class items for which rigid controls are not required. Deliveries are made depending upon the buyer's needs. The system relieves the buyer from routine work, giving him more time for focusing attention on high value items such as 'A' and part of 'B' class. It requires fewer purchase orders and thus reduces clerical work. It often achieves lower prices through quantity discounts by grouping the requirements. The supplier, under the system, maintains adequate inventory to meet the blanket orders, but he does not incur selling costs, once the negotiations are finalised.

Purchasing Cycle

The purchasing cycle begins with a request from within the organization to purchase material, equipment, supplies, or other items from outside the organization, and the cycle ends when the purchasing department is notified that a shipment has been received in satisfactory condition, and managerial accounting is actively involved in each step.

The main steps in the cycle are as under:

- Recognition of need
- Description of need
- Selection of suppliers
- Determination of prices
- Preparation of purchase order
- Placing the order with a selected supplier
- Monitoring and follow up the order
- Receiving the ordered materials
- Checking and approving for payment to supplier

Parameters of Purchasing:

The success of any manufacturing activity is largely dependent on the procurement of raw materials of right quality, in the right quantities, from right source, at the right time and at right price popularly known as **ten 'R's'** of the art of efficient purchasing. They are described as the basic principles of purchasing. There are other well known parameters such as right contractual terms, right material, right place, right mode of transportation and right attitude are also considered for purchasing.

RIGHT PRICE

It is the primary concern of any manufacturing organization to get an item at the right price. But right price need not be the lowest price. It is very difficult to determine the right price; general guidance can be had from the cost structure of the product. The 'tender system' of buying is normally used in public sector organizations but the objective should be to identify the lowest 'responsible' bidder and not the lowest bidder. The technique of 'learning curve' also helps the purchase agent to determine the price of items with high labor content. The price can be kept low by proper planning and not by rush buying. Price negotiation also helps to determine the right prices.

RIGHT QUALITY

Right quality implies that quality should be available, measurable and understandable as far as

practicable. In order to determine the quality of a product sampling schemes will be useful. The right quality is determined by the cost of materials and the technical characteristics as suited to the specific requirements. The quality particulars are normally obtained from the indents. Since the objective of purchasing is to ensure continuity of supply to the user departments, the time at which the material is provided to the user department assumes great importance.

RIGHT TIME

For determining the right time, the purchase manager should have lead time information for all products and analyze its components for reducing the same. Lead time is the total time elapsed between the recognition of the need of an item till the item arrives and is provided for use. This covers the entire duration of the materials cycle and consists of pre-contractual administrative lead time, manufacturing and transporting lead time and inspection lead time. Since the inventory increases with higher lead time, it is desirable to analyze each component of the lead time so as to reduce the first and third components which are controllable. While determining the purchases, the buyer has to consider emergency situations like floods, strikes, etc. He should have 'contingency plans' when force major clauses become operative, for instance, the material is not available due to strike, lock-out, floods, and earthquakes.

RIGHT SOURCE

The source from which the material is procured should be dependable and capable of supplying items of uniform quality. The buyer has to decide which item should be directly obtained from the manufacturer. Source selection, source development and vendor rating play an important role in buyer-seller relationships. In emergencies, open market purchases and bazaar purchases are restored to.

RIGHT QUANTITY

The right quantity is the most important parameter in buying. Concepts, such as, economic order quantity, economic purchase quantity, fixed period and fixed quantity systems, will serve as broad guidelines. But the buyer has to use his knowledge, experience and common sense to determine the quantity after considering factors such as price structure, discounts, availability of the item, favorable reciprocal relations, and make or buy consideration.

RIGHTATTITUDE

Developing the right attitude, too, is necessary as one often comes across such statement: 'Purchasing knows the price of everything and value of nothing'; 'We buy price and not cost'; 'When will our order placers become purchase managers?'; 'Purchasing acts like a post box'. Therefore, purchasing should keep 'progress' as its key activity and should be future-oriented. The purchase manager should be innovative and his long-term objective should be to minimize the cost of the ultimate product. He will be able to achieve this if he aims himself with techniques, such as, value analysis, materials intelligence, purchases research, SWOT analysis, purchase budget lead time analysis, etc.

RIGHTCONTRACTS

The buyer has to adopt separate policies and procedures for capital and consumer items. He should be able to distinguish between indigenous and international purchasing procedures. He should be aware of the legal and contractual aspects in international practices.

RIGHTMATERIAL

Right type of material required for the production is an important parameter in purchasing. Techniques, such as, value analysis will enable the buyer to locate the right material.

RIGHTTRANSPORTATION

Right mode of transportation has to be identified as this forms a critical segment in the cost profile of an item. It is an established fact that the cost of the shipping of ore, gravel, sand, etc., is normally more than the cost of the item itself.

RIGHTPLACEOFDELIVERY

Specifying the right place of delivery, like head office or works, would often minimize the handling and transportation cost.

Types of Purchasing:

Keeping in view the size and requirements of the organization, purchasing may be either centralized or decentralized.

1. Centralized Purchasing:

When all types of purchasing is done at one level, it is known as centralised purchasing. A separate department, known as purchase department, is set up for this purpose. All departments send their purchase requirements to purchase department and it arranges procurement of various goods needed.

2. Decentralized (or Localized) Purchasing:

This type of purchasing is suitable for concerns or when there are more than one plant or the plants are situated at different places. Every department or plant, as the case may be, is authorized to make its own purchases. A separate purchasing agent is appointed for every department or plant. To enforce general purchasing policies all the purchasing agents are put under the charge of general purchasing agent. He gets periodical reports from all purchasing agents. This helps in exercising control over materials. This system has some advantages as well as disadvantages.

Vendor Development & Rating

Vendor Rating

A vendor is any person or company that supplies raw materials/parts, goods or services to the buyer organisations. The effectiveness of the purchasing department is judged by the quality and reliability of its suppliers. Good suppliers need to be cultivated to meet current and future demand of the buyer organisations. The buyer organisations want to work with the suppliers that give them value. Therefore, the suppliers' performance matters a lot. Vendors or suppliers are rated on the basis of their performance, consistency in delivery, lead time, quality products and services, price or some combination of these variables. Rating evaluation is done on a periodic basis and it may take the form of a hierarchical ranking from poor to excellent.

Vendor rating is the result of a formal vendor evaluation system. Vendors or suppliers are given standing, status, or title according to their attainment of some level of performance, such as delivery, lead time, quality, price, or some combination of variables. The motivation for the establishment of such a rating system is part of the effort of manufacturers and service firms to ensure that the desired characteristics of a purchased product or service is built in and not determined later by some after-the-fact indicator. The vendor rating may take the form of a hierarchical ranking from poor to excellent and

whatever rankings the firm chooses to insert in between the two. For some firms, the vendor rating may come in the form of some sort of award system or as some variation of certification. Much of this attention to vender rating is a direct result of the widespread implementation of the just-in-time concept in the United States and its focus on the critical role of the buyer-supplier relationship.

Most firms want vendors that will produce all of the products and services defect-free and deliver them just in time (or as close to this ideal as reasonably possible). Some type of vehicle is needed to determine which supplying firms are capable of coming satisfactorily close to this and thus to be retained as current suppliers. One such vehicle is the vendor rating.

In order to accomplish the rating of vendors, some sort of review process must take place. The process begins with the identification of vendors who not only can supply the needed product or service but is a strategic match for the buying firm. Then important factors to be used as criteria for vendor evaluation are determined. These are usually variables that add value to the process through increased service or decreased cost. After determining which factors are critical, a method is devised that allows the vendor to be judged or rated on each individual factor.

It could be numeric rating or a Likert-scale ranking. The individual ratings can then be weighted according to importance, and pooled to arrive at an overall vendor rating. The process can be somewhat complex in that many factors can be complementary or conflicting. The process is further complicated by fact that some factors are quantitatively measured and others subjectively.

Once established, the rating system must be introduced to the supplying firm through some sort of formal education process. Once the buying firm is assured that the vendor understands what is expected and is able and willing to participate, the evaluation process can begin. The evaluation could be an ongoing process or it could occur within a predetermined time frame, such as quarterly. Of course the rating must be conveyed to the participating vendor with some firms actually publishing overall vendor standings. If problems are exposed, the vendor should formally present an action plan designed to overcome any problems that may have surfaced. Many buying firms require the vendor to show continuing improvement in predetermined critical areas.

Objectives of Vendor Rating

Assessment of vendor's performance on certain criteria is called vendor rating. Vendor rating is the result of a formal vendor evaluation system. It can be used to "assess and monitor supplier performance, provide accurate feedback to suppliers, provide benchmark data, improve overall competitiveness in the market, minimize subjectivity in judgment, make it possible to consider all relevant criteria in assessing suppliers, providing feedback from all areas in one package, establishing continuous review standards for vendors, and select vendors for further development." The key objectives of vendor rating are as under:

- ***Selection of Right Suppliers***

It helps the buyer organisations in the selection of right suppliers.

- ***Rating Assessment of Suppliers***

It rates the entire performance of the suppliers and gives a clear-cut vision about the quality, cost, reliability of the products and services to be provided by the suppliers.

- ***Negotiation with Suppliers***

It provides buyer organisations with the information helpful in subsequent negotiation with suppliers.

- ***Proper Feedback***

It gives a feedback to suppliers to further improve their performances.

- ***Useful Information***

It provides the buyer organisations with the important information which is helpful in the development of the suppliers.

- ***Reward***

It recognizes and rewards outstanding suppliers.

- ***Standardised Practices***

It generates suppliers' standard practices.

Factors Affecting the Selection of Optimal Suppliers or Vendor Rating

Most buyer organisations want all the suppliers to provide supply of quality raw materials/parts, defect - free goods and services and deliver them when required. To fulfil these objectives the buyers need right suppliers and to identify right supplier it is required that to evaluate them from time to time so that their performance can be certified. There are many factors like quality, cost, delivery, service, consistency, reliability, technically upgraded, quality factors etc. on which suppliers' performance is usually evaluated. A more comprehensive approach covers 7 C's (Competency, Capacity, Commitment, Control, Cash Resources, Cost, and Consistency) which are need to be measured to evaluate the suppliers' performance. "From research, it was found that quality, delivery and cost are the most considered criteria with percentages over 90. Quality, delivery, cost, production facility and capability, technical capability and support, and financial criteria are significant basic criteria generally used for last forty years."

Suppliers Evaluation Methods/ Vendor Rating Methods

The buyer organisations know the importance of evaluating the suppliers. It is important to evaluate each supplier before signing an agreement or orders. The improper vendor evaluation and selection process lead to production loss and raw materials/parts rejection. Therefore, the buyer organisation requires an appropriate suppliers evaluation method or vendor rating method. There are three key methods of vendor rating methods: categorical method, weighted score method and cost-ratio method.

- ***Categorical Method***

Categorical method is a very easy method. The buyer organisation prepares the lists of relevant performance variables or factors according to their experience. Then the buyers assign performance ratings of each variable in categorical terms, like 'very good', 'good', 'neutral', 'very poor' and 'poor'. Each supplier is evaluated against each factor on the basis of performance ratings. The supplier who obtains highest score will then be

the best performer. The main advantages of this method are that it is very easy to implement, requires minimal data and low cost.

- ***Weighted-Score method***

Weighted-point method is the most frequently used method for evaluation process. In this method, different weights are given to different variables according to the importance level. The most important variables get maximum weights and lest important variables get least weights. The evaluator assigns the score to each supplier performance in each attribute and then the score will be multiplied by the assigned weight of each variable accordingly. Finally, the weighted score is totalled to find out the final performance rating of each supplier. The supplier who obtains highest score is the best performer. The main advantage of this method is that the weights are given according to the importance of variables/factors. It is very suitable as the importance of different variables is different in different industries.

- ***Cost – Ratio Method***

In this method, the supplier rating is done on the basis of various costs incurred for procuring the materials/parts from various suppliers. The cost ratios are calculated for different factors such as quality, price, timely delivery, etc. the cost ratio is calculated in percentages on the basis of total individual costs and total value of purchases. As for example, the total delivery cost is Rs. 10,000 and the total purchase is of Rs. 1,00,000 then the delivery cost ratio will be (10,000/1,00,000)x100 = 10 per cent. "The supplier with the lowest net adjusted cost would be the best preferred supplier. However, this approach is complicated and requires a comprehensive accounting system to identify the accurate cost data. Hence, it is usually used only in the big-sized companies." (Humphreys et al., 1998).

Advantages of Vendor/Supplier Rating

There are many advantages of vendor rating as follows:

- ***Comparison of Suppliers***

The key advantage of vendor rating is that it is helpful in identification of best suppliers. The best suppliers give best results in terms of right quality, right quantity, right time delivery, at right cost.

- ***Performance of Suppliers/Vendors***

It gives clear-cut picture about the performance of the suppliers.

- ***Feedback about Suppliers***

It provides feedback regarding the suppliers about all areas in one package to the manufacturer.

- ***Feedback to the Suppliers***

It gives feedback to the suppliers about specific action(s) to correct their identified performance weaknesses.

- ***Better Communication***

It facilitates better communication with vendors which generates cordial relationships. It helps building supplier partnerships.

- ***Control***

It provides overall control of the supplier base.

- ***Revision/Review***

It establishes continuous review standards for vendors, thus ensuring continuous improvement of vendor performance.

CRITERIA FOR EVALUATION

Vendor performance is usually evaluated in the areas of pricing, quality, delivery, and service. Each area has a number of factors that some firms deem critical to successful vendor performance.

Pricing factors include the following:

- Competitive pricing. The prices paid should be comparable to those of vendors providing similar product and services. Quote requests should compare favorably to other vendors.
- Price stability. Prices should be reasonably stable over time.
- Price accuracy. There should be a low number of variances from purchase-order prices on invoiced received.
- Advance notice of price changes. The vendor should provide adequate advance notice of price changes.
- Sensitive to costs. The vendor should demonstrate respect for the customer firm's bottom line and show an understanding of its needs. Possible cost savings could be suggested. The vendor should also exhibit knowledge of the market and share this insight with the buying firm.
- Billing. Are vendor invoices are accurate? The average length of time to receive credit memos should be reasonable. Estimates should not vary significantly from the final invoice. Effective vendor bills are timely and easy to read and understand.

Quality factors include:

- Compliance with purchase order. The vendor should comply with terms and conditions as stated in the purchase order. Does the vendor show an understanding of the customer firm's expectations?
- Conformity to specifications. The product or service must conform to the specifications identified in the request for proposal and purchase order. Does the product perform as expected?
- Reliability. Is the rate of product failure within reasonable limits?
- Reliability of repairs. Is all repair and rework acceptable?
- Durability. Is the time until replacement is necessary reasonable?
- Support. Is quality support available from the vendor? Immediate response to and resolution of the problem is desirable.
- Warranty. The length and provisions of warranty protection offered should be reasonable. Are warranty problems resolved in a timely manner?
- State-of-the-art product/service. Does the vendor offer products and services that are consistent with the industry state-of-the-art? The vendor should consistently refresh product life by adding enhancements. It should also work with the buying firm in new product development.

Delivery factors include the following:

- Time. Does the vendor deliver products and services on time; is the actual receipt date on or close to the promised date? Does the promised date correspond to the vendor's published lead times? Also, are requests for information, proposals, and quotes swiftly answered?
- Quantity. Does the vendor deliver the correct items or services in the contracted quantity?
- Lead time. Is the average time for delivery comparable to that of other vendors for similar products and services?

- Packaging. Packaging should be sturdy, suitable, properly marked, and undamaged. Pallets should be the proper size with no overhang.
- Documentation. Does the vendor furnish proper documents (packing slips, invoices, technical manual, etc.) with correct material codes and proper purchase order numbers?
- Emergency delivery. Does the vendor demonstrate extra effort to meet requirements when an emergency delivery is requested?

Finally, these are service factors to consider:

- Good vendor representatives have sincere desire to serve. Vendor reps display courteous and professional approach, and handle complaints effectively. The vendor should also provide up-to-date catalogs, price information, and technical information. Does the vendor act as the buying firm's advocate within the supplying firm?
- Inside sales. Inside sales should display knowledge of buying firms needs. It should also be helpful with customer inquiries involving order confirmation, shipping schedules, shipping discrepancies, and invoice errors.
- Technical support. Does the vendor provide technical support for maintenance, repair, and installation situations? Does it provide technical instructions, documentation, general information? Are support personnel courteous, professional, and knowledgeable? The vendor should provide training on the effective use of its products or services.
- Emergency support. Does the vendor provide emergency support for repair or replacement of a failed product.
- Problem resolution. The vendor should respond in a timely manner to resolve problems. An excellent vendor provides follow-up on status of problem correction.

A 2001 article in *Supply Management* notes that while pricing, quality, delivery, and service are suitable for supplies that are not essential to the continued success of the buying firm, a more comprehensive approach is needed for suppliers that are critical to the success of the firm's strategy or competitive advantage. For firms that fall into the latter category performance may need to be measured by the following 7 C's.

1. Competency—managerial, technical, administrative, and professional competence of the supplying firm.
2. Capacity—supplier's ability to meet physical, intellectual and financial requirements.
3. Commitment—supplier's willingness to commit physical, intellectual and financial resources.
4. Control—effective management control and information systems.
5. Cash resources—financial resources and stability of the supplier. Profit, ROI, ROE, asset-turnover ratio.
6. Cost—total acquisition cost, not just price.
7. Consistency—supplier's ability to exhibit quality and reliability over time.

If two or more firms supply the same or similar products or services, a standard set of criteria can apply to the vendor's performance evaluation. However, for different types of firms or firms supplying different products or services, standardized evaluation criteria may not be valid. In this case, the buying firm will have to adjust its criteria for the individual vendor. For example, Honda of America adjusts its performance criteria to account for the impact of supplier problems on consumer satisfaction or safety. A supplier of brakes would be held to a stricter standard than a supplier of radio knobs.

BENEFITS

Benefits of vendor rating systems include:

- Helping minimize subjectivity in judgment and make it possible to consider all relevant criteria in assessing suppliers.
- Providing feedback from all areas in one package.
- Facilitating better communication with vendors.
- Providing overall control of the vendor base.
- Requiring specific action to correct identified performance weaknesses.
- Establishing continuous review standards for vendors, thus ensuring continuous improvement of vendor performance.
- Building vendor partnerships, especially with suppliers having strategic links.
- Developing a performance-based culture.

Vendor ratings systems provide a process for measuring those factors that add value to the buying firm through value addition or decreased cost. The process will continually evolve and the criteria will change to meet current issues and concerns.

For example, some feel that supplier evaluation must now reflect the strategic direction of the buying company's environmental initiatives. As a result, some firms have recently developed supplier evaluation systems that place significant weight on environmental criteria. It would seem that the concept will remain valid for some time.

Inventory Management

The term 'inventory' originates from the French word 'Inventaire' and Latin word 'Inventariom", which implies ***a list of things found.***

The term 'inventory' can be defined as,

"The term inventory includes materials like – raw, in process, finished packaging, spares and others; stocked in order to meet an unexpected demand or distribution in the future."

Inventory management is the branch of business management that covers the planning and control of the inventory. Priority planning determines what materials are needed and when they are needed in order to meet customers' demands.

Inventory Classes

Materials flow from suppliers, through a manufacturing organization, to the customers. The progressive states of a material are classified as raw materials, semi-finished goods, finished goods, and work-in-process (WIP).

- ***Raw Materials***

Purchased items or extracted materials that are converted via the manufacturing process into components and/or products. Raw materials appear in the bottom level of BOM. They are stored in the

warehouse and are non-phantom items.

- ***Semi-finished Goods***

Semi-finished goods are items that have been stored uncompleted, awaiting final operations that will adapt them to different uses or customer specifications. Semi-finished goods are made under the instruction of a shop order, using the components issued by a picking order, and stored in the warehouse when finished. They are the items between the top and bottom levels in a management BOM (rather than engineering BOM) and are non-phantoms. Semi-finished goods are not sold to the customers.

- ***Finished Goods***

A finished good is a product sold as a completed item or repair part, i.e., any item subject to a customer order or sales forecast. Finished goods are non-phantoms and are stored in the warehouse before they are shipped.

- ***Work-In-Process (WIP)***

Products in various stages of completion throughout the plant, including all material from raw material that has been released for initial processing up to completely processed material waiting for inspection and acceptance as finished goods. WIP inventory is temporarily stored on the shop floor and appears as a phantom in the BOM.

- ***Maintenance, Repair, and Operational Supplies (MRO)***

Items used in support of general operations and maintenance such as maintenance supplies, spare parts, and consumables used in the manufacturing process and supporting operations. These items are used in production but do not become part of the product.

Objectives of Inventory Management

The primary objectives of inventory management are:

(i) To minimize the possibility of disruption in the production schedule of a firm for want of raw material, stock and spares.

(ii) To keep down capital investment in inventories.

So it is essential to have necessary inventories. Excessive inventory is an idle resource of a concern. The concern should always avoid this situation. The investment in inventories should be just sufficient in the optimum level. The major dangers of excessive inventories are:

(i) the unnecessary tie up of the firm's funds and loss of profit.

(ii) excessive carrying cost, and

(iii) the risk of liquidity.

The excessive level of inventories consumes the funds of business, which cannot be used for any other purpose and thus involves an opportunity cost. The carrying cost, such as the cost of shortage, handling insurance, recording and inspection, are also increased in proportion to the volume of inventories. This cost will impair the concern profitability further.

On the other hand, a low level of inventories may result in frequent interruptions in the production

schedule resulting in under-utilization of capacity and lower sales. The aim of inventory management thus should be to avoid excessive inventory and inadequate inventory and to maintain adequate inventory for smooth running of the business operations. Efforts should be made to place orders at the right time with the right source to purchase the right quantity at the right price and quality. The effective inventory management should

(i) maintain sufficient stock of raw material in the period of short supply and anticipate price changes.

(ii) ensure a continuous supply of material to production department facilitating uninterrupted production.

(iii) minimize the carrying cost and time.

(iv) maintain sufficient stock of finished goods for smooth sales operations.

(v) ensure that materials are available for use in production and production services as and when required.

(vi) ensure that finished goods are available for delivery to customers to fulfill orders, smooth sales operation and efficient customer service.

(vii) minimize investment in inventories and minimize the carrying cost and time.

(viii) protect the inventory against deterioration, obsolescence and unauthorized use.

(ix) maintain sufficient stock of raw material in period of short supply and anticipate price changes.

(x) control investment in inventories and keep it at an optimum level.

Important Terminologies

Re-Order Level

Also known as the 'ordering level' the reorder level is that level of stock at which a purchase requisition is initiated by the storekeeper for replenishing the stock. This level is set between the maximum and the minimum level in such a way that before the material ordered for are received into the stores, there is sufficient quantity on hand to cover both normal and abnormal circumstances.

Re-Order Quantity

The quantity, which is ordered when the stock of an item falls to the reorder level, is known as the reorder quantity or the EOQ or the economic lot size. Although it is not a stock level as such, the reorder quantity has a direct bearing upon the stock level in as much as it is necessary to consider the maximum and minimum stock level in determining the quantity to be ordered. The re-order quantity should be such that, when it is added to the minimum quantity, the maximum level is not exceeded. the re-order quantity depends upon two important factors *viz,* order costs and inventory carrying costs.

Safety stock The safety stock level is the minimum level of inventory that the firm wishes to hold as a protection against running out.

Economy Order Quantity

The EOQ refers to the order size that will result in the lowest total of order and carrying costs for an item of inventory. If a firm place unnecessary orders it will incur unneeded order costs. If a firm places

too few order, it must maintain large stocks of goods and will have excessive carrying cost. By calculating an economic order quantity, the firm identifies the number of units to order that result in the lowest total of these two costs.

Reorder Point

The reorder point is the level of inventory at which the firm places an order in the amount of EOQ. If the firm places the order when the inventory reaches the reorder point, the new goods will arrive before the firm runs out of goods to sell.

Lead time This is the amount of time between placing an order and receiving goods. This information is usually provided by the purchasing department. The time to allow for an order to arrive may be estimated from a check of the company's record and the time taken in the past for different suppliers to fill orders.

Inventory Functions

- **Base stock -** that portion of inventory that is replenished after it is sold to customers.
- ***Safety Stock***

An additional quantity of stock kept in inventory to protect against unexpected fluctuations in demands and/or supply. If demand is greater than forecast or supply is late, a stock shortage will occur. Safety stock is used to protect against these unpredictable events and prevent disruptions in manufacturing. Safety stock is also called buffer stock.

- ***Lot-size Inventory***

In order to take advantage of quantity price discounts, reduce shipping and setup costs, or address similar considerations, items are manufactured or purchased in quantities greater than needed immediately. Since it is more economical to produce or purchase less frequently and in larger quantity, inventory is established to cover needs in periods when items are not replenished. Lot-size inventory depletes gradually as customer orders come in and is replenished cyclically when suppliers' orders are received.

- ***De-coupling Stock***

Inventory between facilities that process materials at different rates. De-coupling stock de-couples facilities to prevent the disparity in production rates at different facilities from interfering with any one facility's production. This inventory increases the utilization of facilities.

- ***Pipeline Inventory***

Inventory to fill the transportation network and the distribution system including the flow through intermediate stocking points. This inventory exists because of the time needed to move goods from one location to another. Time factors involve order transmission, order processing, shipping, transportation, receiving, stocking, etc.

- ***Transportation Inventory***

Transportation inventory is part of pipeline inventory. It is inventory in transit between locations. The average amount of inventory in transit is:

$I = (A / 365) * D$

Where I is the average annual inventory in transit, A is annual usage, and D is transit time in days. The transit inventory does not depend upon the shipment size but on the transit time and the annual usage.

The only way to reduce the inventory in transit isto reduce the transit time.

- ***Anticipation Inventory***

Anticipation stock is the stock of components, material, or goods kept at hand by a company or business to meet demand or to meet the shortfall caused by erratic production. It is also called as anticipation inventory, build stock, seasonal inventory, or seasonal stock.

Additional inventory above basic pipeline inventory to cover projected trends of increasing sales, planned sales promotion programs, seasonal fluctuations, plant shut downs, and vacations. Anticipation inventory differs from safety stock in that it is a predictable amount.

- ***Hedge Inventory***

Inventory held to protect against future fluctuations due to a dramatic change in prices, strikes, war, unsettled government, etc. These events are rare, but such occurrences could severely damage a company's initiatives. Risk and consequences are usually high, and top management approval is often required. Hedge inventory is similar to safety stock except that a hedge has a dimension of timing as well as amount. If the incident does not occur in the predicted time period, the hedge rolls over to the time period.

Inventory Costs related to Lot Sizing

- ***Ordering Cost***

Ordering costs are **costs** incurred on placing and receiving a new shipment of inventories.

Ordering costs are the costs associated with placing an order with the factory or a supplier. The ordering cost does not depend on the quantity ordered. It is a composite of all costs related to placing purchase orders or preparing shop orders, including

1. Paperwork,
2. Work station setups,
3. Inspection, scrap, and rework associated with setups,
4. Record keeping for work-in-process.

- ***Carrying Cost***

Carrying costs represent **costs** incurred on **holding** inventory in hand. These include opportunity **cost** of money held-up in inventories, storage **costs** such as warehouse rent, insurance, spoilage **costs**, etc.

Carrying cost is the total of costs related to maintaining the inventory, including

1. Capital cost invested in inventory, or foregone earnings of alternate investment,
2. Storage costs for space, equipment, and people,
3. Taxes and insurance on inventory,
4. Obsolescence caused by market, design, or competitors' product changes,
5. Deterioration from long-term storage and handling,
6. Record keeping for inventory.

Types of Inventory Systems

Perpetual Inventory System

Another method of inventory control is the maintenance of inventory control on a continuous basis. After the material are received into the stores, the storekeeper will arrange for the storing of each item in the allotted rack, bin, shelf or other receptacles and attach a card to each bin for the purpose of making entries there-in, relating to the receipts, issues and balance. The bin card or the locker card, this becomes a perpetual inventory record for each item of stores. If the stores balance is recorded on continuous basis after every receipt and issue, the record is said to be one of perpetual inventory and the method of recording is called the perpetual inventory system. Thus the perpetual inventory is a method of recording store balance after every receipt and issue to facilitate regular checking and to obviate closing down for stock locking

As a perpetual inventory record, the bin card records the receipt, issues and the balance of every item of stores only in physical quantities, and not in value. This feature of the bin card is in accordance with the accepted principle that the storekeeper true to his designation, should be responsible for the safe keeping of the items of stores entrusted to him, and his accounting for stores should always be in physical quantities and not in value. The perpetual inventory system includes continues stock taking also.

Stocktaking or stock verification is done mainly with a view to finding out whether the book balances as revealed by the stock records agree with the physical or the ground balance. Although, therefore, stock verification is one of the tools of inventory control, and is done for exercising control over the stock of every item, is an integral part of material control for the purpose of preparing the B/S, the physical verification of stock must be done at the end of year.

Periodical Inventory System

Verification at the end of the year is known as the **periodical stock taking** as against the continuous stocktaking, which is done throughout the year. The periodic stock taking method usually adopted by concerns which cannot maintain perpetual inventory records due to the nature of the items which are usually stored in open yards and not in bins and as a such, bin cards cannot be employed for them, or do not want to maintain such records and employ stock verification staff to do the work of stock checking throughout the year. Under this method of stocktaking, the verification of the whole of the stock and its valuation are accomplished only once at the close of the financial year and difference in stock is adjusted only once. As such, the stock in hand would tend to be accurate for the balance sheet purposes. It is also possible to find out slow moving items. Nevertheless, the periodic inventory has its own disadvantage. In the first place, it becomes necessary to close down the factory on the day of stock taking. Secondly, discrepancies in stock cannot be corrected by an executive action immediately as and when they occur. Thirdly, since all the items are checked only once in a particular day, a surprise verification will not be possible. Lastly, reason for the discrepancies cannot be found out because of the long interval between two consecutive verifications.

These disadvantages of the periodical inventory system are overcome in the case of the perpetual inventory system. Under this method of continuous stock verification the purpose of verification is carried on throughout the year by a specially trained staff. This duty is to verify a few selected items in details so that each item is checked up a number of times during the year. The day and time of checking not being known to the staff, they are taken by a surprise. As such, not only secrecy of the items to be

verified cannot maintained, a manipulation of every type can be prevented. Discrepancies are located, reasons are ascertained, the necessary adjustment are made in the accounting records, and correlative action is taken then and there to prevent their recurrence. The advantages of a continuous stocktaking where perpetual inventory records are maintained may thus be summarized as follows:

(i) The elaborate and costly work involved in periodic stock taking can be avoided.

(ii) The stock verification can be done without the necessity of closing down the factory.

(iii) The preparation of interim financial statement becomes possible.

(iv) Discrepancies are easily located, and corrected immediately.

(v) It ensure a reliable check on the stores.

(vi) It exercises a moral influence on the stores staff.

(vii) Fast and slow moving items can be distinguished and the fixation of proper stock levels prevents not only over-stocking, but under-stocking also.

(viii) A perpetual inventory record of the nature of the bin cards enables the storekeeper to keep an eye on the stock levels, and replenish the stock of every item whenever the limit falls to the reorder level.

(ix) It provides a reliable information to the management of the number of units, and the value of every item of stores.

(x) It ensures secrecy of the items that are verified.

Inventories Control Techniques

- A-B-C Analysis
- X-Y-Z Analysis
- V-E-D Analysis
- F-S-N Analysis
- H-M-L Analysis
- S-D-E Analysis
- S-O-S Analysis
- G-O-L-F Analysis

- **ABC Analysis of Inventories**

The ABC inventory control technique is based on the principle that a small portion of the items may typically represent the bulk of money value of the total inventory used in the production process, while a relatively large number of items may from a small part of the money value of stores. The money value is ascertained by multiplying the quantity of material of each item by its unit price.

According to this approach to inventory control high value items are more closely controlled than low value items. Each item of inventory is given A, B or C denomination depending upon the amount spent for that particular item. “A”

or the highest value items should be under the tight control and under responsibility of the most

experienced personnel, while “C” or the lowest value may be under simple physical control.

It may also be clear with the help of the following examples:
“A” Category – 5% to 10% of the items represent 70% to 75% of the money value.
“B” Category – 15% to 20% of the items represent 15% to 20% of the money.
“C” Category – The remaining number of the items represent 5% to 10% of the money value.

The relative position of these items show that items of category A should be under the maximum control, items of category B may not be given that much attention and item C may be under a loose control.

Advantages of ABC Analysis

1. It ensures a closer and a more strict control over such items, which are having a sizable investment in there.
2. It releases working capital, which would otherwise have been locked up for a more profitable channel of investment.
3. It reduces inventory-carrying cost.
4. It enables the relaxation of control for the ‘C’ items and thus makes it possible for a sufficient buffer stock to be created.
5. It enables the maintenance of high inventory turnover rate.

- X-Y-Z Analysis - Based on value of inventory of materials actually held in stores at a given time. Actual inventory value of items in stores instead of their estimated annual consumption value.
- V-E-D Analysis - Usually applied for spare parts on the basis of criticality. Classification is on the basis of ‘V’ stands for vital, ‘E’ for essential, ‘D’ for desirable.
- FSN Analysis - FSN stands for Fast moving, Slow moving and Non moving items. The classification is on past based consumption pattern Useful to control obsolescence of raw materials, components, tools and spare parts
- HML Analysis - HML stands for High value, Medium value and Low value items based on unit price of the item. On this basis, Materials management may delegate authority to various levels of purchase officers to authorize and sign Purchase Orders.
- SDE Analysis - SDE stands for Scarce items, Difficult to produce items and Easy to procure items
- SOS Analysis - SOS stands for Seasonal items and Off- Seasonal items. It may be advantageous to buy seasonal item at low prices and keep inventory or buy at high price during off seasons
- GOLF Analysis - Government, Open Market, Local or Foreign source of supply.

Unit V

Quality Management

In business, engineering, and manufacturing, quality has a pragmatic interpretation as the non-inferiority or superiority of something; it's also defined as being suitable for its intended while satisfying customer expectations.

Quality is the degree to which an object or entity (e.g., process, product, or service) satisfies a specified set of attributes or requirements. **Quality** is the degree to which a set of inherent characteristics fulfils requirements.

Quality refers to how good something is compared to other similar things. In other words, its degree of excellence. The ISO 8402-1986 standard defines **quality** as: "The totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs."

"Quality in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for." – Peter Drucker

Quality in **manufacturing**, a measure of excellence or a state of being free from defects, deficiencies and significant variations. It is brought about by strict and consistent commitment to certain standards that achieve uniformity of a product in order to satisfy specific customer or user requirements.

Some attributes used to help define quality are:

1. Freshness: Some products are perishable, i.e., the quality declines over time. Vegetables fall "into this category. Fashion items also are subject to obsolescence. At the other extreme, "the value associated with some products increases with age, as is the case with antiques and red wine.
2. Reliability: The quality associated with a product often increases with the dependability of the product customer experience. Patients expect the hospitals to have competent staff. Customers expect telephones to work. Ni-Cd Batteries manufactured by ECIL should be as reliable as other internationally manufactured batteries.
3. Durability: The quality attribute that implies product performance under adverse conditions. Eveready's Red commercials are designed to convey the durability of its batteries.
4. Safety: This is an attribute of quality that measures the likelihood of harm from goods or service. What is safe can be a controversial issue. For instance, is a gun with a safety clip safe? Is the packaging of a product tamper proof?
5. Environmental Friendly: As is the case with safety, this quality attribute has both societal aspects and is individual specific. The requirements for being considered an environmental friendly product are becoming more stringent. For example, firms must now also focus on how a product is disposed off after its useful life.
6. Serviceability: This attribute relates to the ease and cost associated with servicing a product after the sale has been made. Products are now being increasingly designed so that they do not need service, such as car batteries. But many others do require service and this capability must be both designed into the product and the post-sale service system. This is especially important for consumer durables. ECIL, perhaps, has not been able to convey that it has an adequate service organization for the televisions it manufactures.

7. Aesthetics: A product's appearance, feel, sound, taste, or smell reflects its aesthetics. Aesthetics are hard to define; it is customer specific and sometimes situation specific. What is aesthetically pleasing to one individual may be considered ugly by another.
8. Attribute Consistency: The attributes associated with a product should be internally consistent. It would make little sense to build a Maruti 800 with airfoils, or a biodegradable cigarette filter. Products with inconsistent combinations of features aren't likely to match the needs of their buyers.

Quality management is the act of overseeing different activities and tasks within an organization to ensure that products and services offered, as well as the means used to provide them, are consistent. It helps to achieve and maintain a desired level of quality within the organization.

Quality management consists of four key components, which include the following:

- **Quality Planning** – The process of identifying the quality standards relevant to the project and deciding how to meet them.
- **Quality Improvement** – The purposeful change of a process to improve the confidence or reliability of the outcome.
- **Quality Control** – The continuing effort to uphold a process's integrity and reliability in achieving an outcome.
- **Quality Assurance** – The systematic or planned actions necessary to offer sufficient reliability so that a particular service or product will meet the specified requirements.

The aim of quality management is to ensure that all the organization's stakeholders work together to improve the company's processes, products, services, and culture to achieve the long-term success that stems from customer satisfaction.

- The process of quality management involves a collection of guidelines that are developed by a team to ensure that the products and services that they produce are of the right standards or fit for a specified purpose.
- The process starts when the organization sets quality targets to be met and which are agreed upon with the customer.
- The organization then defines how the targets will be measured. It takes the actions that are required to measure quality. It then identifies any quality issues that arise and initiates improvements.
- The final step involves reporting the overall level of the quality achieved.
- The process ensures that the products and services produced by the team match the customers' expectations.

Principles of Quality Management

There are several principles of quality management that the International Standard for Quality Management adopts. These principles are used by top management to guide an organization's processes towards improved performance. They include:

1. Customer Focus

The primary focus of any organization should be to meet and exceed the customers' expectations and needs. When an organization can understand the customers' current and future needs and cater to them, that results in customer loyalty, which in turn increases revenue. The business is also able to identify new customer opportunities and satisfy them. When business processes are more efficient, quality is higher and more customers can be satisfied.

2. Leadership

Good leadership results in an organization's success. Great leadership establishes unity and purpose among the workforce and shareholders. Creating a thriving company culture provides an internal environment that allows employees to fully realize their potential and get actively involved in achieving company objectives. Leaders should involve the employees in setting clear organizational goals and objectives. This motivates employees, who may significantly improve their productivity and loyalty.

3. Engagement of People

Staff involvement is another fundamental principle. The management engages staff in creating and delivering value whether they are full-time, part-time, outsourced, or in-house. An organization should encourage the employees to constantly improve their skills and maintain consistency. This principle also involves empowering the employees, involving them in decision making and recognizing their achievements. When people are valued, they work to their best potential because it boosts their confidence and motivation. When employees are wholly involved, it makes them feel empowered and accountable for their actions.

4. Process Approach

The performance of an organization is crucial according to the process approach principle. The approach principle emphasizes achieving efficiency and effectiveness in the organizational processes. The approach entails an understanding that good processes result in improved consistency, quicker activities, reduced costs, waste removal, and continuous improvement. An organization is enhanced when leaders can manage and control the inputs and the outputs of an organization, as well as the processes used to produce the outputs.

5. Continuous Improvement

Every organization should come up with an objective to be actively involved in continuous improvement. Businesses that improve continually experience improved performance, organizational flexibility, and increased ability to embrace new opportunities. Businesses should be able to create new processes continually and adapt to new market situations.

6. Evidence-based Decision Making

Businesses should adopt a factual approach to decision-making. Businesses that make decisions based on verified and analyzed data have an improved understanding of the marketplace. They are able to perform tasks that produce desired results and justify their past decisions. Factual decision making is vital to help understand the cause-and-effect relationships of different things and explain potential unintended results and consequences.

7. Relationship Management

Relationship management is about creating mutually beneficial relations with suppliers and retailers. Different interested parties can impact a company's performance. The organization should manage the supply chain process well and promote the relationship between the organization and its suppliers to optimize their impact on the company's performance. When an organization manages its relationship with interested parties well, it is more likely to achieve sustained business collaboration and success.

Benefits of Quality Management

- It helps an organization achieve greater consistency in tasks and activities that are involved in the production of products and services.
- It increases efficiency in processes, reduces wastage, and improves the use of time and other resources.
- It helps improve customer satisfaction.
- It enables businesses to market their business effectively and exploit new markets.
- It makes it easier for businesses to integrate new employees, and thus helps businesses manage growth more seamlessly.
- It enables a business to continuously improve their products, processes, and systems.

Quality Circles

Meaning of Quality Circles:

Prof. **Ishikawa** is called the Father of the QC Circle.

Conceptually Quality Circles can be described as a small group of employees of the same work area, doing similar work that meets voluntarily and regularly to identify, analyse and resolve work related problems.

This small group with every member of the circle participating to the full carries on the activities, utilising problem solving techniques to achieve control or improvement in the work area and also help self and mutual development in the process.

Quality circles built mutual trust and create greater understanding between the management and the workers. Cooperation and not confrontation is the key element in its operation. Quality Circles aims at building people, developing them, arousing genuine interest and dedication to their work to improve quality, productivity, cost reduction etc.

Thus we can say that a quality circle is a group of 5 to 8 employees performing similar work, who volunteer themselves to meet regularly, to identify the cause of their on-the-job problems, employ advanced problem-solving techniques to reach solutions and implement them.

The concept is based on the premise that the people who do a job everyday know more about it than anyone else and hence their voluntary involvement is the best way to solve their work related problems.

The Quality Circle concept provides an opportunity to the circle members to use their wisdom, creativity and experience in bringing about improvements in the work they are engaged in by converting the challenging problems into opportunities and it contributes to the development of the employees and in turn benefits the organisation as well. The concept encourages the sense of belongingness in circle members and they feel that they have an important role to play in the organisation.

A **quality circle** is a participatory **management** technique that enlists the help of employees in solving problems related to their own jobs. **Circles** are formed of employees working together in an **operation** who meet at intervals to discuss problems of **quality** and to devise solutions for improvements.

Quality circles built mutual trust and create greater understanding between the management and the workers. **Quality Circles** aims at building people, developing them, arousing genuine interest and dedication to their work to improve **quality**, productivity, cost reduction etc.

A **Quality Circle** is a participation **management** technique to **manage** and improve the **quality** of the entire organisation. The **purpose** of a **Quality Circle** is to build towards a good relationship with employees, so they will show more interest and devotion in the work they do.

By solving the problems and also making desirable improvements, **quality circles** contribute in **increasing** the **quality**, **productivity** and safety of the operations. More importantly the workers develop a positive and problem solving attitude by participating in the QC activities and derive more job satisfaction.

Lack of Management Commitment: The top management may not be committed to the concept of quality circle. The employees may not be allowed to hold meetings of quality circles during the working hours. The management should allow the **workers** to hold quality circle meetings periodically during the working hours.

The steps involved in the **implementation** process of **Quality Circle** are following: 1) Identification of problem: First of all the problem is identified by the **Quality Circle** members which is to be solved. 2) Analysis of the problem: The selected problem is then analyzed by basic problem solving techniques.

Quality Circle concept was first **introduced** by BHEL, Ramachandrapuram Hyderabad in the year 1981 in **India** with the initiation of Mr. S.R. Udpa – GM-Operations. He received the needed support from senior management of BHEL

Circle members are able to take the problem, analyse and solve them. After observing the results, they prepare the case studies in **12 step** method format or 7 QC step method which reflects that they know all the steps of problem solving very well.

Characteristics of Effective Quality Circles:

1. The atmosphere should be informal, comfortable and relaxed. The members should feel involved and interested.
2. Everyone should participate.
3. The objectives should be clear to the members.
4. The members should listen to each other.
5. The group should feel comfortable even when there are disagreements.

6. The decisions should generally be taken by a kind of consensus and voting should be minimum.
7. When an action is required to be taken, clear assignments should be made and accepted by all the members.
8. The leader should not dominate the group. The main idea should not be as to who controls but how to get the job done.
9. Until a final solution is found and results are attained feedback is necessary.

Objectives of Quality Circles:

Some of the broad objectives of the Quality Circle are:

(i) To improve quality, productivity, safety and cost reduction.
(ii) To give chance to the employees to use their wisdom and creativity.
(iii) To encourage team spirit, cohesive culture among different levels and sections of the employees.
(iv) To promote self and mutual development including leadership quality,
(v) To fulfill the self-esteem and motivational needs of employees.
(vi) To improve the quality of work-life of employees.
What are the elements of quality circle?

The basic **elements** in the formation of a **quality circle** are (i) top management (ii) steering committee (iii) coordinator or facilitator (iv) leader (v) members and (vi) non member. Top management plays an important role in ensuring the success of implementation of **quality circles** in the organization.

Implementation of Quality Circles in an Organisation:

For the success of Quality Circle programme, following actions are necessary in the Organisation:

(a) Few managers representing production, quality control, design, process planning form the Quality Circle (Q.C.) steering committee. This acts as a policy making body and will monitor the Q.C. in the Organisation.
(b) Top management must attend the orientation courses designed for them.
(c) A committed top and middle management is necessary.
(d) A facilitator must be appointed, who serves as a link between top management, Q.C., steering committee, middle management circle leaders and circle members. Facilitator will coordinate training courses; get the support from all concerned including top management Q.C., steering committee, circle leader and circle members to help the circle leader in conducting the meetings, and to provide necessary resources.

Organisation and Working of Quality Circles:

Q.C. was conceived in Japan in 1962 as a forum for training its work force for improving the quality of products. Q.C. is a voluntary one. Employees are free to join or not to join. In it, 8 to 10 employees including the Supervisor from same workshop doing similar work join together as a group. The Supervisor can become leader of the group, if the members of Q.C. so desire.
It is a part time activity; members of Q.C. are allowed to meet for an hour every week. During the various meetings, these groups progressively identify, select, analyse and solve the problems. Later they offer their proposed solutions to management for consideration, approval and implementation.

Additionally a senior officer from same workshop is nominated as facilitator who guides the activities of the group.
A Management Committee at senior level is also formed, which overview the progress of Quality Circles.
Training of members, leaders and facilitators is very important for the success of programme.

Rules for Quality Circles:
(a) Each member can contribute an idea on his turn in rotation.
(b) Each member offers only one idea per turn regardless of how many he or she has in mind.
(c) Not everyone has an idea during each rotation, when this occurs just say "Pass".
(d) No criticism or comments should be passed on the ideas being contributed by the member whatever old it may look to be, welcome their ideas.
(e) During brain-storming, no evaluation of suggested idea should occur. This applies equally to leader, phrases such as "We have tried it before", "Impractical", "Well" "May be it would work". "Doubtful", "Very good" etc. should not be uttered.
(f) Members can vote by raising their hands.
(g) Only supporting votes are taken. Votes against the ideas are not allowed.
(h) The time allotted for brain-storming session should be variable. The length of time that can be spent profitably will vary widely with nature of problem and the group itself. As a general practice, one hour is probably the minimum.
(i) While members give their ideas, they are recorded by the Recorder on a large sheet.
(j) It is often helpful to set a goal originally, i.e. Let us start for 30 ideas.
(k) When all members say "pass" then the first phase of brain-storming session is over. This means all ideas have been exhausted.
(l) Now all the ideas recorded on the sheet are displayed.
(m) These massive number of ideas are then narrowed down by the process of voting. The voting technique works because the members are experts in their areas. Members vote on each idea. The leader records each vote next to the idea.
(n) Members can vote for as many ideas as they feel have value. Only supporting votes are taken.
(o) Leader draws a circle around those ideas that receive the most votes. The members thus find that many of the top ideas will be so identified.
(p) Now the members can focus on a few important ideas instead of being somewhat confused by a large number of them. These few important ideas are voted on to give ranking to the circle ideas. Leader writes the ranking number beside each idea that has been circled.
(q) A member can ask for voting on any idea and argue for or against it. Others can join, if they wish. Only when the discussion has finished then the voting take place.
Idea ranked in the session can then be taken up for analysis or solution later on.

Duties of Circle Leader:
For the success of Quality Circles, circle leader must have following duties:
(i) He must assume the responsibility of guiding the members.
(ii) He must make his members sure about what is going on.
(iii) He must channelise the discussions.

(iv) Every member is allowed equal opportunity.
(v) Specific task be assigned to each member.
(vi) He must work in coordination with facilitator.

Steps for Setting up Quality Circles:

For starting Quality Circles in an organisation, following steps should be taken:

(i) First of all Managers, Supervisors and Foremen must be made to understand the concepts and activities of Q.C.
(ii) Management's total support and commitment should be made known to everyone in the organisation.
(iii) Steering committee is formed with the top management personnel to give direction to Quality Circle activities.
(iv) A facilitator (or sometimes known as promoter) is selected from the senior management level, who will serve as coordinator and advisor to the circle.
(v) Supervisor and foreman are then trained to act as Q.C. leaders.
(vi) Members of each circle must be selected from the persons who are doing similar type of work or belong to the same department or section.
(vii) Membership to the circle is voluntary.
(viii) First few meetings of the circle are held with a view to train them.
(ix) To start with, only one to two circles should be formed in an organisation, and then increase the number gradually as more and more experience is gained.
(x) Meetings must be held regularly, may be once in a week initially and once in a month on completion of basic training of members.
(xi) Everyone's suggestion or problem matching with the circle's objectives is discussed.
(xii) Total participation of team members must be encouraged.
(xiii) Recommendations of the circle must be considered and decisions should be taken without delay.

Benefits of Quality Circles (Q.C.):

1. Through the forum of Q.C. the chronic problems-of organisations which really create hurdles in work get resolved by the grass root employees of organisation, whose knowledge and experience otherwise is not fully utilized.
2. With such a capable work force, any organisation can easily undertake more difficult and challenging assignments for its growth and profit.
3. As the employees gain experience they take more challenging projects, in due course they undertake projects on cost reduction, material handling, quality improvement, preventing wastage, improving delivery schedule, improving customer service, improving inspection and test methods, preventing accidents improving design and process etc.
4. Cost reduction.
5. Increased productivity.
6. Improved quality.
7. Better communication.
8. Better house-keeping.

9. Increased team work.
10. Smooth working.
11. Better mutual trust.
12. Greater sense of belongingness.
13. Increased safety.
14. Better human relations.

Launching of Quality Circle Programme:

The typical steps for launching programme are as under:

(i) Orientation Programme for Senior Management Personnel.
(ii) Orientation Programme for Managers and Executives.
(iii) Orientation Programme for Selected Supervisors.
(iv) Orientation Programme for Workers (selected area).
(v) Formation of Circles (Minimum 2 and Maximum 4).
(vi) Training of Facilitators.
(vii) Training of Leaders.
(viii) Q.C. meetings for projects.

Control Charts

The control chart was invented by Walter A. Shewhart working for Bell Labs in the 1920s. The company's engineers had been seeking to improve the reliability of their telephony transmission systems.

Control charts, also known as Shewhart charts or process-behavior charts, are a statistical process control tool used to determine if a manufacturing or business process is in a state of control. It is more appropriate to say that the control charts are the graphical device for Statistical Process Monitoring.
The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. These lines are determined from historical data.

Types of Control Charts.

- X **bar** control chart.
- Range "R" control chart.
- Standard Deviation "S" control chart.
- "p" and "np" control charts.
- Pre-control Charts.

Three characteristics of a process that is in control are:

1. Most points are near the average.
2. A few points are near the **control** limits.
3. No points are beyond the **control** limits.

Types of Control Charts

Control charts fall into two categories: Variable and Attribute Control Charts.

- Variable data are data that can be measured on a continuous scale such as a thermometer, a weighing scale, or a tape rule.
- Attribute data are data that are counted, for example, as good or defective, as possessing or not possessing a particular characteristic.

The type of control chart you use will depend on the type of data you are working with.
- It is always preferable to use variable data.
- Variable data will provide better information about the process than attribute data.
- Additionally, variable data require fewer samples to draw meaningful conclusions.

Variable control charts

Variables control charts plot quality characteristics that are numerical (for example, weight, the diameter of a bearing, or temperature of the furnace).

There are two types of variables control charts: charts for data collected in subgroups, and charts for individual measurements. For subgrouped data, the points represent a statistic of subgroups such as the mean, range, or standard deviation. For individual measurements, the points represent the individual observations or a statistic such as the moving range between successive observations.

- **Xbar-R chart**

An Xbar-R chart is a combination of control charts used to monitor the process variability (as the range) and average (as the mean) when measuring subgroups at regular intervals from a process.

- **Xbar-S chart**

An Xbar-S chart is a combination of control charts used to monitor the process variability (as the standard deviation) and average (as the mean) when measuring subgroups at regular intervals from a process.

- **Xbar chart**

An Xbar-chart is a type of control chart used to monitor the process mean when measuring subgroups at regular intervals from a process.

- **R chart**

An R-chart is a type of control chart used to monitor the process variability (as the range) when measuring small subgroups ($n \leq 10$) at regular intervals from a process.

Types of Attribute Charts

There are four types of Attribute Charts:
- p Charts (proportion charts)
- np Charts
- C Charts
- u Charts

Attribute Charts: p Chart (proportion chart)

What is a p Chart:

- Evaluates the stability of a process when we are evaluating the proportion of defects vs in good order as a percentage.

- The plot shows the percentage of defectives.

When to Use a p Chart:
- Sample sizes are NOT equal.
- Have discrete data.

How to Use a p Chart:

Step 1)Measure P-bar:

p bar = the fraction rejected = total defectives / total inspected.

Step 2) Find Control Limits:

3 SD = 3 (SQRT((pbar * (1-pbar))/n))

N refers to a SINGLE instance of a sample size, not the # of sample sizes (or rows) listed. Since there are multiple sample sizes, we use the largest one on the list – the worst case. (You can establish UCL & LCL with the best case to get a different interpretation.

Upper control limit = pbar + 3 SD

Lower control limit = pbar – 3 SD

Attribute Charts: np Chart

What are np Charts:

- Evaluates the stability of a process when we are evaluating the proportion of defects as a raw number.
- The plot shows the # of defectives.

When to Use np Charts:

np Charts are for monitoring the number of times a something binary happens (normally an error or defect). You're also dependent on the sample size because you. You're looking for a binary case to trigger adding the point to the graph – like the hamburger was either cooked or undercooked.
- Sample sizes are equal or constant.
- Subgroups are the same size.
- Attributes are discrete and binary (ex. yes vs no; up vs down)

How to Use np Charts:

Step 1) Calculate p as above.

Step 2) Calculate np.

np bar = total # defective / total samples.

The total samples are the # of rows listed.

Step 3) Calculate the control limits

UCL = np bar + 3 * (SQRT(npbar*(1-pbar)))

LCL = np bar – 3 * (SQRT(npbar*(1-pbar)))

Attribute Charts: C Charts

What they do:

- Evaluates the stability of counted data
- Measures defects per unit. Helpful if you have a list of # of defects per unit ID.
- The plot shows the # of defectives.

When to Use:

- Total opportunity population is large compared to # defects.
- When you cannot count "not a defect."
- Data type is discrete but each count has an equal opportunity of coming up.

c bar = total # defects / # units

UCL = c bar + 3 * (SQRT(c))

LCL =c bar – 3 * (SQRT(c))

Attribute Charts: u Chart

What are u Charts:

- Evaluates the stability of counted data
- Measuring variable defects per unit. Helpful for when you have lots of varying sample size.
- The plot shows the % of defectives.

When to Use u Charts:

- Sample size varies – ex. Multiple types of a defect.

How to use u Charts

Step 1) Calculate the number of defects per unit in each lot.

u = c / n = number of defects in the lot / # of units in the lot.

Then repeat this for all of the lots.

Step 2) Calculate u bar

u bar = total defects in all of the lots total / total # units in all of the lots combined.

Step 3) Calculate UCL & LCL for EACH lot size

Ex. if you have lot sizes of 1, 2, 3, and 4 – you must create an UCL & LCL for each of them!

UCL = ubar + 3* (SQRT(ubar / n)) where n is the # of items in the lot size

LCL = ubar – 3* (SQRT(ubar / n))

Total Quality Management

Total Quality Management (TQM) is a management framework based on the belief that an organization can build long-term success by having all its members, from low-level workers to its highest ranking executives, focus on improving quality and, thus, delivering customer satisfaction.

TQM is considered a customer-focused process and aims for continual improvement of business operations. It strives to ensure all associated employees work toward the common goals of improving product or service quality, as well as improving the procedures that are in place for production.

A core definition of total quality management (TQM) describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work.

Total quality management consists of organization-wide efforts to "install and make permanent climate where employees continuously improve their ability to provide on demand products and services that customers will find of particular value."

TQM has a strong emphasis on improving quality within a process, rather than inspecting quality into a process. This not only reduces the time needed to fix errors, but makes it less necessary to employ a team of quality assurance personnel.

In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work. In the logistics sphere, TQM is an approach that integrates all quality-related functions and processes companywide to improve the quality and performance of the finished product.

Total quality management (TQM) is the continual process of detecting and reducing or eliminating errors in manufacturing, streamlining supply chain management, improving the customer experience, and ensuring that employees are up to speed with training.

TQM can have an important and beneficial effect on employee and organizational development. By having all employees focus on quality management and continuous improvement, companies can establish and uphold cultural values that create long-term success to both customers and the organization itself.

Principles of TQM

The eight principles are:

1 Customer focus.

2 Leadership.

3 Involvement of people.

4 Process approach.

5 System approach to management.

6 Continuous improvement.

7 Factual approach to decision making.

8 Mutually beneficial supplier relationships.

Objectives of TQM

- Decrease of mistakes in all operating areas,
- Early mistake recognition,
- Mistake prevention as a preventive step,
- Avoidance of wastes,
- Reduction of the lead times,
- Increase of the flexibility and profitability,
- Better capture and conversion of the customer's needs,

Characteristics of TQM

- Customer Focused. Quality begins and ends with the customer. ...
- Involved Employees.
- Process Oriented.
- Mutually Dependent Systems.

- Strategic Approach.
- Continuous Improvement.
- Data-Driven Decisions.
- Effective Communications.

Companies using TQM

Companies as diverse as Ford Motor Company, Toyota, Motorola, and the Xerox Corporation use this methodology. With its focus on the customer, it can create or deepen customer loyalty to the organisation.

Pillars of TQM

Product, Process, Organization, Leadership, and Commitment.

Obstacles of TQM

The Total Quality Management (TQM) obstacles or roadblocks are; Lack of Management Commitment, Inability to Change Organizational Culture, Improper Planning, Lack of Continuous Training and Education, Incompatible Organizational Structure and Isolated Individuals and Departments, Ineffective Measurement Techniques

Barriers to TQM implementation

- Lack of management commitment.
- Inability to change organizational culture.
- Improper planning.
- Lack of continuous training and education.
- Incompatible organizational structure and isolated individuals and departments.

Bureau of Indian Standards (BIS)

The Bureau of Indian Standards is the national Standards Body of India working under the aegis of Ministry of Consumer Affairs, Food & Public Distribution, Government of India. It is established by the Bureau of Indian Standards Act, 1986 which came into effect on 23 December 1986.

Bureau of Indian Standards (BIS) is the National Standard Body of India. BIS is responsible for the harmonious development of the activities of standardization, marking and quality certification of goods and for matters connected therewith or incidental thereto.

BIS has its Headquarters at New Delhi and its 05 Regional Offices (ROs) are at Kolkata (Eastern), Chennai (Southern), Mumbai (Western), Chandigarh (Northern) and Delhi (Central).

Bureau of Indian Standards (BIS) And Indian Standards Institute (ISI) ISI is meant for a quality standard set by the Indian government. However the term “ISI mark” continues to be used for the quality standards. BIS is authorized to use the ISI mark and offers the product certification, which is basically voluntary.

BIS Certification is a means for providing third party guarantee of quality, safety and reliability of products to the customer. BIS Certification is voluntary in nature; however, the Government of India has made BIS certification mandatory for certain products taking into consideration public health.

Products that Require Mandatory BIS License or BIS Certificate

Certain products are required to have BIS License or Certification mandatorily considering public health and safety. No one can manufacture or sell products without BIS Certification. The following are products that require mandatory BIS License or Certification.

1. Cement
2. Household electrical goods
3. Food and related products
4. Diesel engines
5. Oil pressure stoves
6. Automobile accessories
7. Cylinders, Valves and Regulators
8. Medical Equipment
9. Steel Products
10. Electrical Transformers

Types of BIS Certification Schemes

In India, the Government provides BIS Certification for products under different types of schemes as follows:

Normal Procedure for Domestic Manufacturers – The applicant is required to submit the BIS Certification application with required documents and requisite fee. After submitting the application, a preliminary factory evaluation is carried out by a BIS officer. Then samples are tested in the factory and also drawn for independent testing. BIS certification is provided if the sample is acceptable. In this method, BIS Certification is expected to be granted within 4 months of submission of application.

Simplified Procedure for Domestic Manufacturers – In the simplified procedure, the applicant submits a test report of the sample from a BIS approved lab along with the application for BIS Certification. If the test report is satisfactory, then a verification of the factory premises is carried out by a BIS Officer. BIS Certification is granted if the verification of the BIS Officer is satisfactory. Under this method, the license is expected to be granted within 30 days of submission of BIS Certification application with the required documents and test report.

Tatkal Scheme: Those manufacturers who need BIS standard mark mandatorily as per Government notification can obtain BIS license under the tatkal scheme. Under the tatkal scheme, the application is processed within strict timelines and the total time for processing is specified as 30 days. I addition, an application received under the Tatkal Scheme will be processed on a priority basis to adhere to the strict time norms.

ECO Mark Scheme – BIS License for eco-friendly products are granted in a scheme separate from the normal BIS Certification process. Eco-friendly products should conform to additional requirements specified in the Indian Standards to qualify for the ECO mark. The procedure for grant of licence is however similar to that of Domestic Manufacturer's scheme.

Foreign Manufacturers Certification Scheme – Overseas applicants/foreign manufacturers are granted a licence for the use of ISI mark under separately designed scheme within 6 months period.

International Organization for Standardization (ISO)

ISO (International Organization for Standardization) is an independent, non-governmental, international organization that develops standards to ensure the quality, safety, and efficiency of products, services, and systems.

The International Organization for Standardization is an international standard-setting body composed of representatives from various national standards organizations.

All ISO Standards are voluntary. The ISO International Standards Organisation is a non-governmental organisation that's main interest is the design and implementation of standards however it has no power to enforce these standards.

Certification can be a useful tool to add credibility, by demonstrating that your product or service meets the expectations of your customers. For some industries, certification is a legal or contractual requirement.

ISO compliance means adhering to the requirements of ISO standards without the formalized certification and recertification process. For example, organizations can meet the requirements of the ISO 9000 management standard and obtain the certificate of compliance.

Many companies want ISO 9001 certification just to satisfy one customer requirement. The customer states that it will only do business with vendors that are certified as ISO 9001 compliant, so to get (or keep) the business they need that certification.

For a business, International Standards are thought to bring many benefits: Cutting costs through improvement in systems and processes. Increasing customer satisfaction with improvements in safety and quality. The ability to access new markets is also a benefit as products and services can be compatible.

ISO DOES NOT PERFORM CERTIFICATION

At ISO, we develop International Standards, such as ISO 9001 and ISO 14001, but we are not involved in their certification, and do not issue certificates. This is performed by external certification bodies, thus a company or organization cannot be certified by ISO.

However ISO's Committee on Conformity Assessment (CASCO) has produced a number of standards related to the certification process, which are used by certification bodies. Read more about CASCO Standards.

Certification – the provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements.

Accreditation – the formal recognition by an independent body, generally known as an accreditation body, that a certification body operates according to international standards.

CHOOSING A CERTIFICATION BODY

When choosing a certification body, you should:

- Evaluate several certification bodies.
- Check if the certification body uses the relevant CASCO standard
- Check if it is accredited. Accreditation is not compulsory, and non-accreditation does not necessarily mean it is not reputable, but it does provide independent confirmation of competence. To find an accredited certification body, contact the national accreditation body in your country or visit the International Accreditation Forum.

DISPLAYING YOUR CERTIFICATE

Remember, when labelling a product or system as certified to an ISO standard:

- **Don't say**: "ISO certified" or "ISO certification"
- **DO say**: "ISO 9001:2015 certified" or "ISO 9001:2015 certification" (for example).

What are the different ISO standards?

ISO standards and Business

- **ISO** 9000 - Quality Management.
- **ISO** / IEC 27000 - Information Security Management Systems.
- **ISO** 14000 – Environmental Management.
- **ISO** 31000: 2018 - Risk Management.
- **ISO** 50001: 2018 - Energy Management.
- **ISO** 26000: 2010 - Social Responsibility.

ISO 9000

ISO 9000 is a quality management standard that presents guidelines intended to increase business efficiency and customer satisfaction. The goal of ISO 9000 is to embed a quality management system within an organization, increasing productivity, reducing unnecessary costs, and ensuring quality of processes and products.

The ISO 9000 family is the world's most best-known quality management standard for companies and organizations of any size.

ISO CERTIFICATION

ISO Certification is a seal of approval from an external body whereby a company complies to one of the internationally recognised ISO Management Systems.

There are many reasons why you may want to adopt a management system. You could increase your success in tenders, improve internal efficiency, reduce costs or simply prove to your potential customers that you are credible.

Each standard supports its own benefits within every industry, however the common benefits across the certifications include: widened market potential, compliance to procurement tenders, improved efficiency and cost savings, higher level of customer service, and therefore satisfaction, and heightened staff morale and motivation. By having a recognised management standard it tells your customers that you are serious about their needs.

STEPS TO OBTAIN ISO CERTIFICATION

You can achieve ISO Certification in just 6-8 weeks using our step by step process.

Step 1: Choose a Management Standard

With over 22,000 international standards available, finding the right one for your business might seem a little daunting.

The **ISO 9001 Quality** Management System is the most popular place to start. This standard helps ensure you deliver a consistent level of quality and satisfaction. Other well-known standards are ISO 27001 Information Security**,** ISO 14001 Environmental and ISO 45001 Occupational Health and Safety.

This best way to determine which management system is right for your business is to discuss your needs with us.

Step 2: Contact Us

If you haven't done so already, please contact our account management team to discuss your requirements. We will then book a visit with one of our consultants to come and run through your needs in more detail. Following this visit, we will then be able to provide you with a proposal.

We pride ourselves on keeping the process as simple as possible.

Step 3: The Initial Assessment

If you accept our proposal, we will book an initial assessment with one of our experienced Lead Auditors. They will conduct a gap analysis to identify what works need to be done in order to become compliant. We will make a series of recommendations.

Step 4: Documentation Preparation

We prepare documentation to include compulsory procedures (as required by the Standard), in line with your current company procedures.

Step 5: Certification

Provided all requirements are met, we will present you with your ISO certification.

The systems are focused on continual improvement and we will continue to support you through the term of your contract by carrying out a six monthly review, ensuring you stay on track and are ready for re-certification each year.

Step 6: Maintaining Compliance

Management systems focus on continual improvement of your products, services or processes so you will be required to continually maintain your management system.

We'll visit you again in six months time to undertake an internal review or 'health check'. At this point, our auditor will provide support and review how your system is being managed at that time. If they spot anything that may cause a problem with your re-certification audit in six months time, they will raise it with you, giving you clear instructions on what you need to do to ensure compliance.

Our internal review will allow you to feel more supported and confident as your annual re-certification audit approaches. Failure to be re-certificated is therefore rare.

Types of Certification

- **ISO 9001:2015**
- A quality management system which enhances and ensure customer satisfaction with quality delivery of product and services.
- **ISO 14001:2015**
- It helps an organization achieve the intended outcomes of its EMS, which provides value for the environment, the organization itself, & interests
- **ISO 45001:2018**
- It ensures the organization has an effective health and safety management system
- **ISO 20000-1:2018**
- It helps to frame best practices in IT & improvement in the delivery of IT services.
- **ISO 22000:2018**
- This standard ensures customers that the organisation has effective food safety management.

- **ISO 13485:2016**
- Ensure medical devices & related services consistently meet Clients & applicable regulatory requirements.

Unit VI

Safety Management

Safety is the state of being "safe", the condition of being protected from harm or other non-desirable outcomes. Safety can also refer to the control of recognized hazards in order to achieve an acceptable level of risk.

“Safety means keeping yourself and others free from harm or danger. It means taking care not to fall or bump or run into things. It also means to avoid accidents.

Reduced the likelihood of injury & accidents - Safety reduces the chances of accidents or injury happening. Improved productivity - A safe work environment with adequate safeguards promote an employee to focus on their works instead of the danger or hazard. Safety reduces injury thereby decreasing lost work hours.

Full Form of **SAFETY -** Stay Alert For Every Task You do.

Five types of workplace hazards and take steps to mitigate employee risk.

- **Safety**. **Safety** hazards encompass any **type** of substance, condition or object that can injure workers.
- Chemical.
- Biological.
- Physical.
- Ergonomic.

Benefits of Safety

A safe and healthy workplace not only protects workers from injury and illness, it can also lower injury/illness costs, reduce absenteeism and turnover, increase productivity and quality, and raise employee morale. In other words, safety is good for business.

Types of Safety Measures

It may be possible to reduce risk by replacing materials, chemicals, equipment or methods with something that is less hazardous.

Personal protective equipment (PPE)

- Gloves.
- Eye protection/face protection.
- Hearing protection.
- Coats/aprons.
- Footwear.
- Head protection.
- Height safety equipment.

10 Easy Ways to Improve Safety in a Manufacturing Work Environment

1. Inform Supervisors of Unsafe Conditions
2. Use Equipment, Machines, and Tools Properly
3. Wear Safety Equipment (PPE)

4. Prevent Slips and Trips

5. Keep Work Areas and Emergency Exits Clear
6. Eliminate Fire Hazards-
7. Avoid Tracking Hazardous Materials
8. Prevent Objects from Falling
9. Use Correct Posture when Lifting
10. Take Work Breaks From Time to Time

Safety Management

Safety management is managing business activities and applying principles, framework, processes to help prevent accidents, injuries and to minimise other risk.

A safety management system is a management system designed to manage safety elements in the workplace. It includes policy, objectives, plans, procedures, organisation, responsibilities and other measures.

Safety management is commonly understood as applying a set of principles, framework, processes and measures to prevent accidents, injuries and other adverse consequences that may be caused by using a service or a product.

A safety management system is a series of policies and procedures organizations use to reduce accidents and illnesses among employees. According to OSHA, "Effective Safety and Health Management Systems (SHMS) have proven to be a decisive factor in reducing the extent and severity of work-related injuries and illnesses.

Objectives of Safety Management

The objective of a Safety Management System is to provide a structured management approach to control safety risks in operations. Effective safety management must take into account the organisation's specific structures and processes related to safety of operations.

Basic Principles of Safety Management

SMS is composed of four functional components:

- Safety Policy.
- Safety Risk Management.
- Safety Assurance.
- Safety Promotion.

Safety Management System (SMS)

A safety management system is a series of defined, organization-wide processes that provide for effective risk-based decisionmaking related to your daily business.

SMS focuses on maximizing opportunities to continuously improve the overall safety of the aviation system. SMS

Builds on existing processes;

Integrates with other management systems by tailoring a flexible regulatory framework to your organisation; and

Demonstrates good business practice.

Roles and Responsibilities within the SMS

The senior manager/accountable executive is accountable for establishing the SMS and allocating resources to support and maintain an effective SMS;

Management is responsible for implementing, maintaining and adhering to SMS processes in their area; and

Employees are responsible for identifying hazards and reporting them.

Key Processes of an SMS

Hazard Identification – a method for identifying hazards related to your organization;

Occurrence Reporting – a process for the acquisition of safety data;

Risk Management – a standard approach for assessing risks and for applying risk controls;

Performance Measurement – management tools for analyzing whether the organization's safety goals are being achieved; and

Quality/Safety Assurance – processes based on quality management principles that support continuous improvement of the organization's safety performance.

Effectiveness of Implementing SMS

A top-down commitment from management and a personal commitment from all employees to achieve safety performance goals;

A clear roadmap of what the SMS is and what it is supposed to accomplish;

An established practice of open communication throughout the organization that is comprehensive and transparent, and where necessary, non-punitive; and

An organizational culture that continuously strives to improve.

Benefits of SMS

Provides for more informed decision-making;

Improves safety by reducing risk of accidents;

Provides for better resource allocation that will result in increased efficiencies and reduced costs;

Strengthens corporate culture; and

Demonstrates corporate due-diligence.

Waste

Waste are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or is worthless, defective and of no use. A by-product by contrast is a joint product of relatively minor economic value.

Types Of Waste

Sources of waste can be broadly classified into four types: Industrial, Commercial, Domestic, and Agricultural.

- Industrial Waste. These are the wastes created in factories and industries. ...

- Commercial Waste. Commercial wastes are produced in schools, colleges, shops, and offices. ...
- Domestic Waste.
- Agricultural Waste.

Causes of Waste

The mismanagement of landfill waste caused by garbage pollution

- Litter on every corner or on the side of the road.
- Oil spills.
- Illegal dumping in natural habitats.
- Debris or damage caused from unsustainable logging practices.
- Pesticides and other farming chemicals.
- Nuclear accidents or radiation spills.

Harmful Effects of Waste

Exposure to hazardous waste can affect human health, children being more vulnerable to these pollutants. Waste from agriculture and industries can also cause serious health risks. Other than this, co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards.

Leachate produced as waste decomposes may cause pollution. Badly-managed landfill sites may attract vermin or cause litter. Incinerating waste also causes problems, because plastics tend to produce toxic substances, such as dioxins, when they are burnt.

Causes of Pollution

Overflowing waste causes air pollution and respiratory diseases. The toxic substances in air contaminated by waste include carbon dioxide, nitrous oxide and methane. In everyday life we identify the polluted air especially through bad odors, which are usually caused by decomposing and liquid waste items.

Waste Management

Waste can be solid, liquid, or gas and each type has different methods of disposal and management. Waste is produced by human activity, for example, the extraction and processing of raw materials. Waste management is intended to reduce adverse effects of waste on human health, the environment or aesthetics.

Waste management include the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process.

Waste management involves the regular collection, transportation as well as processing and disposal or recycling and monitoring of different types of waste materials. These services can save your business a considerable amount of money, and can also prevent the environment from being harmed

Types of Waste Management

There are eight major groups of waste management methods, each of them divided into numerous categories. Those groups include source reduction and reuse, animal feeding, recycling, composting, fermentation, landfills, incineration and land application.

Objectives of Waste Management

- for the protection of environment through effective waste management techniques.
- to protect health, well being and environment.
- to prevent pollution .
- to reduce and reuse of waste.
- safe disposal of waste.
- to minimize the production of waste.

Causes of Waste Management

The mismanagement of landfill waste caused by garbage pollution

- Litter on every corner or on the side of the road.
- Oil spills.
- Illegal dumping in natural habitats.
- Debris or damage caused from unsustainable logging practices.
- Pesticides and other farming chemicals.

Nuclear accidents or radiation spills.

Effects of Waste Management

Some of the catastrophic effects of today's poor waste management systems are listed below:

- Waste Management & Soil Contamination.
- Water Contamination via Improper Wastes.
- Severe Weather Due to Climate Contamination.
- How The Air is Contaminated.
- Harm Towards Animal and Marine Life.
- Human Damage.

Benefits of Waste Management

Proper safety measures and waste disposal methods make for a cleaner, safer world with less diseases and lower potential harm to both humans and animals. When done right, waste management can also conserve energy and reduce dangerous deforestation including cutting down less trees for paper production.

Disadvantages of Waste Management

- The process is not always cost-effective
- The resultant product has a short life
- The sites are often dangerous
- The practices are not done uniformly
- Waste management can cause more problems

Company’s strategies for the wastes and recycling

For small and medium size manufacturing industry for manufacturing products with increase materials it is likely to reduce waste production. When waste minimization has been introduced, innovative and commercially successful products are consumed as replacements. This term “waste management” is a great benefit for not only industry but also the environment.

Waste minimization never comes free of cost and investment is required. This investment is remunerated by savings but it is known fact that if a portion is processed for waste reduction then it is possible that other portion may get in to the excessive production of waste.

Government is putting forward incentives for waste reduction and focus on the benefits for environment over the adoption of strategies for waste reduction.

Following is mentioned the list for the waste reduction or minimization process:

- Utilization of resources: waste reduction at individual and institutional level goes side by side with the proper utilization of raw materials.
- Reuse of the Scrap Material: this is the process in which individual and industry reuse the waste material as much as possible it is produced. This keeps it from becoming a waste material.
- Quality control improvement and process monitoring: this technique is to ensure that products produced are kept from rejection and this is increased by the inspection of frequency and monitoring point's inspection.
- Exchanging Waste: this is the technique in which the waste product, which comes out of a process, becomes a raw material for another process. This is another way for reducing waste.
- Supplychain: to maintain and making deliveries for the raw materials to be used with the manufacturing process, at the point of assembly with fewer packages and wrappings can save from the waste production.

Prevention of waste

Our production and consumption lead to large quantities of waste. An important element in work on over production is therefore sustainable waste management. Sweden considers it necessary for the volume of waste to decrease if we are to come close to sustainable management of waste [5]. Manufacturer must already take account of a product's environmental impact in a lifecycle perspective when it is manufactured. Design and material selection, as well as energy consumption in manufacturing and use must be taken into account. In addition, sustainable cycles can only be achieved if a greater proportion of waste can be reused and recycled. Which can saves both materials and energy, while also reducing the use of hazardous chemicals and environmental problems in waste management.

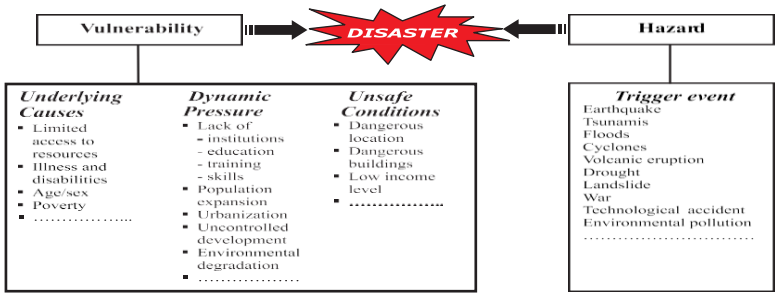
DISASTER MANAGEMENT

Almost every day, newspapers, radio and television channels carry reports on disaster striking several parts of the world. But what is a disaster? The term disaster owes its origin to the French word "Desastre" which is a combination of two words 'des' meaning bad and 'aster' meaning star. Thus the term refers to 'Bad or Evil star'. A disaster can be defined as *"A serious disruption in the functioning of the community or a society causing wide spread material, economic, social or environmental losses which exceed the ability of the affected society to cope using its own resources"*.

A disaster is a result from the combination of hazard, vulnerability and insufficient capacity or measures to reduce the potential chances of risk.

A disaster happens when a hazard impacts on the vulnerable population and causes damage, casualties and disruption. The figure would give a better illustration of what a disaster is. Any hazard – flood,

earthquake or cyclone which is a triggering event along with greater vulnerability (inadequate access to resources, sick and old people, lack of awareness etc) would lead to disaster causing greater loss to life and property. For example; an earthquake in an uninhabited desert cannot be considered a disaster, no matter how strong the intensities produced.



An earthquake is disastrous only when it affects people, their properties and activities. Thus, disaster occurs only when hazards and vulnerability meet. But it is also to be noted that with greater capacity of the individual/community and environment to face these disasters, the impact of a hazard reduces. Therefore, we need to understand the three major components namely hazard, vulnerability and capacity with suitable examples to have a basic understanding of disaster management.

Hazard and its classification

Hazard may be defined as *"a dangerous condition or event, that threat or have the potential for causing injury to life or damage to property or the environment."* The word 'hazard' owes its origin to the word 'hasard' in old French and 'az-zahr' in Arabic meaning 'chance' or 'luck'. Hazards can be grouped into two broad categories namely natural and manmade.

1. Natural hazards are hazards which are caused because of natural phenomena (hazards with meteorological, geological or even biological origin). Examples of natural hazards are cyclones, tsunamis, earth- quake and volcanic eruption which are exclusively of natural origin. Landslides, floods, drought, fires are socio-natural hazards since their causes are both natural and manmade. For example flooding may be caused because of heavy rains, landslide or blocking of drains with human waste.

2. Manmade hazards are hazards which are due to human negligence. Manmade hazards are associated with industries or energy generation facilities and include explosions, leakage of toxic waste, pollution, dam failure, wars or civil strife etc.

The list of hazards is very long. Many occur frequently while others take place occasionally. However, on the basis of their genesis, they can be categorized as follows:

Various types of hazards

Types	Hazards	
Geological Hazards	1. Earthquake	4. Landslide
	2. Tsunami	5. Dam burst
	3. Volcanic eruption	6. Mine Fire

Water & Climatic Hazards	1. Tropical Cyclone 2. Tornado and Hurricane 3. Floods 4. Drought 5. Hailstorm	6. Cloudburst 7. Landslide 8. Heat & Cold wave 9. Snow Avalanche 10. Sea erosion
Environmental Hazards Biological	1. Environmental pollutions 2. Deforestation 1. Human / Animal Epidemics 2. Pest attacks	3. Desertification 4. Pest Infection 3. Food poisoning 4. Weapons of Mass Destruction

Types	Hazards	
Chemical, Industrial and Nuclear Accidents	1. Chemical disasters 2. Industrial disasters	3. Oil spills/Fires 4. Nuclear
Accident related	1. Boat / Road / Train accidents / air crash Rural / Urban fires Bomb /serial bomb blasts 2. Forest fires	3. Building collapse 4. Electric Accidents 5. Festival related disasters 6. Mine flooding

Vulnerability

Vulnerability may be defined as *"The extent to which a community, structure, services or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrains or a disaster prone area."*

Vulnerabilities can be categorized into physical and socio-economic vulnerability.

Physical Vulnerability*:* It includes notions of who and what may be damaged or destroyed by natural hazard such as earth- quakes or floods. It is based on the physical condition of people and elements at risk, such as buildings, infrastructure etc; and their proximity, location and nature of the hazard. It also relates to the technical capability of building and structures to resist the forces acting upon them during a hazard event.

Unchecked growth of settlements in unsafe areas exposes the people to the hazard. In case of an earth-quake or landslide the ground may fail and the houses on the top may topple or slide and affect the settlements at the lower level even if they are designed well for earthquake forces.

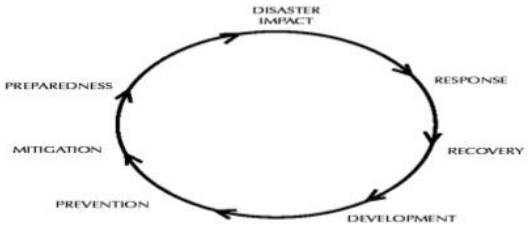
Socio-economic Vulnerability*:* The degree to which a population is affected by a hazard will not merely lie in the physical components of vulnerability but also on the socio- economic conditions. The socio-economic condition of the people also determines the intensity of the impact. For example, people who are poor and living in the sea coast don't have the money to construct strong concrete houses. They are generally at risk and loose their shelters whenever there is strong wind or cyclone. Because of their poverty they too are not able to rebuild their houses.

7 PHASES OF THE DISASTER MANAGEMENT CYCLE

THE DISASTER MANAGEMENT CYCLE

• ***Basic Format***

Figure 1: Basic Format of the Disaster Management Cycle



Disaster management aims to reduce, or avoid, the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The Disaster management cycle illustrates the ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after a disaster has occurred. Appropriate actions at all points in the cycle lead to greater preparedness, better warnings, reduced vulnerability or the prevention of disasters during the next iteration of the cycle. The complete disaster management cycle includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

The mitigation and preparedness phases occur as disaster management improvements are made in anticipation of a disaster event. Developmental considerations play a key role in contributing to the mitigation and preparation of a community to effectively confront a disaster. As a disaster occurs, disaster management actors, in particular humanitarian organizations, become involved in the immediate response and long-term recovery phases. The four disaster management phases illustrated here do not always, or even generally, occur in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.

- **Prevention:** Activities aimed at trying to prevent future disasters occurring, such as building dykes or a dam to control flooding.
- **Mitigation:** Activities aimed at trying to mitigate the impact of a disaster if prevention is not possible, such as building schools to be more earthquake resistant. Minimizing the effects of disaster. Examples: building codes and zoning; vulnerability analyses; public education.

Mitigation activities actually eliminate or reduce the probability of disaster occurrence, or reduce the effects of unavoidable disasters. Mitigation measures include building codes; vulnerability analyses updates; zoning and land use management; building use regulations and safety codes; preventive health care; and public education.

Mitigation will depend on the incorporation of appropriate measures in national and regional development planning. Its effectiveness will also depend on the availability of information on hazards, emergency risks, and the countermeasures to be taken. The mitigation phase, and indeed the whole disaster management cycle, includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

- **Preparedness:** Activities aimed at trying to prepare communities for a disaster, such as emergency drills or pre-stocking relief items in logistic hubs. Planning how to respond.

The goal of emergency preparedness programs is to achieve a satisfactory level of readiness to respond to any emergency situation through programs that strengthen the technical and managerial capacity of governments, organizations, and communities. These measures can be described as logistical readiness to deal with disasters and can be enhanced by having response mechanisms and procedures, rehearsals, developing long-term and short-term strategies, public education and building early warning systems. Preparedness can also take the form of ensuring that strategic reserves of food, equipment, water, medicines and other essentials are maintained in cases of national or local catastrophes.

During the preparedness phase, governments, organizations, and individuals develop plans to save lives, minimize disaster damage, and enhance disaster response operations. Preparedness measures include preparedness plans; emergency exercises/training; warning systems; emergency communications systems; evacuations plans and training; resource inventories; emergency personnel/contact lists; mutual aid agreements; and public information/education. As with mitigations efforts, preparedness actions depend on the incorporation of appropriate measures in national and regional development plans. In addition, their effectiveness depends on the availability of information on hazards, emergency risks and the countermeasures to be taken, and on the degree to which government agencies, non-governmental organizations and the general public are able to make use of this information. Examples: preparedness plans; emergency exercises/training; warning systems.

- **Disaster:** An event that causes significant damage to people, property and infrastructure.
- **Response:** Activities aimed at understanding needs and responding to them, including rapid assessments, provision of food and non-food items, provision of water, sanitation and hygiene services, and health and shelter interventions. In the immediate hours and days after a disaster, when search-and-rescue activities are critical, it is most often local actors who are first to respond. Information is often patchy and confused, there can be significant damage to infrastructure, and large movements of people. Efforts to minimize the hazards created by a disaster.

The aim of emergency response is to provide immediate assistance to maintain life, improve health and support the morale of the affected population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transport, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations. It also may involve initial repairs to damaged infrastructure. The focus in the response phase is on meeting the basic needs of the people until more permanent and sustainable solutions can be found. Humanitarian organizations are often strongly present in this phase of the disaster management cycle. Examples: search and rescue; emergency relief.

- **Recovery:** Activities aimed at trying to return communities to normal life, such as livelihoods development or formal education. Recovery activities can start when the disaster has stabilised, and the affected population has access to food and water and some form of transitional shelter. This stage is sometimes divided into two: early recovery and medium-term recovery. Returning the community to

normal.

As the emergency is brought under control, the affected population is capable of undertaking a growing number of activities aimed at restoring their lives and the infrastructure that supports them. There is no distinct point at which immediate relief changes into recovery and then into long-term sustainable development. There will be many opportunities during the recovery period to enhance prevention and increase preparedness, thus reducing vulnerability. Ideally, there should be a smooth transition from recovery to on-going development.

Recovery activities continue until all systems return to normal or better. Recovery measures, both short and long term, include returning vital life-support systems to minimum operating standards; temporary housing; public information; health and safety education; reconstruction; counseling programs; and economic impact studies. Information resources and services include data collection related to rebuilding, and documentation of lessons learned. Examples: temporary housing; grants; medical care.

- **Reconstruction:** Activities aimed at rebuilding infrastructure and housing. This can often take years and many activities may also blend back into mitigation, such as retrofitting schools to make them more earthquake resistant.

Stores Management

A storehouse is a building provided for preserving materials, stores and finished goods. The in-charge of store is called storekeeper or stores manager. The organisation of the stores department depends upon the size and layout of the factory, nature of the materials stored and frequency of purchases and issue of materials.

According to Alford and Beatty “storekeeping is that aspect of material control concerned with the physical storage of goods.” In other words, storekeeping relates to art of preserving raw materials, work-in-progress and finished goods in the stores.

Store management is concerned with ensuring that all the activities involved in storekeeping and stock control are carried out efficiently and economically by the store personnel. In many cases this also encompasses the recruitment, selection, induction and the training of store personnel, and much more. Store management is “to receive materials, to protect them while in storage from damage & unauthorized removal, to issue the material in the right quantities, at the right time to the right place and to provide these service promptly and at least cost”.

Store and Storekeeping

Stores plays a vital role in the operation of a company. Generally unworked material is stored and the place where it is stored is called Store Room. It is in direct touch with the user departments in its day-to-day activities. The chief aim of the stores is to ensure the smooth flow of production without any interruption. Stores generally include raw materials, work in progress and finished goods.

Effective storekeeping and inventory control are indispensable to the control of material cost.

Further, stores often equated directly with money, as capital is blocked in inventories.

'Store keeping' refers to the safe custody of all items of raw materials, supplies, finished parts, purchased parts etc., in the store-room for which the store-keeper acts as a trustee. ... According to Alford and Beatty, “Store keeping is that aspect of material control concerned with the physical storage of goods.”

Purpose of Storekeeping

(1) Storekeeping helps to examine carefully all goods and materials on receipts.
(2) It is essential to arrange for a systematic and efficient storing of materials.
(3) Storekeeping ensure accurate and prompt distribution of materials to user departments as per issue requisition note.
(4) It is essential because stores often equated directly with money, as capital is blocked in inventories.

Functions of the Storekeeper

The store is a service department headed by the storekeeper who holds the responsible position in the organisation of the stores department. He is as much responsible for the articles incharge as a cashier for the cash. Important functions of the storekeeper are given below:

(1) He must receive raw materials, components, tools, equipment and other items and account for them properly.
(2) He must provide adequate and proper storage and preservation to the various items.
(3) He must check, and provide proper classification and codification of materials.
(4) Issue the materials as per material issue requisition duly signed by an authorized person.
(5) He has to take steps to prevent leakage, theft, wastage and deterioration.
(6) He must ensure good storekeeping.
(7) He should not permit any person without authorization.
(8) He should maintain proper records in order to know desired quantities available.
(9) He must provide adequate information to the top executives for verifications and effective decision making.

Functions of Stores

1. Receipt
2. Storage
3. Retrieval
4. Issue
5. Records
6. Housekeeping
7. Control
8. Surplus management
9. Verification
10. Interaction & coordination

Stores Layout

In order to achieve the objectives of effective inventory control, well planned layout of stores should be required. A planned stores layout will facilitate easy movement of materials, good housekeeping, sufficient space for materials handling. It ensures effective utilization of storage space and judicious use of storage equipments. The stores department should be equipped with shelves, racks, pallets and proper preservation from rain. light and other such elements. An ideal location of stores should facilitate the volume and variety of goods to be handled. In order to bring down the transport cost it should be close to roads or railway stations. And also as far as possible, a the stores department should be near to

the receiving department. In the case of large organizations usually stores attached to each consuming department, whereas receiving is done centrally.

Types of Stores

The types of stores depend on the size, types and policy of the organization. Organization of stores varies from concern to concern. As per the requirement of the firm the stores organization may be classified into :

(a) Centralized Stores.
(b) Decentralized Stores.
(c) Combination of both, i.e., Centralized Stores with Sub Stores.

(a) Centralized Stores: This system is suitable to small-scale industries where it is desirable to centralize the materials in one department. Under this system, the store room will be most conveniently situated where it is near to all the departments.

Advantages of Centralized Stores

(1) Well planned layout of stores.
(2) Effective utilization of floor space.
(3) Better supervision of stores is possible.
(4) Effective material handling is possible.
(5) Lot of manual work may be eliminated.
(6) Better control is possible.
(7) Less investment is required.
(8) Ensures minimum wastages.
(9) Facilitates prompt flow of materials.
(10) Better forecasting is possible.

Disadvantages

(1) Increases transportation costs.
(2) Delay and inconvenience because of over-crowding of materials.
(3) Greater risk of loss in case of fire.
(4) Break down in transport will affect continuous flow of production.
(5) Increases cost of materials handling.

(b) **Decentralized Stores**: Under this system each department has its own stores. It is suitable to large concern where there are several departments each using a different type of material from its own stores. In this system all the disadvantages of centralized stores can be eliminated.

(c) **Combination of Both** : This system is also termed as Imprest System or stores control. Centralized Stores with Sub Stores is usually adopted in large factories where departments are situated at a distance from the central stores. In order to minimize the cost of transportation and materials handling, this type of organization would be located nearer to the receiving department. Under this system material receipts are stored in the central stores and issues are made to the sub-stores. Under imprest system of stores control sub stores which are located nearer to the central stores for the purpose of draw supplies from central stores and issue the required quantity to production. To maintain the stocks at the predetermined level, the sub-stores make requisition from the central stores.

Working of the stores:

There are four sections in the process of storekeeping viz.

(a) Receiving section,
(b) Storage section,
(c) Accounting section, and
(d) Issue section.

These are explained as under:

(a) Receiving Section:

There are four kinds of inventories received by stores viz., (i) raw materials, (ii) stores and supplies, (iii) tools and equipments, (iv) work-in- progress or semi-finished goods.

Following procedure is followed in receiving these inventories:

(i) Receiving these incoming materials in stores.
(ii) Checking and inspection of these incoming materials and stores etc.
(iii) Recording the incoming materials in goods received book.
(iv) Preparing and forwarding goods inwards note to purchasing section.
(v) Informing the purchase department about damaged and defective goods and surplus or deficit supplies etc. along with rejection forms and notes.
(vi) Returning damaged or defective goods to the suppliers in accordance with the instructions of the
(vii) Forwarding the materials to respective stores and locations where these are to be stored or preserved.

(b) Storage Section:

The store room should be located at a convenient and appropriate place. It should have ample facilities to store the materials properly viz. bins, racks and shelves etc. There can be a single store room in case of a small organisation, but a large scale concern can have different or multiple stock rooms in addition to general or main store.

The separate stockrooms may be used for different classes of inventories. The material should be stored in such a manner as to protect it against the risks of damage, destruction and any kind of loss. Each article should have identifying marks viz., stamping, embossing, colour, coding and painting etc. These risks are very useful in locating or identifying an article in the stores.

(c) Accounting Section:

This section is concerned with keeping proper records with regard to receipt and issue of materials. The primary task of this section is to undertake the process of inventory control.

(d) Issue Section:

The materials should be issued to respective departments on receiving duly authorised requisition slips. An entry should be made immediately on the bin card attached with the bin from where the material has been issued.

Bin cards contain valuable information with regard to receipt and issue of materials, which is greatly helpful in exercising a system of inventory control. These cards are further helpful in determining various levels of materials viz., maximum, minimum, and re-ordering level.

Store System

- **Closed door system**: the stored material is held under lock and key. Entry into the store is restricted authorized persons only. Physical movement of the material is only with authorized documents only. Maximum security and tight control on movement are features of this system

☐ **Open stores system**: In this system material is stored near point of use and there is restriction on consumption. Control passes on to the operations department

Classification & Codification

Definition of Classification

This is the division of stores into different groups based on similarities or technical affinity.

Definition of Codification

This is a system of symbols designed to be applied to a classified set of items to give a brief accurate reference, facilitating entry, collation and analysis.

Classification of stores

These are the common classes are:

- Raw materials e.g. Cotton, Sugarcane etc
- Consumables e.g. fuels, petrol, rivets etc
- Machinery and equipments e.g. Bench vice, grinder, wheel barrow etc
- Inflammable stores e.g. methylated spirit, thinner – paint solvents etc
- Chemicals e.g. Acids, elements like potassium etc
- Furniture e.g. Desks, tables, shelves etc
- Scrap Materials e.g. residual value engine parts, fish and chicken from firms
- Packaging materials e.g. Paper, wood, straw etc
- Fuel Stocks e.g. Coal, crude oil etc
- Defective Goods e.g. Bata Mini Shops products
- Dead Inventory e.g. John Deere Tractor Spare Parts in Mumias Sugar Company Books, etc
- General Stores e.g. Uniforms, brushes etc.

CONDITIONS OF STORES / MATERIALS: WHAT ARE THEIR STATES?

- Serviceable and unserviceable
- Finished, semi-finished and unfinished
- Dead Stock items or obsolete stores
- Unused Stock

IMPORTANCE OF CLASSIFICATION

It helps the firm in these areas:

i. Controlling stock
ii. Purchasing
iii. Selling / Distributing
iv. Storing
v. Accounting

CODIFICATION

Advantages /Merits/ Benefits of Codification

- Helps to avoid the long and unwieldy description,
- Provides accurate and logical identification,
- Prevents duplication and repetition,
- Helps in standardization,
- Reduces varieties,

- Helps to create an efficient purchasing function department,
- Simplifies and facilitates the mechanical recording,
- Creates an efficient accounting system; accounting is the systematic recording of items in the monetary terms e.g.in Kshs, In Euros etc
- Simplifies and facilitates the pricing and costing,
- Ensures a proper system of location and indexing,
- Ensures a correct and efficient inspection,
- Ensures the production plan is implemented as required.

Disadvantages / Demerits of Codification

- Mistakes in coding
- Herculean task to detect the coding mistake
- Misunderstanding the codification
- Challenge of the choice codification e.g. numbering often large numbering in one group
- Use of dummy codes

CODIFICATION SYSTEM

Characteristics

A code system should have the following characteristics to be scientific and easily adoptable:

- Simple to use: easy to understand with minimum and /or no need for training,
- Flexible: ease to expand and accommodate more codes,
- Good formulation: adopted system should be able to be used in all functional areas in the entire organization.

Common Codification Systems

i. Alphabetical – the use of the letter of the alphabet as the basis e.g. Iron ore rep. I-O etc

ii. Numerical – the use of the numbers as the basis of the codes e.g. simple number 01, 02, or complex systems which combines "/" – strokes or "–" dashes e.g. 1-100, 2-200 etc

iii. Alpha-numeric – the combination of alphabets and numbers. This is the mixing of numbers and letters of the alphabets e.g. SP-11 etc

iv. Decimal – the use dash or stroke in the coding e.g. Main, Sub I, sub II an sub III e.g. 47.1.1 etc

v. Brisch – this is the use of numeric system. It combines numbers and decimals. E.g. 47.002

vi. Kodak – this originated by Eastman Kodak Co. of the USA. This system borrows all the good points from all other systems. It is much based on the numerical codification system and in the place of decimals hyphens are used in the Kodak System.

Marking of stores / materials

This is another method of codification. There are two types of marking of stores:

Types

i. **Color marking** – this is used to supplement the other codification systems e.g. use of paint such as blue, red, aluminum etc

ii. **Secret Marking** – expensive stores items are highly susceptible to theft and pilferage. These are discreetly marked to help detect / identify from where they have been sold out. The secret marks are not easily visible.