Production Management

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Introduction to Production

Introduction

Production/operations management is the process, which combines and transforms various resources used in the production/operations subsystem of the organization into value added product/services in a controlled manner as per the policies of the organization. Therefore, it is that part of an organization, which is concerned with the transformation of a range of inputs into the required (products/services) having the requisite quality level.

The set of interrelated management activities, which are involved in manufacturing certain products, is called as **production management**. If the same concept is extended to services management,

then the corresponding set of management activities is called as **operations management**.

1. Historical Evolution of Production and Operations Management

Product Management has evolved significantly over the years, adapting to changing business landscapes, technological advancements, and customer expectations. In this post, we will discuss and cover the brief history and evolution of Product Management.

1. Early 20th Century: The Birth of Product Management

- The roots of Product Management can be traced back to the early 20th century when brand management and marketing functions began to take shape.

- The focus during this period was on sales, distribution, and advertising, with limited attention given to the strategic aspects of managing a product over its lifecycle.

2. **1950s-1960s: Rise of Brand Management**

- The concept of brand management gained prominence, and companies started recognizing the need for individuals responsible for overseeing a brand's development and market success.
- Procter & Gamble is often credited with pioneering brand management during this era.

3. 1970s: Introduction of the Marketing Mix

- The marketing mix, popularized by Neil Borden and refined by E. Jerome McCarthy, became a foundational concept in marketing.
- The mix included the four Ps: Product, Price, Place, and Promotion, emphasizing the

importance of product strategy within the marketing framework.

4. 1980s: Cross-Functional Teams and Software Development

- The software industry played a crucial role in shaping modern Product Management.
- Cross-functional teams emerged, involving collaboration between product development, marketing, and other departments.
- The role of a "Product Manager" began to crystallize, especially in technology companies.

5. 1990s: Agile Development and the Internet Boom

- The Agile development methodology gained popularity, emphasizing iterative development, customer collaboration, and rapid responses to change.
- The rise of the internet and e-commerce led to a shift in focus towards online products and

services, further highlighting the need for strategic Product Management.

6. 2000s: Product Management in the Digital Age

- With the proliferation of digital products and the rise of startups, the role of Product Manager became more defined and critical.
- Silicon Valley played a significant role in shaping modern Product Management practices.
- Lean Startup principles, popularized by Eric Ries, emphasized a more iterative and customer-centric approach.

7. 2010s: Expansion of Product Management Influence

- The importance of Product Management expanded beyond the tech industry to various sectors, including finance, healthcare, and consumer goods.
- Product Management frameworks and certifications gained popularity (e.g.,

Pragmatic Marketing, Certified Scrum Product Owner).

8. Present: Agile, Data-Driven Decision-Making, and User-Centricity

- Agile methodologies continue to dominate product development, with a focus on adaptability and responsiveness.
- Data-driven decision-making has become integral to Product Management, leveraging analytics and user feedback for informed choices.
- User-centric design principles, such as Design Thinking, are increasingly influencing product development strategies.

9. Future: Continued Evolution and Integration

- The future of Product Management is likely to involve even greater integration with emerging technologies, such as artificial intelligence and machine learning.

- Continued emphasis on user experience, sustainability, and ethical considerations will shape the evolution of Product Management.
- Timeline:

- **Early 20th Century:**
    - 1900s-1910s: Birth of product management roots with a focus on sales and distribution.
- **Mid-20th Century:**
    - 1931 – In 1931, product management started with a 800 word memo named "Brand Men" written by Neil McElroy. Individual managers were assigned to manage particular brands. These brand managers were in charge of not only the production of their assigned brands, but also their marketing, promotion, and overall strategy.
    - 1940's- Kanban was introduced in the late 1940's in Japan by Toyota

Production System(TPS). The term Kanban comes from two Japanese words, “Kan” which means sign and “Ban” meaning board.

- **1970s:**
    - Introduction of the marketing mix, including Product as a key element.
- **1980s:**
    - Emergence of cross-functional teams and the role of the product manager in technology companies.
- **1990s:**
    - Popularization of Agile development methodology.
    - Internet boom and the shift towards online products and services.
    - Scrum, XP and DSDM was developed in 1990

- **2000s**:
    - Expansion of product management influence beyond tech.
    - Adoption of Lean Startup principles for iterative and customer-centric approaches.
    - 2001 – Agile Manifesto was written in 2001, the Agile Manifesto is similar to a set of important rules developed by a group of people. These guidelines are not meant to implement strict procedures, but rather to help in the improvement of product management.
- **2010s:**
    - Dominance of Agile methodologies in product development.
    - Rise of data-driven decision-making and user-centric design principles.

- **Present**:
    - Ongoing emphasis on Agile, data-driven decision-making, and user-centricity.
- Future:
    - Integration with emerging technologies like AI and ML.
    - Continued emphasis on user experience, sustainability, and ethical considerations.

Evolution of Product Management:

Table 1 Evolution of Product Management

Era	Key Developments
Early 20th Century	Birth of product management with a focus on sales and distribution.
1950s-1960s	Rise of brand management, recognizing the need for overseeing a brand's development.

Era	Key Developments
1970s	Introduction of the marketing mix, emphasizing the importance of product strategy.
1980s	Emergence of cross-functional teams and the role of the product manager in technology companies.
1990s	Popularization of Agile development methodology.
	Internet boom and the shift towards online products and services.
2000s	Expansion of product management influence beyond tech.
	Adoption of Lean Startup principles for iterative and customer-centric approaches.
2010s	Dominance of Agile methodologies in product development.
	Rise of data-driven decision-making and user-centric design principles.

Era	Key Developments
Present	Ongoing emphasis on Agile, data-driven decision-making, and user-centricity.
Future	Integration with emerging technologies like AI and ML.

2. Concept of Production

Production function is that part of an organization, which is concerned with the transformation of a range of inputs into the required outputs (products) having the requisite quality level.

Production is defined as “the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user.” Thus production is a

value addition process. At each stage of processing, there will be value addition.

Edwood Buffa defines production as ‘a process by which goods and services are created’. Some examples of production are: manufacturing custom-made products like, boilers with a specific capacity, constructing flats, some structural fabrication works for selected customers, etc., and manufacturing standardized products like, car, bus, motor cycle, radio, television, etc.

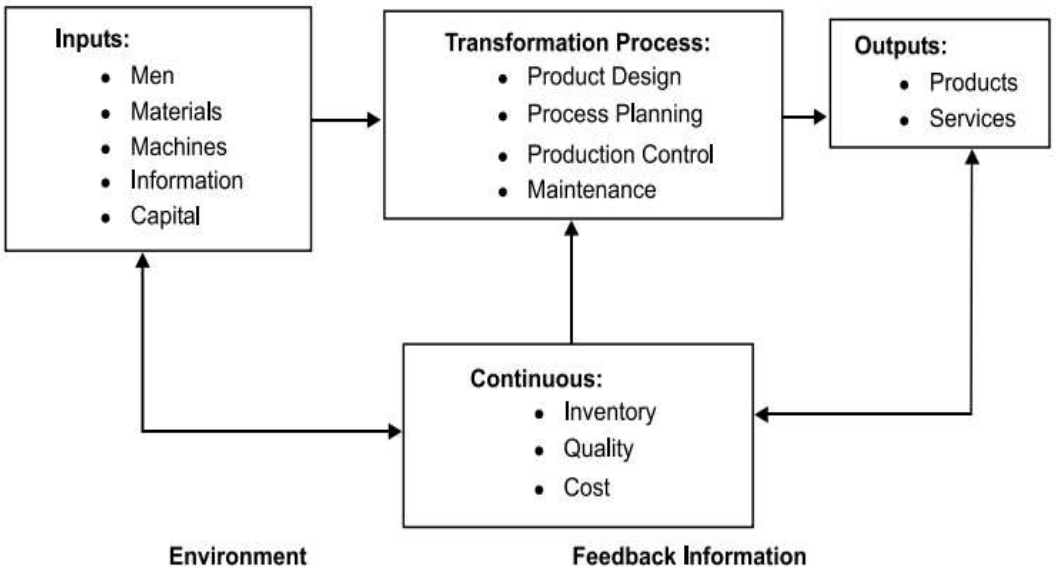

Figure 1 production as a process

1. According to E. L. Brech, "Production management is the process of effective planning and regulating the operations of that section of an enterprise which is responsible for the actual transformation of materials into finished products.

2. According to E. S. Buffa, "Production management deals with decision making

related to production process so that the resulting goods or service is produced according to specifications, in the amounts and by the schedule demanded and at minimum cost."

Production refers to a sequence of processes that transform inputs into a desired form. It is a process by which raw materials are transformed into semi-finished goods and semi-finished goods into finished items. The transformation from inputs to outputs, may be done in any one or in the combination of the following ways:

1. **Transformation by Disintegration**: There is essentially one ingredient as input and producing several outputs. For example, producing rolling steel bars from steel ingots or producing a number

of nails from a piece of iron.

2. **Transformation by Integration or by Assembly**: In this case, there is a use of several components as inputs and obtaining essentially one product as output. For example, producing a television set, automobiles, machines, etc.
3. **Transformation by Service**: In this case, certain operations are undertaken that may add to the value or utility of the item. For instance, regular maintenance of a machine would increase its life, and better performance.

3. Production System

The production system of an organization is that part, which produces products of an organization. It is that activity

whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management. A simplified production system is shown above.

The production system has the following characteristics:

a) Production is an organized activity, so every production system has an objective.
b) The system transforms the various inputs to useful outputs.
c) It does not operate in isolation from the other organization system.
d) There exists a feedback about the activities, which is essential to control and improve system performance.

- Classification of Production System

Production systems can be classified as Job Shop, Batch, Mass and Continuous Production systems.

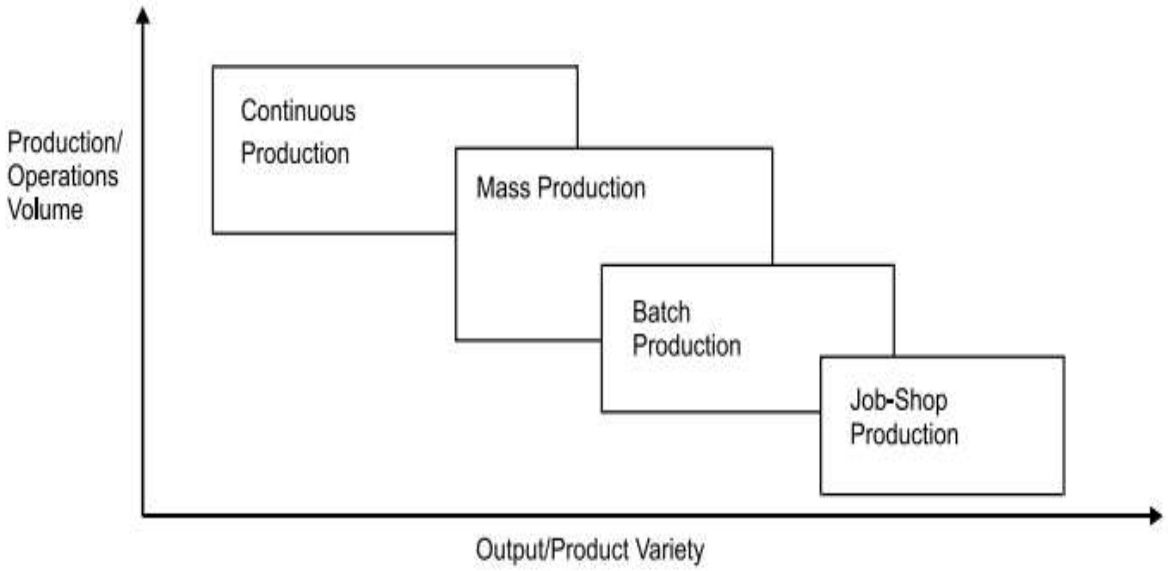

Figure 2 Classification of Production System

- **JOB SHOP PRODUCTION:**

Job shop production are characterized by manufacturing of one or few quantity of products designed and produced as per the

specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products.

A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

Characteristics

The Job-shop production system is followed when there is:

- High variety of products and low volume.
- Use of general purpose machines and facilities.
- Highly skilled operators who can take up

each job as a challenge because of uniqueness.

- Large inventory of materials, tools, parts.
- Detailed planning is essential for sequencing the requirements of each product, capacities for each work center and order priorities.

Advantages

Following are the advantages of job shop production:

- Because of general purpose machines and facilities variety of products can be produced.
- Operators will become more skilled and competent, as each job gives them learning opportunities.
- Full potential of operators can be

utilized.

– Opportunity exists for creative methods and innovative ideas.

Limitations

Following are the limitations of job shop production:

– Higher cost due to frequent set up changes.

– Higher level of inventory at all levels and hence higher inventory cost.

– Production planning is complicated.

– Larger space requirements.

- BATCH PRODUCTION:

Batch production is defined by American Production and Inventory Control Society (APICS) “as a form of manufacturing in

which the job passes through the functional departments in lots or batches and each lot may have a different routing." It is characterized by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales.

Characteristics

Batch production system is used under the following circumstances:

- When there is shorter production runs.
- When plant and machinery are flexible.
- When plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.
- When manufacturing lead time and cost are lower as compared to job order production.

Advantages

Following are the advantages of batch production:

- Better utilization of plant and machinery.
- Promotes functional specialization.
- Cost per unit is lower as compared to job order production.
- Lower investment in plant and machinery.
- Flexibility to accommodate and process number of products.
- Job satisfaction exists for operators.

Limitations

Following are the limitations of batch production:

- Material handling is complex because of irregular and longer flows.

- Production planning and control is complex.
- Work in process inventory is higher compared to continuous production.
- Higher set up costs due to frequent changes in set up.

- MASS PRODUCTION:

Manufacture of discrete parts or assemblies using a continuous process are called mass production. This production system is justified by very large volume of production. The machines are arranged in a line or product layout. Product and process standardization exists and all outputs follow the same path.

Characteristics

Mass production is used under the following circumstances:

- Standardization of product and process sequence.
- Dedicated special purpose machines having higher production capacities and output rates.
- Large volume of products.
- Shorter cycle time of production.
- Lower in process inventory.
- Perfectly balanced production lines.
- Flow of materials, components and parts is continuous and without any back tracking.
- Production planning and control is easy.
- Material handling can be completely automatic.

Advantages

Following are the advantages of mass production:

- Higher rate of production with reduced cycle time.
- Higher capacity utilization due to line balancing.
- Less skilled operators are required.
- Low process inventory.
- Manufacturing cost per unit is low.

Limitations

Following are the limitations of mass production:

- Breakdown of one machine will stop an entire production line.
- Line layout needs major change with the changes in the product design.

- High investment in production facilities.
- The cycle time is determined by the slowest operation.

- CONTINUOUS PRODUCTION:

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

Characteristics

Continuous production is used under the following circumstances:

- Dedicated plant and equipment with zero flexibility
- Material handling is fully automated.
- Process follows a predetermined

sequence of operations.

- Component materials cannot be readily identified with final product.
- Planning and scheduling is a routine action.

Advantages

Following are the advantages of continuous production:

- Standardization of product and process sequence.
- Higher rate of production with reduced cycle time.
- Higher capacity utilization due to line balancing.
- Manpower is not required for material handling as it is completely automatic.
- Person with limited skills can be used

on the production line.

- Unit cost is lower due to high volume of production.

Limitations

Following are the limitations of continuous production:

- Flexibility to accommodate and process number of products does not exist.
- Very high investment for setting flow lines.
- Product differentiation is limited.

4. Production Management

Production management is a process of planning, organizing, directing and controlling the activities of the production function. It combines and transforms various resources used in the production subsystem

of the organization into value added product in a controlled manner as per the policies of the organization.

E.S. Buffa defines production management as, “Production management deals with decision making related to production processes so that the resulting goods or services are produced according to specifications, in the amount and by the schedule demanded and out of minimum cost.”

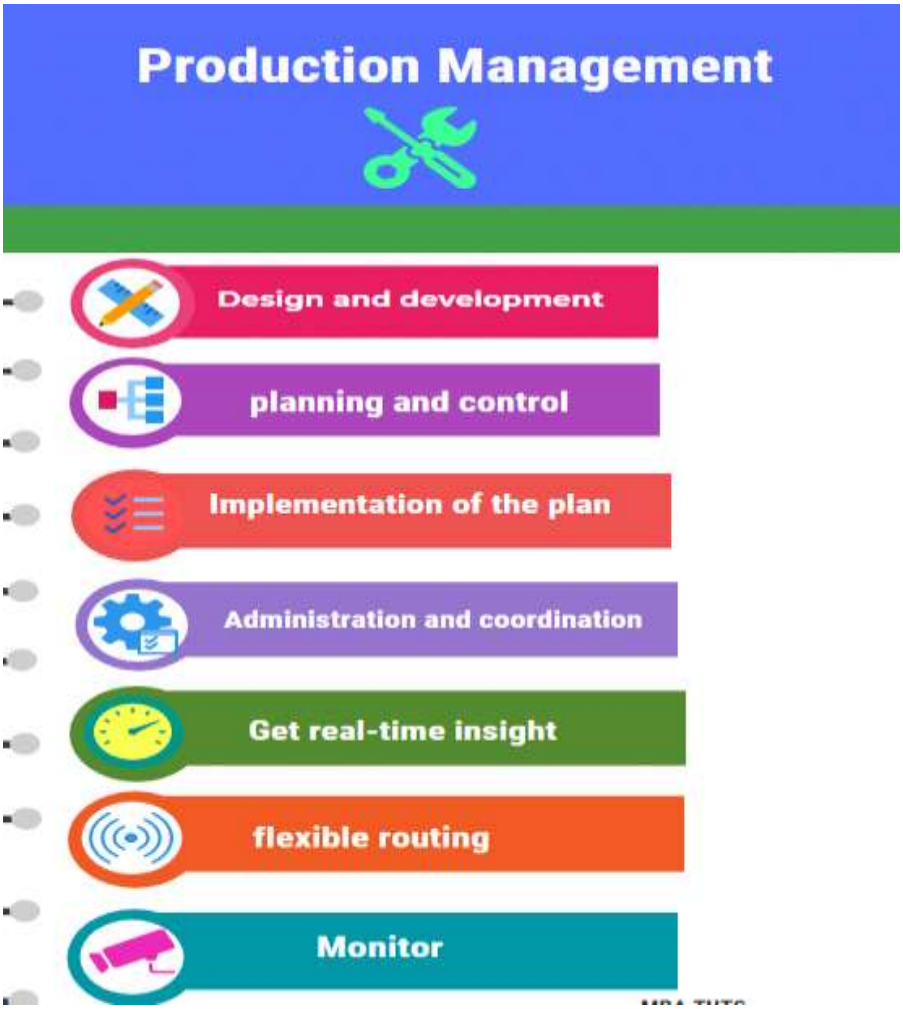

Figure 3 Production management process

– According to E. L. Brech, "Production management is the process of effective planning and regulating the operations of

that section of an enterprise which is responsible for the actual transformation of materials into finished products.

- According to E. S. Buffa, "Production management deals with decision making related to production process so that the resulting goods or service is produced according to specifications, in the amounts and by the schedule demanded and at minimum cost."

Figure 4 production v/s Productivity

Production	Productivity
1. Meaning Production: Merely means volume or value of output producedin a given period irrespective of the volume or value of input. Production is an absolute concept.	1. Productivity is the ratio of output to input. It refers to output in relation to the resourcesemployed. Productivity is a relative concept as it relates output-input relationship.
2. Nature: Production is concerned with the end results of factors' contributions in the shape of volume or quantity of goods and services obtained out of an organization.	2. Productivity views the volume or value of production in relation to resources utilized in the making of such goods and services. It is the ratio of input of resources to output of products.
3. Rate of increase: Increased production is brought about by making larger capital investments and	3. Increased productivity is only possible through the making of larger production by the use of lesser capital investment and

Production	Productivity
employing additional personnel and raw materials.	smaller number of personnel.
4. Narrow/Broad Meaning: Production has a narrow meaning since it denotes only volume or value of output not in relative butin absolute terms.	4. Productivity has a wider meaning sinceit is related to input and output ratio.
5. How to raise? Increase in production is possible increasing thefactors of input.	5. Increase in productivity is possible by moreefficient utilization of the input factors.
6. **Measurement:** Measurement of production is simple and easy as it is made in terms of units or value	6. Measurement of productivity is complicated as different input factors have to be reduced to a common denominator for such measurement
7. Effect on standards of living: Production by itself does not raise standards of living of the people as it has no direct effect on the real incomes of the people	7. Productivity raises the standards of living of the people as increase in the real income of the people is possible only through increase in productivity.

The term ‘production’ is also referred as ‘manufacturing’ or ‘operations’. It is to be noted that ‘operations’ is a broader concept as compared to production. The term production management is used for a system where tangible goods are produced, whereas, the term operations is used both for production of tangible goods and intangible services such as

that of airlines, hospitals, educational institutions, etc.

Importance of Production Management

Production management is important to business firms as well as to the customers and to the society. The importance of production management is stated as follows:

- Importance to Business Firms:

The importance of production management to business firms is stated as follows:

– **Accomplishment of Firm's Objectives:** The production function helps a business firm to achieve its overall objectives. By producing products that satisfy customer's needs and wants, the company can increase its

sales, which in turn enables a firm to achieve it objectives such as:

- Optimum utilization of production capacity,
- Higher profits, etc.

– Reputation and Goodwill: Effective production enables a firm to earn reputation and goodwill in the market. Satisfied customers, dealers and others develop a good image of firms that provide efficient and effective goods and services. A good image helps a firm to expand and grow.

– **Helps to Introduce New Products:** The production function helps to introduce new products in the market. Through research and development,

production management enables a firm to develop new and better quality of goods and services.

- **Supports Other Functional Areas:** The production function supports other functional areas in an organization, such as marketing, finance and personnel. For instance, the marketing department would find it easier to market quality products, and the finance department would be able to generate more funds by way of increase sales revenue.
- **Helps to Face Competition:** Production management enables production of quality goods due to R&D and quality control. Therefore, a business firm would be able to face competition effectively with the help of

right quality products, at the right price and at the right time.

- **Optimum Utilization of Resources:** Production management facilitates optimum utilization of resources such as manpower, machines, etc. Thus, a firm can meet its capacity utilization objective, which in turn can bring higher returns to the organization.
- **Minimizes Cost of Production**: The production management helps to minimize cost of producing goods. The production department tries to maximize output of goods and services with the minimum resource inputs. This helps a firm to achieve its cost and efficiency objective.

– **Expansion of the Firm**: The production management enables a firm to expand and grow. This is due to the fact that the production department strives to improve the quality and to reduce costs. This, in turn helps a firm to generate more returns in the form of higher profits.

In the words of Peter Drucker, "Productivity means the balance between all factors of production that will give the greatest output for the smallest effort," Thus, productivity is the ratio of output to input.

$$\text{productivity} = \frac{output}{input}$$

It is to be noted that productivity and production are not one and the same because

productivity is a relative concept expressed as a ratio or percentage, whereas, production denotes the quantum of output; also increase in productivity is due to more efficient utilization of resources and reduction in wastage of resources, whereas, increase in production is due to increase in inputs.

Measurement of Industrial Productivity

Productivity is the ratio of output to input. The general or overall productivity of an industrial unit can be measured with the help of the following formula.

Where P = Productivity

$$P = \frac{O}{I}$$

O = output

I = Input

The output can be expressed in terms of volume (i.e, the number of units produced). Similarly, the input can be expressed in terms of the amount of inputs used, (i.e., the number of units of materials used, the amount of capital invested, the number of man-hours worked, the number of machine hours worked, the area of land used and so on.)

It is to be noted that there are practical difficulties in measuring the overall productivity. This is because one cannot just add the amount of capital invested and number of man-hours worked, or number of units of raw materials used in producing goods or services. Therefore, productivity of specific factor of production is usually measured.

Productivity of Specific Factor

Basically, the various factors of production are labor, capital, materials, machines and land. The productivity of each of these factors can be measured as follows:

- Labor Productivity: Labor productivity is the relation between output to man-hours worked. Labour productivity can be expressed as follows:

Where LP= Labor productivity

$$LP = \frac{O}{MH}$$

MH = Man-hours worked

Labor productivity is higher when:

- The output increases with the same man-hours or lesser man-hours.
- The output remains the same with lesser man-hours.

- **Capital Productivity**: Productivity of capital is the relation between output and capital employed. It can be expressed as follows:

Where CP = Capital Productivity

$$CP = \frac{O}{CE}$$

— O = Output

CE = Capital employed

Capital productivity is said to be higher when:

- The output increases at the same capital or lower capital cost.
- The output remains the same at a lower capital cost.

- Raw Materials Productivity: The productivity of raw materials is the relations between output to raw materials consumed. It can be expressed as follows:

Where RMP = Raw materials productivity

$$RMP = \frac{O}{RMC}$$

— O = Output

RMC = Raw materials consumed

It is to be noted that the raw materials productivity can be measured in terms of number of units of raw materials consumed as well as the cost of raw materials.

- Machines Productivity: The productivity of machines is the relation between output to machine-hours

worked. It can be expressed as follows:

Where MP = Machines productivity

$$MP = \frac{O}{MHW}$$

— MHW = Machine-hours worked

- Productivity of Land: The productivity of land is the relation between output to area of land used. It can be expressed as follows:

Where PL = Productivity of land

$$PL = \frac{O}{AL}$$

— O = Output

AL = Area of land used

Exercise

How to Calculate Productivity?

Here are the steps to calculate productivity:

- **Step 1:** Identify the input for the production process. Inputs can include materials, labor, time, and energy.
- **Step 2:** Determine the value of the output produced in the process. Output can be **revenue**, the number of units manufactured, or any other relevant measure.
- **Step 3:** Calculate productivity using this formula:

  Productivity = Output / Input

1. Suppose a team of five employees completes 50 tasks in a week. The total working hours for the team during the week are 200 hours.

Calculate the team's productivity.

2. Consider a scenario where a production manager needs to evaluate their company's productivity. Based on information from the accounts department, the company manufactured 150,000 units in the last quarter. This production necessitated the employment of 20 laborers who worked 22 days per month, with each laborer putting in 8 hours of work per day. Calculate the employee productivity in terms of units produced per hour.

Particulars	value
output	150000
No. of Labor	20
No. of months	3
No. of Working days per month	22
No. of working hours per day	8

3. Consider another scenario where senior management within a company seeks to determine employee productivity by calculating the revenue generated per

employee. In 2022, the company achieved a total revenue of $35.0 million. At the beginning of the year, the company had 200 employees, and by the year's end, this number had increased to 220 employees. Calculate the revenue per employee based on the provided data.

Particulars	value
Output (Revenue)	35.000.000
Opening employee count	200
Closing employee count	220

4. Imagine a team leader at a financial services company who wants to evaluate the productivity of three recently hired financial analysts: Jason, David, and Henry. To measure their productivity, he considers the number of months each analyst has been with the company as the input and the number of

cases they have successfully handled as the output. With this data in mind, he intends to calculate the productivity ratio.

Based on the given information, calculate who is the most productive analyst.

analysis	Jaber	Hasan	Wafy
No. of months served	4	7	5
No. of cases Executed	16	25	19

Chapter Two

PLANT LOCATION AND LAYOUT

1. Meaning and Definition:

Plant location refers to the choice of region and the selection of a particular site for setting up a business or factory.

Plant layout is a plan of optimum management of facilities which include; personnel, operating equipment, storage space, material handling equipment, and all other support services.

It includes the arrangement and location of work centers and various service center's like inspection, storage, and shipping within the manufacturing/factory building.

According to Riggs, "the overall objective of plant layout is to design a physical arrangement that most economically meets the required output – quantity and quality."

2.Factors Affecting the Plant Location:

Many factors are considered while selecting a plant site. According to their importance these are classified as primary factors and secondary factors.

- **Primary factors:**
  - **Raw material supply:** Production process will continue properly when adequate supply of raw material is there. Raw material cost is a part of total production cost. Inadequate supply of raw material will result in the reduction

in production. It will increase downtime and hence reduce efficiency of industry. Due to this inadequacy, profit maximization may not be obtained. The time to transport & cost of transportation is also important. Hence, industries are situated where raw material is available easily.

- **Nearness to market:** This factor will produce the product to customer in short time period and hence it will be less damage to the product. It also reduces transportation cost. Also it will help the supplier to know the requirement of customers.
- **Transportation Facility**: While selecting a site one thing has to be considered that is transportation of any

raw material, semi- finished & finished goods should be as less as possible. By this factor material will be transported less, which will affect the material quality, cost of transportation, time to transport etc. Hence for all above reasons producer has to select cheap and speedy transportation with various sources like road, airways, railways, waterways etc.

– **Labor Supply:** Labor is most effective part of the industry, which produces the product(s). The prospective plant owner has to choose the site in such a way that labor should be present in adequate numbers with low cost. The labor should also be skilled to a good level. If labor is not present in sufficient numbers it will

increase downtime of production and decrease plant efficiency.

- **Power Supply:** Electrical, diesel, automatic etc. energies are required to produce the product and also required for transportation. For continuous production process regular and sufficient power supply is necessary. Many companies go to the industrial areas because of availability of regular & sufficient power supply.
- **Supply of Capital:** Capital is required for the industries for production, day to day working, expansion, marketing etc. Large scale production requires large amounts of capital which may be raised by shares, debentures etc.

- **Secondary factors:**
  - **Natural factors:** Factors like land, water, climate etc. are very important for industries.
  - **Government Policy:** in particular areas, a new plant cannot be started due to some rules and regulations made by government. There are also some subsidies and other facilities to support small scale industries to grow.
  - **Availability:** Availability of housing, hospitality, entertainment, education facilities also helps in deciding plant location.
- **Miscellaneous factors:**
  - Sufficient water supply
  - Danger of attack during war
  - Personal factors

- Environmental and ecological factors
- Availability of safety facilities like fire-fighting, police etc.

3. Theory and practices:

Alfred Weber propounded his famous industrial location theory in 1909 which was written in German language. In 1929, it was translated into English and published in 'The Theory of Location of Industries'. This theory is also known as ' Pure Theory' and 'Least Cost Theory'.

The basis of this theory is the study of general factors which pull an industry towards different geographical regions. It is thus deductive in approach. In his theory he has taken into consideration factors that decide the

actual setting up of an industry in a particular area.

Assumptions of the theory:

- The area is typically uniform or isotropic in form of terrain or relief, climate, soils, economic system, technology and distribution of population.
- Manufacturing involves single product at a time and the product is supplied to a single market.
- Raw materials are not evenly distributed in space but at a few known and fixed locations which are available at equal transportation cost throughout.
- Markets are known as fixed at specific places.

Aim of the Theory:

Weber Classified the factors affecting location of industries into two broad groups:

- Regional factors or primary causes of regional distribution of industries.
- Agglomerative and deglomerative factors or secondary causes responsible for redistribution of industry.

Regional factors: According to Weber, there are two general regional factors which affect the cost of production

- Transportation costs and
- Labour costs

Agglomerative and deglomerative factors or secondary causes: Agglomerative factors make industries centralize at a particular

place. Such factors may include banking and insurance facilities, external economies and the like. deglomerative factors are those which decentralize the location of industries. Examples of such factors are local taxes, cost of land, residence, labor costs and transportation costs. Weber formulated his theory within the context of heavy manufacturing industry in Germany in the 19th century, where transportation costs played a fundamental role in determining location decision.

The validation of the Weber's theory is still seen in present time where examples can be seen in the location of industries like sugar and iron and steel industries which are located near the availability of raw materials. The availability of cheap labor have encouraged

General Motors to locate their manufacturing plants in Vietnam. But with the technology and transport revolution as well as effect of globalization, the industrial composition and organization have changed due to new products and production processes, advance in communication and transportation technologies and most recently the rise of a knowledge based economy. Knowledge inputs, in the form of human capital, training and skill development and research need to be brought together for development of industries. Apart from these, major expenditure is accounted for by advertising and branding which has become far more important in this tough competing market.

4. Cost factor in location:

Cost location factors, also referred to as location factors or area cost factors, are multiplying factors for instantaneously translating the total overall construction cost of projects, from one geographic location to another. Cost Location factors take into account various local components that contribute to construction costs, such as labor cost, material cost, logistic costs and business environment which are as follows:

- **Labor cost.** It includes wage rates, directly paid benefits, and other expenditures incurred by the employer to employ a worker, as well as the difference in local productivity data.

- Material cost. It considers steel prices, import needs, availability of local equipment, need of spare equipment, and freight, taxes, and duties on imported and domestic materials.
- **Logistic costs.** It refers to all costs associated with a country's infrastructure, such as: availability and quality of ports, roads, airports, and rails; communication technologies; warehouse infrastructure; border clearance; and local incentives.
- **Business environment.** It takes into account the costs associated with doing business in the country, such as: readiness of bureaucratic procedures; legal protection of investors; enforcing contracts; and getting credit.

All components that make-ups the previous major components are then weighted according to their relative importance. Finally, the factors are calculated in a comparative manner,

5. Principles of Plant Layout:

– Overall integration of factors

A good layout is one that integrates men, materials, machines and supporting activities and others in a way that the best compromise is obtained. no layout can satisfy each and every principle of a good layout.

– Minimum Movement

A good layout is one that permits the minimum movement between the operations. The plant and machinery in case of product

layout and departments in case of process layout should be arranged as per sequence of operations of most of the products.

A straight line is the shortest distance between any two points. men and materials should be made to move along the straight path.

– Uni-direction flow

A good layout is one that makes the materials move only in the forward direction, towards the completion stage.

When a straight line flow is not possible, other flows like a U-shaped flow, circular or zig-zag flow may be adopted but the layout must ensure that materials move in a forward direction.

– Effective use of available space

A good layout is one that makes effective use of available space both horizontal and vertical.

Backtracking and duplicated movements consume more time, involve unnecessary materials handling, add to costs and lead to inefficiency.

Raw materials, work-in-progress and finished goods should be piled vertically one above another rather than being strewn on the floor.

Pallets or equivalent should be made use of to pile up several layers one above another.

– Maximum Visibility

A good layout is one that makes men, machines and materials ready and observable at all times.

All departments should be integrated, convenient to service and easy to supervise

Enclosures, cupboards, offices, partitions should be avoided except when their utility is established beyond doubt.

– Maximum Accessibility

A good layout is one that makes all servicing and maintenance points readily accessible.

Machines should be kept sufficiently apart and with reasonable clearance from the wall so that lubrication, adjustment,

replacement of belts, removal of parts at times of repair can be done conveniently by the maintenance staff.

The area of electrical panels and fire extinguishers should be kept free from obstructions.

Chapter Three

MATERIAL HANDLING AND MANAGEMENT

1. What is Material Handling?

Material handling is a system or combination of methods employed to transport goods from one location to another. It includes protecting, packaging, moving, **storing** and controlling goods, from production to distribution. To that end, material handling relies on automatic, semi-autom atic and manual equipment.

2. Objectives of Material Handling

Implementing processes and protocols for **correctly managing transfers of goods**

reduces manufacturing costs, improves flows of movements, optimises space and traffic in your facility, ensures safe conditions for operators and increases productivity. For orderly, consistent logistics operations, it's advisable to follow established industry standards for product handling and to be familiar with specific strategies, techniques and tools.

3. The different types of material handling

Material handling equipment is grouped into four main categories: storage and handling, bulk material, industrial trucks and engineered (automated) systems.

a) **Storage and handling**. The purpose of this equipment is to safeguard the goods when not in use. It includes pallet racking, boxes and other containers, and mezzanines.

b) **Bulk material**. Liquids, food, mineral products (e.g., stones and rocks) and metal parts such as nails may require other material handling equipment. In these cases, it's best to employ conveyor belts, stackers for loading and unloading heavy materials, reclaimers, bucket elevators and hoppers.

c) **Industrial forklift trucks**. These machines move materials within the warehouse, loading and unloading heavy objects. They come in different models,

such as forklifts, hand trucks, turret trucks, pallet trucks and order pickers.

d) **Engineered systems**. These incorporate cutting-edge technology to store and transport products. They typically comprise several elements controlled by a warehouse management system (WMS). Engineered systems include stacker cranes, conveyors, transfer cars, automated guided vehicles (AGVs) and autonomous mobile robots (AMRs).

4. The Benefits of Material Handling:

One of the main reasons to **overhaul your material handling methods** is the possibility of storing stock in smaller spaces. This enables you to bring down internal operational costs in material transport and

picking, for instance. You'll also simplify inventory management and optimise product flows. Additional incentives include:

- **Enhanced workplace safety**. The right material handling equipment saves operators from physical exertion and limits the risk of falls.
- **Greater productivity and efficiency**. With assistance in transporting, locating and picking items, employees can dedicate their time to other tasks, such as quality control or shipment preparation.

5. Material Handling in Logistics:

These methods and systems can be used across the different supply chain phases:

- **Manufacturing**. In industry, material handling begins in production, when stock is sent to manufacturing warehouses.
- **Internal transport**. These systems help place items into unit loads — primarily pallets and boxes — facilitating their transfer to specific areas of the facility.
- **Storage**. Housing products safely until they're needed or distributed keeps them in good condition.
- **Distribution**. The boxes, pallets or other storage units are handled again during shipping — whether with forklifts, pallet trucks or automated conveyors — for distribution to retailers, wholesalers or end customers.

Using pallets and storage containers in material handling reduces strain and movements throughout the warehouse

6.Where is material handling applied?

Experts from the Material Handling Institute published **the 10 principles to consider** to make material handling as safe and productive as possible:

a) **Planning**: Identify beforehand what you'll be transporting, where you'll store it and what equipment you'll employ.
b) **Standardization**: Although you should be flexible, standardizing the measurements of all elements makes forecasting simpler. For instance, all boxes should be the same size.

c) **Work**:One of the greatest advantages of material handling is restricting unnecessary and repetitive tasks through automation.

d) **Ergonomics**: Investing in handling equipment that protects the health of operators improves safety.

e) **Unit loads**: Using pallets and storage containers limits physical exertion and travel in the warehouse.

f) **Space utilization**: Organise your facility optimally to maximise storage locations. You can also leverage space vertically with automated solutions.

g) **System**:Integrating traceability tools such as a WMS lets you identify products and their location instantly.

h) **Environment**:Choosing environmentally friendly machinery reduces energy consumption and prevents the emission of greenhouse gases.

i) **Automation**: Implementing technology advances in processes such as order picking cuts costs and drives employee productivity.

j) **Life cycle cost**: Consider all the stages the material handling equipment will go through: its installation and programming, operations, repairs and so on.

7.How to Maintain Material Handling Equipment:

All equipment used in manufacturing, handling, packing, storage and distribution

requires maintenance. **Not carrying it out can lead to safety risks and** malfunctions.

Be sure to follow the instructions and advice provided by each manufacturer, which generally include:

- **Conducting regular inspections** of different elements, such as the pallet racking.
- **Updating equipment** when necessary.
- **Training operators appropriately**.
- **Scheduling maintenance sessions**.

Looking for guidance on organizing your products and shipments as efficiently and safely as possible? **Be sure to contact us**. As **storage experts** since 1966, we can help you improve the flow of goods at every stage — from receiving to shipping — with our

automatic, semi-automatic and conventional solutions. Moreover, our **Easy WMS warehouse management system** will provide you with real-time control over all your materials.

Chapter four

FORECASTING

INTRODUCTION TO FORECASTING:

Every business enterprise interested in planning its activities must have clear idea about the demand for its product .Important business planning decisions, including the strategies to be followed, the amount of capital that is likely to be necessary, labor requirement and skills, the necessary distribution and after-sale service networks, sales incentives, sourcing of raw material, etc. are all critically dependent on the perception of the demand of its product. If this perception is substantially faulty, most of these decisions of the enterpriser likely to prove to be erroneous and lead to avoidable losses. A

reasonably correct estimate of demand on the other hand can prove to be the key for a successful venture.

Every organization invariably engages in annual planning exercise. The heads of various functional areas such as marketing, production, materials and finance take part in this exercise with specific objectives. The marketing function provides data on sales that the organization should target in coming year.

This is primarily achieved through forecasting. Based on this inputs, the production function prepares an annual production plan and projects various requirements on the basis of this plan. The material function prepares a procurement plan to match the requirements projected by the

production function. Finally, on the basis of all these, the finance function undertakes cash planning and funds management. Therefore, forecasting plays a vital role in every organization.

1. What is Demand Forecasting?

The formulation of appropriate and useful production policy is an important aspect for an enterprise. This involves determination of level of production, manpower requirements equipment and inventory level etc. All these decisions are basically related to the size of production which in turn can be determined from potential demand of the product. Thus, the starting point of decision related to production strategy is the product demand forecast for a

specified period. To know what a business should perform we must know its future Sales. In the absence of this information , both short and long term planning will rest on the foundation which is much less substantial than sand. A poor job of demand forecasting will lead to an ineffective production planning and towards an inventory that is either too large or too small.

In a literal sense forecasting means prediction. Forecasting may be defined as a technique of translating past experience in the prediction of things to come. It tries to evaluate the magnitude and significance of forces that will affect future operating conditions in an enterprise.

In the words of Garfield, “Production is an integral part of any of any scientific generalization that holds the relationship between two or more factors. The generalization must hold not only with respect to past observations related to the same phenomenon but also for all future observations related to the same phenomenon. Production is even more organically related to these that those generalization which establish a definite time sequence in the occurrence of certain factors; Due to dynamic nature of market phenomenon demand forecasting has become a continuous process and requires regular monitoring of the situation. Demand forecasts are first approximations to production planning. These provide

foundations upon which plans may rest and adjustments may be made.

“Demand forecast is an estimate of sales in monetary or physical units for a specified future period under a proposed business plan or program or under assumed set of economic and other environmental forces, planning premises outside the business organization for which the forecast estimate is made.”

Sales forecast is an estimate based on some past information, the prevailing situation and prospect of future. It is based on an effective system and is valid only to some specified period. The following are some main components of a sales forecasting system:

• Market Research Operations to get the relevant and reliable information about the trends in the market.

• A data processing and analyzing system to estimate and evaluate the sales performance in the various markets.

• Proper co-ordination of steps (i) and (ii) and then to place the findings before the top management for making final decisions.

Why do we forecast? Since forecasting activity typically precedes a planning process one can identify specific reasons for the use of forecasting in organizations. Organizations face a different set of issues while they engage in planning and in each of these, forecasting plays an important role as a tool for planning

process. The key areas of application of forecasting are summarized below:

• Dynamic and complex environment: Only if an organization has complete control over market forces and knows exactly what the sale of its products is going to be in the future is there no role for forecasting.

• Short term fluctuation in production: A good forecasting system will be able to predict the occurrence of short fluctuations in demand. Therefore, from this knowledge, organizations can avoid knee-jerk reactions to the unfolding reality. Production planning decisions could utilize this information and develop plans that minimize the cost of adjusting the production system for short term fluctuations.

• Better material management: Since the impending events in an organization are predicted through a forecasting system, organizations can benefit from better material management and ensure better resource availability.

• Rationalized man-power decisions: A forecasting system provides useful information on the nature of resources required, their timing and magnitude.

Therefore, organizations could minimize hiring and lying off decisions. Moreover, better planning on overtime and idle time could also be done based on this information.

• Basis for planning and scheduling: With proper forecasting, planning and scheduling activities can be done on a rational basis.

• Strategic decisions: Forecasting plays an important role in long term strategic decision making. This includes planning for product line decisions.

Importance of Fore-casting: Production and distribution are two main activities of a business enterprise. Demand forecasts tries to maintain a balance between production and distribution policies of the enterprise. With decentralization of functions and increase in the

size of the organizations, forecasting of demand is of great value for proper control and coordination of various activities.

An efficient demand forecast helps the management to take suitable decisions regarding plant capacity, raw material

requirements space and building needs and availability of labor and capital. Production schedules can be prepared in conformity with demand requirements minimizing inventory, production and other related costs.

Demand forecasting also helps evaluating the performance of the sales department. Thus, demand forecasting is a necessary and effective tool in the hands of management of an enterprise to have finished goods of right quality and quantity at right time with minimum cost.

Steps in Forecasting: The following are the main steps in demand forecasting;

- Determine the objective of forecast,
- Select the period over which the forecast is to be made,

- Select the technique to be used for forecasting,
- Collect the information to be used,
- Make the forecast.

Techniques of forecasting: Implicit in forecasting is that there exist a pattern in the past demand data which can be extrapolated or generalized for the future with the desired measure of certainty. The demand pattern though regular is found to be stable in statistical sense. Since the only input to the forecasting system is the past history of the demand of an item, no direct information concerning the market, the industry, the economy, the sale of competition and complementary products, products price changes, advertising campaigns and so on is

used. Forecasting methods involve construction of suitable mathematical relationship to describe the appropriate demand pattern. Management experts have developed many forecasting techniques to help managers to handle the increasing complexity in management decision making it is tricky and experimental process. No one method of forecasting can be applied to all enterprises. In many cases the decisions are based on a combination of several, if not all of these approaches. Final forecast generally include the contributions of many men of varied experience. The use of particular method depends upon the nature of the enterprise, the products manufactured, information system in use.

Elements of Forecasting: Forecasting consists basically of analysis of the following elements;

- **Internal factors:**
  - •Past
  - •Present
  - •Proposed or future
- **External Factors:**
  - • Controllable: (a) Past (b) Present.
  - • Non controllable: (a)Past (b) Present Future.

Fore- casting is essentially a study of internal and external forces that shape demand and supply. The shape of things to come will depend partially upon how one shapes the controllable factors. With different strategies, the forecasting will be different offering

multiple scenarios in management decision making.

2. Forecasting Models

One can classify the various models available for forecasting into three categories:

a) **Extrapolative models**: They make use of past data and essentially prepare future estimates by some methods of extrapolating the past data. For example, the demand for soft drinks in a city or a locality could be estimated as 110 percent of the average sales during the last three months. Similarly, the sale of new garments during the festive season could be estimated to be a percentage of the festive season sales during the previous year.

b) **Casual models:** It analyses data from the point view of cause-effect relationship. For instance, to the process of estimating the demand for the new houses, the model will identify the factors that could influence the demand for the new houses and establish the relationship between these factors. The factors, for example, may include real estate prices, housing finance options, disposable income of families, and cost of construction and befits derived from tax laws. Once tea relationship between these variables and the demand is established, it is possible to use it for estimating the demand for new houses.

c) **Subjective judgments:** Another set of models consist of subjective judgment using qualitative data. In some cases, it could be

based on quantitative and qualitative data. In several of these methods special mechanisms incorporated to draw substantially from the expertise of group of senior managers using some collective decision making framework.

Selection of a forecasting technique: The selection of a forecasting technique depends on the following three factors:

i. The characteristics of the decision making situation, which include: (i) The time horizon (ii) Level of detail (iii) Number of items (iv) Control versus planning.
ii. The characteristics of the forecasting methods: (i) the time horizon (number of periods for which forecasting required)

(ii) The pattern of data (horizontal, seasonal trend etc.) (iii) Type of model(casual, time series or sta6tistical) (iv) Cost (v) Accuracy (vi) Ease of application.

iii. Present situation which includes: (i) The item that is being forecast (ii) Amount of historical data available (iii) Time allowed for preparing forecast.

Although there are the below mentioned forecasting models we shall be concentrating on Weighted moving averages model.

- Weighted moving averages.
- Casual forecasting model.
- Linear regression analysis
- Multiple regression analysis.

3.Weighted Moving Average:

Equal weights are assigned to all periods in the computation of simple moving average. The weighted moving average assigns more weight to some demand values (usually more recent ones) the Table 2.1 Shows the computation for three months weighted moving average with a weight of 0,5 assigned to the most recent demand value, a weight of 0, 3 assigned to the next most recent value and a weight of 0, 2 assigned to the oldest of the demand value included in the average.

Table 2 Three Months Weighted moving average

Time	Months (T)	Demand (DT)	Moving average Forecast (MT)
1.	120	-	-
2.	130	118	-
3.	110	-	-
4.	140	129	1
5.	110	119	1
6.	130	126	9

$$\text{Weighted MA3} = \frac{0.2 * 120 + 0.3 * 130 + 0.5 * 110}{0.2 + 0.3 + 0.5} = 110$$

$$\text{Weighted MA3} = \frac{\$\, WtDt}{\$\, Wt}$$

Where I =1, 2, 3 if we use these periods moving average, i=3 corresponds to the most recent times period and i=1 correspond to oldest time period Wt=Weight for the time period t In the example, Wi=0, 2 W2=0, 3 and so on.

An advantage of this model is that it allows you to compensate for some trend in seasonality If you want to, you can weight recent months more heavily and still dampen somewhat the effect of noise by placing small weightings on older demands. Of course the modeler or manager still has to choose the coefficients and this choice is critical to model success or failure.

4.CAUSAL FORECASTING MODELS

These methods construct a forecasting logic through a process of identifying the factors that cause some effect on the forecast and building a functional form of the relationship between the identified factors. In other words, a set of independent variables are identified and associated with the dependent

variable through a functional relationship. For example, let us consider the demand in the country for a new product such as Direct to Home receivers (DTH). Since this is a new product, we may not have adequate past data on the demand and may need other means of establishing the potential demand. Even in the case of existing product, the number of factors that influence demand may be several requiring us to understand interaction among these, Several factors – including exchange rate fluctuation, installed capacity in the country, new product launches customers tariffs and price of raw material at the international markets—influence the demand. Forecasting in these situations uses casual methods.

In general, let us consider the forecast for a dependent variable Y using independent variables X1, X2, X3, … Xn. Then developing a forecasting logic requires establishing a establishing as follows: Y= f (X1, X2, X3, … Xn)

Use of casual method to extract the trend component in times series is a frequent application of casual method. Other casual methods include econometric models, multiple regression models and technological forecasting techniques.

Casual methods of forecasting require greater degree of mathematical treatment of data. There are several computer packages such as SPSS available today to help the forecast designer in this process.

Example: A manufacturer of tricycles in the age group of two to four years commissioned a market research firm to understand the factors that influence the demand for its product. After some detailed studies, the market research firm concluded that the demand is a simple linear function of the number of newly married couples in the city. Based on this assumption, build a causal model for forecasting the demand for the product using the data given below for a residential area in the city Also estimate the demand for tricycles if the number of new marriages is 150 and 250 .

Table 3 model for forecasting

X	Y
New Marriages	Demand for Tricycles
200	165
225	184
210	180
197	145
225	190
240	169
217	180
225	170

Solution: Since the causal relationship is a simple linear regression the method of least squares is used to determine the coefficient of linear regression Y= a + b

Table 4 simple linear regression

New marriages	**Demands for tricycles**		
X	Y	X*Y	X*X
200	165	33,000	40,000
235	184	43,200	55,225
210	180	37800	44100
145	197	28,565	38,809
225	190	42,750	50,625
240	169	40560	57600
217	180	39060	47089
225	170	38250	50,625
Sum: 1749	**1383**	**303,225**	**384,073**
Average 216-625	172.875	-	-

From the equation

$$b = \frac{\$X1Y1 - nXY}{\$X1 * X1 - nX * X}$$

a =Y- bX

We have

$$b = \frac{303{,}225 - (8 * 218{,}625 * 172.875)}{384{,}073 - 8 * 218{,}625 * 218{,}625}$$

$$= 0.5104$$

a= 172.875-0, 5104 ore the demand for tricycles is given by relationship.

Number of tricycles demanded= 61.29+0.5104 *no. of new marriages.

- ✓ If the no. of new marriages is 159 then the demand-138 tricycles.
- ✓ If the no. of new marriages is 250 then the demand = 189 tricycles.

5. LINEAR REGRESSION ANALYSIS

Linear regression analysis is a forecasting technique that establishes a relationship between variables. One variable is known or assumed, and used to forecast the value of an unknown variable. Past data establishes a functional relationship between the two variables. We will consider the simplest regression situation between the two

variables and the linear relationship. Our forecast of the period's demand is expressed by:

$Ft = a + bX1$

Where F1 is the forecast for the period t, given we know the value of the variable X in the period t. The coefficients a and b are constants: a is the intercept value for the vertical (F) axis and b is the slope of the line. Often the equation is expressed as: $Y=a + bX$

In this equation we have substituted F for Y, to indicate b is the forecasted value. In order to find coefficients a and b, old demand is utilized rather than the old forecast. These coefficients are computed by the following two equations:

$$b = \frac{(\$X1D1)) - (\$X1)(\$D1)}{n\ (\$X1 * \$X1) - (\$X1)(\$X1)}$$

$$a = \frac{\$D1 - b\&\ X1}{n}$$

Where D = a + bX, and a= no. of periods

Example: A pepperbox company carryout pizza boxes. The operation planning department knows that the pizza sales of major client are a function of the advertisement amount, the client spends, on account of which they receive in advance of the expenditure. Operation planning is interested in determining the relationship the client's advertisement and sales. The amount of pizza the client would order. In money value is known to be a fixed percentage of sales>

Table 5 Quarterly advertising and sales

Quarter	Advertising (in 1,00,000 Rs.)	Sales (in 1, 00,000 Rs.)
1.	4	1
2.	10	4
3.	15	5
4.	12	4
5.	8	3
6.	16	4
7.	5	2
8.	7	1
9.	9	4
10.	102	

Computing b and a, where advertising is X1 for the quarter t, sales are D1 for the quarter t and forecast is F1 for the future Period t.

Table 6 Computing b and a

Quarter (t)	Advertisement(X1)	Sales (D)	Xi*Xi	X1D1
1	4	1	16	4
2	10	4	100	40
3	15	5	225	75
4	12	4	144	48
5	8	3	64	24
6	16	4	256	64
7	5	2	25	10
8	7	1	49	7
9	9	4	81	36
10	10	2	100	20
Sum	**96**	**30**	**1060**	**328**

$$b = \frac{10\,(328) - 30\,(96)}{10\,(1060) - 96 * 96}$$

b= 0.29

$$a = \frac{30 - 0.29\,(96)}{10}$$

A = 0.22

Thus the estimated regression line, the relationship between future sales F, and advertising X is

$F=0.22 + 0.29 X$

The operation planner can now ask for planned expenditure expenditures, and from that sales can be forecast.

Exercise

Farewell Corporation manufactures Integrated Circuit boards(I.C board) for electronics devices. The planning department knows that the sales of their client goods depends on how much they spend on advertising, on account of which they receive in advance of expenditure. The planning department wish to find out the relationship between their clients advertising and sales, so as to find demand for I.C board.

The money spend by the client on advertising and sales (in dollar) is given for different periods in following table:

Period (t)	Advertising X_t (in 1,00,000 Rs.)	Sales D_t (in 1, 00,000 Rs.)
1.	20	6
2.	25	8
3.	15	7
4.	18	7
5.	22	8
6.	25	9
7.	27	10
8.	23	7
9.	16	6
10.	20	8

Chapter five

PRODUCTION PLANNING AND CONTROL

Production planning and control manages and schedules the allocation of human resources, raw materials, work centers, machinery, and production processes. It finds the most efficient way to produce finished goods with the lead times needed to meet production demand. Production planning and control are two strategies that work cohesively in manufacturing. Planning involves what to produce, when to produce, how much to produce, and more. Production control ensures optimum performance from the production system by using different control techniques for better throughput targets

1.What is production planning?

Production planning helps manufacturers work smarter by efficiently managing internal resources to meet customer orders or demands. It solves what, when, and how much to produce. It establishes production capacity and identifies what raw materials, bill of materials, or alternate bill of materials are needed to meet demand. Then it prepares a workable production plan.

2. What is production control?

Production control monitors production and measures performance, providing visibility and reporting. If any corrective action is needed, it gets initiated with production control. It includes different

control techniques to achieve optimal levels of production performance.

3. objectives of production planning and control?

The overall objectives of production planning and control are to:

- Optimize resources and the scheduling of resources to meet production demand
- Ensure an efficient schedule
- Have resources ready when needed
- Keep inventory at optimal levels
- Increase productivity of internal resources (people, work centers, machines, tooling, etc.)
- Improve customer satisfaction
- Ensure the right person gets assigned to specific processes

- Coordinate with other departments (sales, customer service, purchasing, etc.)

Production planning and control is the core of any manufacturing unit. It includes material forecasting, master production scheduling, long-term planning, demand management, and more. The planning process kicks off with demand forecasting of a product. Using that forecast data and the internal resources available, the production plan is created.

Production planning and control is a strategy to plan a chain of operations that supports manufacturers to be at the right place and time. It helps them achieve the most efficiency from their resources. It also

includes activities of other departments, such as sales, marketing, and procurement.

4. benefits of production planning and control:

Some of the many benefits to production planning and control include:

- Optimized manufacturing capacity- ensures machines and employees work to capacity. That keeps costs down, increases efficiency, and provides greater profitability. It helps to identify areas of improvement and to plan for growth.
- Reduced inventory costs – allows manufacturers to only hold the necessary inventory. The software can predict demand and have a Just-in-Time

scheduling strategy. Without a surplus of inventory, costs are kept low.

- On-time deliveries – helps to ensure production optimization and prompt deliveries. Getting products to their destination on time improves customer satisfaction. That increases customer retention and referrals.
- Better procurement of materials – shows when materials should get purchased for production. Having this information helps to know when to order and what is needed to meet customer and production demand. Knowing when to order lets procurement buy in advance to find the best deal. This also helps to save money and improves relationships with suppliers.

- Streamlined production processes – ensures that materials and internal resources for production are ready when needed and shows what capacity is available, and when. This keeps production running smoothly. It also helps employee satisfaction as it eliminates frustration from interruptions in production and workflows.
- Minimal resource waste – eliminates material shortages or surpluses for less resource waste. This lessens employee time wasted. Capital is not tied up in inventory that is not used. There is less production waste because delays that cause discarded materials get eliminated.

5. The role of production planning and control in manufacturing

Production planning and control ensures the resources for production are ready when needed. Materials, equipment, and labor must be available at the right time to optimize production. It is the central part of a manufacturing business. The larger a business gets, the more PPC becomes essential for a smooth-running operation.

6. steps in production planning and control

Figure 5 steps in production planning and control

a) Planning

Planning determines what will be produced, by whom, and how. It formulates the plan for labor, equipment, work centers, and material requirements needed for production.

Relevant information from various sources helps to develop a production plan.

For instance, data from sales on order quantities and promised delivery dates. Product specifications from the engineering department may also be needed. The planning step helps to keep a streamlined approach to the production process.

b) Routing

Routing determines the path raw materials flow within the factory. Using the sequence, raw materials are transformed into finished goods.

Coordinating every production process and scheduling every step is important to measure the production process duration. Routing shows the quantity and quality of materials and resources needed. It also shows

the operations used and the place of production.

Routing manages the “How”, “What”, “How much”, and “Where” of production. It systematizes the process and optimizes resources for the best results.

c) Scheduling

Scheduling emphasizes “when” the operation will be completed. It aims to make the most of the time given for the completion of the operation.

As per Kimball and Kimball, the definition of scheduling is –“The determination of the time that should be required to perform the entire series as routed, making allowance for all factors concerned.”

Organizations use different types of schedules to manage the time element. These include Master Schedule, Operation Schedule, Daily Schedule, and more.

d) Loading

Loading looks into the amount of work loaded against machines or workers. The total time to perform new work is added to the work already scheduled for the machine or workstation.

If a machine or workstation has capacity available, more orders can make up the under load. If there is a capacity overload, proactive measures can prevent bottlenecks. Adding a shift, requesting overtime, bringing in operators from another shop, or using a sub-contractor are possible options.

e) Dispatching

Dispatching is the release of orders and their instructions. It follows the routing and scheduling directions. This step ensures all items are in place for the employees to do their jobs.

Here are the points that are part of "Dispatching":

- Issue materials or fixtures that are important for production
- Issue orders or drawings for initiating the work
- Maintain the records from start to finish
- Start the control procedure
- Cascade the work from one process to another

f) Follow-up

Also known as expediting, follow-up locates fault or defects, bottlenecks, and loopholes in the production process. In this step, the team measures the actual performance from start until the end and then compares it with the expected performance.

Areas that have problems, must get addressed. Follow-up gets to the root of the issue and helps resolve it. For instance, if schedules are not met, is it from an unusual circumstance? Or is it something that needs to get adjusted? The production manager may need to revise production targets, loads, or schedules to correct the issue.

Chapter Six

MAINTENANCE MANAGEMENT

Introduction:

Maintenance management is a system of processes designed to protect and properly maintain the physical assets and resources of a company.

Machine maintenance is the work that keeps mechanical assets running with minimal downtime. Machine maintenance can include regularly scheduled service, routine checks, and both scheduled and emergency repairs. It also includes replacement or realignment of parts that are worn, damaged, or misaligned.

Maintenance management is the systematic process of planning, organizing,

and controlling maintenance-related activities and upkeep of physical assets. The primary objectives of maintenance management are optimizing maintenance costs, improving asset life cycles, and reducing unplanned equipment breakdowns. It involves predicting potential issues and scheduling regular maintenance tasks to eliminate them. A basic example is scheduling regular oil changes and checkups for the trucks in your fleet.

1. Installation of New Machines and Equipment:

When planning the installation of industrial machines, we take into account the individual needs of each client. The installation carried out during the plant construction phase requires careful planning.

However, it is usually the case that clients want to expand their business and decide to purchase new machinery to be installed without significantly interfering with other processes taking place on site. Therefore, the work should be coordinated with the clients to ensure that all installation stages take place as quickly as possible and without interrupting other logistics or production operations. The work is planned in advance and the client is informed about any restrictions so that they can take this into account when planning their internal processes.

The installation of a machine is usually a rather time-consuming and complicated project, so one of the main tasks of the concerned specialists is to create an appropriate work schedule. This ensures that

the client always knows exactly what work will be carrying out and in what location. In this way, they can redirect employees to another location, ensuring the efficiency of processes and safety of employees. Together, the next steps are planned so that the installation of industrial machines has as little impact as possible on what is currently happening on the shop floor.

2.Taking Care of Machines, Buildings, Devices, and All Fixed Assets

Fixed Asset Management is the term you must have heard of in your business, irrespective of its industry. You must also be well aware of the end of the financial year, but maybe you are still clueless about the actual worth of your business.

Fixed Asset Management plays an important role in your business, it directly affects the supporting of future planning and vision for the organization. Not only this but with proper planning and data- driven information, your business can lead to effective decision-making to enhance the outcome.

Fixed assets are also known as tangible assets or property, plant, and equipment (PP and E). In terms of accounting, fixed assets are the assets and property that can be easily converted into cash.

Fixed assets can be defined as a long-term tangible part of a property or equipment that an organization owns and uses its operation to generate income. It is anticipated

that the fixed assets cannot be consumed or converted into income within a year.

These fixed assets basically appear on the balance sheet as property, plant, and equipment (PP and E).

Here are a Few Examples of Fixed Assets:

- Office equipment.
- Computer equipment.
- Buildings.
- Furniture.
- Manufacturing equipment.
- Vehicles.
- Machinery.

Basically, these assets depreciate over their useful life.

In simpler words, Fixed Asset Management is the process of tracking and maintaining the organization's physical equipment and assets. They can be managed by asset tagging or barcoding.

The main reason for implementing fixed asset management is asset maintenance, asset tracking and preventing losses.

With the fixed asset management system, an organization can do the following:

- Track and monitor fixed assets.
- Overlook equipment and machinery at multiple locations.
- Low maintenance costs.
- Improves operational efficiency.

- Maintain a record of retired, sold, stolen or lost assets.

Fixed Asset Management allows an organization to monitor equipment and vehicles, to assess their location, and to keep them in good working order.

This also helps to minimize lost inventory, equipment failures, and downtime, thus, improving the overall value of an asset.

Fixed Asset Management is a comprehensive term that describes the origin of the process of managing an organization's assets in every aspect (from the time it is acquired to its disposal).

It also keeps detailed asset records of an organization's valuable property. The information it records are as follows:

Purchasing Details, Inventory, Maintenance Schedules, Upgrades, Quantity, Location, Depreciation, and Pattern of Use.

The asset management software incorporated with a fixed asset management process assists to improve visibility and control over assets.

3. Sections of the Maintenance Department

- Operations Department.
- Electrical Department.
- Building and Construction Department.
- Mechanical Department.
- Production Department.
- Porters and cleaners.

- Sub-contractors from abroad (i.e. consulting workshops and expertise houses specialized in the field).

4. Rules Governing Maintenance Work

- All maintenance requests must be made in writing to a specific central authority (i.e. the supervisor addresses the maintenance department in writing with the malfunctions to be repaired).
- All work related to maintenance must not be done with productive labor unless it is done under the supervision of the maintenance department.
- All maintenance stores must be carefully monitored like other stores (i.e. all spare parts must be provided, especially the most consumable).

- Recording and storing all work done, including materials and equipment used, to benefit from them when making a decision regarding purchasing a new mechanism or equipment.

5. Maintenance Objectives and Types

a) Objectives of Maintenance

- Maintaining equipment, machines, mechanisms and buildings and keeping them in good condition throughout their lifespan.
- Reducing the loss of life and equipment through regular periodic inspection.
- Reducing repair and maintenance costs to the lowest possible value.

- Increasing the level of production quality increases the reputation of the product and thus increases the demand for the service.
- Maintaining buildings, roads and networks (i.e. electricity, water, steam networks) and installing new equipment.
- Maintaining the general layout of the facility where new required modifications can be introduced.
- Capital preservation.
- Establish a timetable for maintenance of machines, mechanisms and equipment before they stop. This way, the machine can be avoided suddenly stopping and the serious loss caused by the impact of its stopping on the rest of the other

production units associated with it can be avoided

b) Types of Maintenance

You've most likely heard the term "industrial maintenance activities", but what does that mean? In general, it refers to the processes required to take care of machines in the industry. There are four main types: corrective maintenance, preventive maintenance, predictive maintenance, and proactive maintenance. Without knowing about these in detail, challenges can arise.

For a maintenance plan to be as assertive as possible, the manager must master all maintenance types and subtypes. This helps them designate the correct method for each piece of equipment. Once that decision is

made, they will define what, where, and when the maintenance plan should be executed.

- **Preventive Maintenance**

The Concept of Preventive Maintenance:

Preventive maintenance is defined as a set of activities and procedures taken by the maintenance department, in order to maintain machines and equipment in good operating conditions, and to avoid breakdowns and sudden malfunctions, by addressing any shortcomings before they reach a state of breakdown or failure.

It also keeps the devices in good operational condition at all times, and returns them to their normal state when they break down, to obtain high-quality

production lines, within a reasonable cost and a specific system, and to conform to the required specifications, in terms of quantity, and quality of the product, as well as health and safety requirements.

A good preventive maintenance system is considered the pulse of effective maintenance, as the success of the preventive maintenance program depends on achieving the least malfunctions, as well as the lowest repair costs, so it must be a kind of balance between corrective maintenance and preventive maintenance works, as preventive maintenance contributes to preventing the occurrence of malfunctions and breakdowns and discovering them before their occurrence.

Preventive maintenance occurs periodically, and according to a specific time plan, set by machine manufacturers, or by experienced technicians, taking into account reviewing and inspecting the condition of the equipment in a way that allows it to continue working without being exposed to any sudden stop. Productive maintenance is also concerned with punctuality.

- **The Importance of Preventive Maintenance:**

Preventive maintenance contributes to achieving the following:

✓**Reducing Breakdowns**:

Reducing breakdowns by increasing the overall effectiveness of equipment, machines, and mechanisms, within worldly limits, ensuring the overall effectiveness of the equipment, maintaining product quality, and ensuring that outputs are within the required quantities, and at low costs, which makes production more efficient and less expensive.

✓Good Preventive Maintenance:

Good preventive maintenance is followed to achieve consumer satisfaction and acceptance of the product, and reduce interruptions in production processes, and thus the organization's commitment to

customers, in terms of transportation and delivery on time.

✓High-Quality Products:

The quality of the product increases by conforming to the specified specifications.

✓Avoid Sudden Malfunctions:

Continuous preventive maintenance prevents sudden malfunctions, which may lead to work stoppage.

✓Extending the Productive Life of Machines:

Good maintenance ensures the use of equipment and devices for a long period, thus reducing the company's overall costs.

- **Preventive Maintenance Activities**

Preventive maintenance activities are carried out using the following:

– The human senses, such as smell, touch, sight, and hearing.
– Examination or detection (inspection).
– Installation or fixing.
– Settings or Adjustment.
– Cleanliness.
– Oiling, lubrication and greasing.

Figure 2 below shows how to set a preventive maintenance plan in 5 steps.

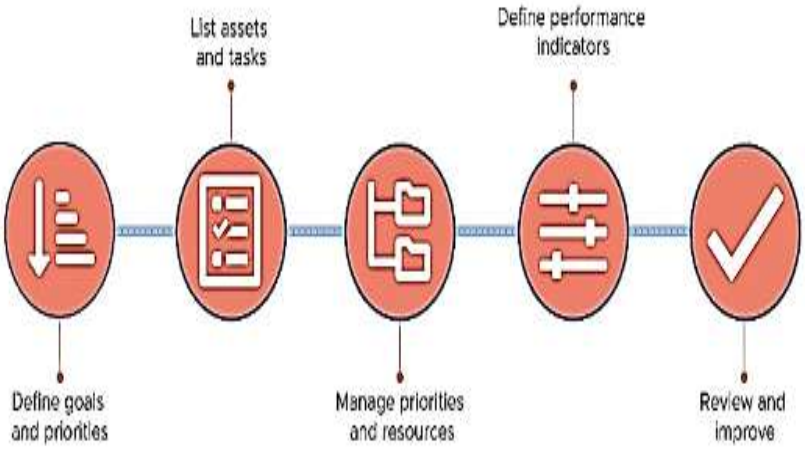

Figure 6how to set a preventive maintenance plan in 5 steps

- **The preventive maintenance plan is set up in five steps as shown below:**
  - ✓ Setting goals and priorities.
  - ✓ Make a list of assets and tasks.
  - ✓ Managing priorities and resources.
  - ✓ Determine performance indicators.
  - ✓ Review and improvement.

- **Corrective Maintenance**

Corrective maintenance means efforts aimed at returning the equipment to an acceptable condition after the occurrence of a malfunction. Remedial maintenance activities refer to the detection, inspection, and replacement operations that take place on machines as a result of their stopping or breakdown. Some writers consider this type of maintenance to be unplanned maintenance.

It is also a group of operations that are carried out to repair machines according to a set time plan determined by the machine manufacturers or by experienced technicians carrying out maintenance work, in which repair operations are performed on some parts with the aim of reusing them again,

such as repairing the corroded or cracked part by welding, and operations are also carried out in it. Adjusting and calibrating some parts of the machine that require this.

Remedial or corrective maintenance can be classified into two main categories: programmed or scheduled remedial maintenance, such as engine overhaul, and seasonal maintenance for industrial facilities. The second category is programmed or unscheduled therapeutic maintenance, such as various repairs.

Corrective maintenance consists of fixing or replacing components after failure, or when it’s about to happen. It’s often unscheduled, delaying production and costing money, increasing its financial impact.

Emergency corrective maintenance should be avoided with the help of the other types of maintenance, but can be included in the plan when scheduled. But not everything is predictable or avoidable. Managers should always be prepared for the repair of critical equipment or a "surprise" replacement.

- **Unplanned Corrective Maintenance**

This is what we call "emergency" or "reactive" maintenance. It consists of unplanned maintenance activities done after the failure has happened. The idea is that the machine failure preceding a corrective activity occurs in less critical equipment. This way the financial impact is lower, allowing you to be cost effective and continue production.

To make sure the most important assets don't need emergency corrections, managers should prioritize other maintenance techniques in the plan. This can mean using tools such as condition monitoring of critical assets.

- **Planned Corrective Maintenance**

  Urgent or planned corrective maintenance happens after a functional failure in a machine has occurred. It's used to solve problems that aren't directly affecting the full operation of the equipment.

  This kind of corrective maintenance is programmed, making it less expensive, safer, and faster than emergency corrective maintenance. Once planning is done, it can

be applied to assets of both low and high importance.

Figure 3 below shows the two types of maintenance: preventive maintenance and curative or corrective maintenance

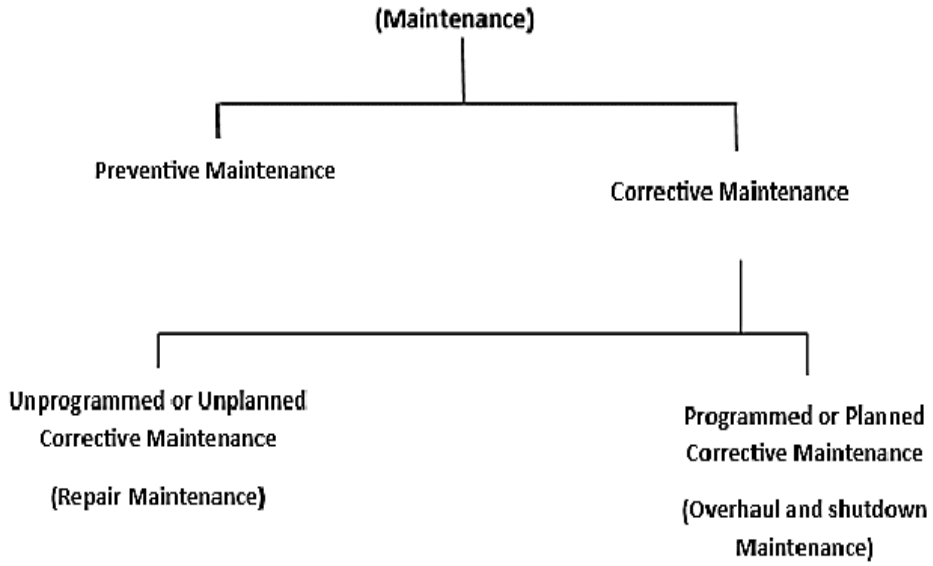

Figure 7 Types of Maintenance

- Predictive Maintenance

Like the condition-based preventive maintenance, predictive maintenance is based on the current conditions of the asset. Predictive maintenance work can be classified as routine monitoring, ideally performed in real time. It can be done offline as well as online.

Predictive monitoring aims to reduce possible failures and equipment wear. This is done through data collection, data analysis, and the measurement of variables and performance parameters. Once collected, that data is analyzed and you can see the condition of your assets.

Some of the smartest and most useful tools for maintenance today come from

predictive maintenance practices, like condition monitoring software.

With these tools, the manager is aware of everything that happens inside and outside the equipment all the time. They can receive diagnoses and accurate data to help in the preparation ofa strategic plan. Corrective and preventive activities can then be scheduled in a purposeful and wise way, not unnecessary and random.

- **Proactive Maintenance**

When you have both predictive and preventive maintenance approaches, they work together to create a proactive maintenance strategy. By collecting and analyzing machine data, you're able to create this strategy. The goal is to identify

and fix machine faults before they become failures.

Because wear and tear are inevitable, proactive maintenance focuses on machine reliability and reduced downtime. This helps managers delegate resources if, and when, necessary. Having a proactive maintenance plan not only creates efficiency, it can extend the life and increase the reliability of your machines.

Proactive Maintenance is not tied to a schedule. It’s aimed at common failures, suggesting interventions based on calculated possibilities from the analyzed data.

6. Special Purpose Machines

This type of machine is designed to perform specific industrial operations faster, more accurately, and at a lower cost than general-purpose machines. It requires a small number of people to operate it and performs most operations automatically without significant intervention on the part of the worker or technician.

Features and Specifications of Special-Purpose Machines (Advantages and Limitations of Special Purpose Machines):

- ✓ Larger in size than general-purpose machines.
- ✓ It performs the work with high precision and does not require careful inspection of

Production.

- ✓ Purchase and operating costs are greater than general-purpose machines.
- ✓ It is only used to perform one purpose.
- ✓ Repairing and maintaining them requires great technical expertise and huge repair costs.
- ✓ Due to technological progress in maintenance, its design changes rapidly, which requires changing the used machine with a newer one to keep pace with the production of competing companies, even though the current machine may be usable.

Figure 4 below shows a special-purpose machine used for the purpose of material handling.

Figure 8 special-purpose machine used for the purpose of material handling

- **Replacement of Machines**

Changing machines may be necessary for the following reasons:

- Obtaining abundant and economical production.
- Obtaining high accuracy of products.
- Reducing the cost of production to the minimum possible.

- **Policies followed during Replacement of Machines**
  - ✓ It depends on the expected, productive or economic life.
  - ✓ The machine must be changed if it has been in use for ten years or more.
  - ✓ The change is made based on a comparison between continuing to use the old machine or purchasing a new machine, and the comparison element is often the cost.

☒ **Meaning of Costs**

- ✓Investment capital (i.e. the purchase price of machinery, equipment and machines).
- ✓Operating costs include direct and indirect labor, raw materials, energy used, maintenance and repair operations, insurance premiums, interest on invested capital, annual depreciation, and the remaining value after the end of the expected life.

- ✓According to the available space in the factory.
- ✓The number and quality of skilled workers required.
- ✓The suitability of safety devices on the machine to protect workers from industrial accidents.
- ✓Modern equipment and facilities available in the machine.
- ✓The warranty period allowed by the supplier or agent.
- ✓Viewpoints of supervisors and workers on the machine.
- ✓The period it takes to train on the new machine.
- ✓Abundance of spare parts.

Chapter Seven

WASTE MANAGEMENT

1.Introduction to Waste Management:

Waste disposal leads to direct and in direct environmental impacts, such as land occupation, resource depletion, amplification of global warming due to methane and other greenhouse gas emissions, waters intoxication due landfilling, as well as acidification and toxic effects from emissions to air in the case of incineration.

Direct impacts of waste represent a significant but comparatively small share of climate change, while resource depletion among similar effects is linked to indirect environmental

impacts. This is mainly because indirect results of wastes are linked with the extraction and processing of different resources to produce different types of products while focusing on the output rather than the input in many industries. This shows how indirect impacts of incorrect management of waste can be more devastating and present the highest potential compared to its counterpart.

Waste management is defined as: the different approaches and procedures designed and implemented to identify, control and handle the different types of waste from generation and until disposal. Full implementation of waste management processes, including waste prevention and reuse, and recycling wherever possible, has

and can further help avoid considerable environmental impacts when assessed from a life-cycle perspective – considering direct effects such as emissions and indirect effects such as resource depletion.

From a material resource-efficient perspective, disposal options such as landfill and incineration do not represent best practice for separately collected recyclables and mixed Municipal Solid Waste, it is important to quantify the impacts associated with such disposal operations, in order to quantify the environmental, economic and societal benefits realized through the adoption of proper waste management practices, which you will be introduced to in this text.

There are multiple governmental and international organizations that are meant with regulating and managing different aspects of the waste management sector, some of these are:

- Municipalities and Environmental Governmental Agencies: work together to create legislation and benchmarks for waste management in facilities, while handling municipal waste management as well as hazardous waste treatment in their operations.
- US Green Building Council worked on standardizing Waste management of construction waste as well as the daily operations of facility through their Leadership in Energy and Environmental Design LEED program.

- International Standards Organization ISO and the European Union EU are both involved in creating frameworks and regulation for waste management among many other fields. This is mostly represented by the ISO14001 (Environmental Management Standard) and EMAS (Eco Management and Audit Scheme).

All these entities share common goals which are:

- Improve resource efficiency.
- Reduce waste.
- drive down costs.
- Increasing Competitive advantage in supply chain.
- Meet legal obligations.

– Increase customer trust.
– Improve and manage a consistent environmental impact.

All in all, this represents the basis on which waste management approaches can be built on, this text will allow you to develop a further understanding of what goes into waste management and should a low you to grasp the full potential benefits of waste management, across different commercial, industrial, and residential applications.

2.Sustainability and Waste Management:

This chapter will introduce you to the concept of sustainability and present you with its role across the field of waste management. Sustainability is defined by meeting our needs

to complete a certain task or activity in an efficient and productive manner that benefits the implementer and does not negatively affect the environment around us, in an approach that allows us to better utilize resources in three key areas, they are: economy, environment, and society.

- economic impact, is represented in the financial benefits of adopting different plans in the operations involved at achieving a certain task.
- Environmental impact, involves the effect outputted from the activities we perform, this comes in the form of emissions, non-natural or non-native products outputted to the planet's ecosystem.

- Societal impact, targets the effect of our activities on humans' quality of life. this involves their access to resources, employment and as well as the presence of a healthy ecosystem for them to live in.

For example: back in 2012, the third sector in the UK benefited by an estimated 430 million Pounds through the reuse of different commercial and residential waste. this process supported the creation of 11,000 full-time equivalent jobs and reduced market need for intensive water consuming and GHG producing industries such as clothing. Additionally, in calculating waste generated from the clothing industry alone. Each household‘s waste of clothing per year accounts to 1000 bathtubs and the carbon

emissions from driving a modern 5 passenger car for 10000 Km.

Sustainability and Waste Management Introduction to Waste Management| Sustainability is deeply rooted within waste management as some consider it to be the basis on which it is built on. governing this relation is the concept of the 3rs of waste management and what will further be introduced as part of the environmental pyramid.

The three Rs of sustainability are reduce, reuse and recycle, and they can be utilized across our waste management operations by follow three key recommendations, which are:

- Waste Reduction, is most preferable to us as it provides the best sustainable

outcome of the 3 R's of waste management.

- Waste Reuse, whenever we find an inevitable source of waste, we look at opportunities to reuse, either for the same purpose or for another. this provides us with moderate sustainable payback.
- Waste Recycling, is the least preferable as it provides the least sustainable returns.

Note: These three represent positive areas of investment. And should not be confused with the profitability of these approaches, for example recycling some materials could use up to ten times the energy it took to originally create them, but at the same time it can be highly feasible and profitable for an independent business. While, in parallel,

reducing the need for such waste if that were possible would have saved the original cost in addition to the recycling cost.

3. Types of Waste:

A waste is any solid, liquid, or contained gaseous material that is being discarded by disposal, recycling, burning or incineration. It can be a byproduct of a manufacturing process or an obsolete commercial product that can no longer be used for intended purpose and requires disposal. Waste can be categorized on many different bases, for the purpose of the applications displayed through this text, we will focus on three of the most prominent approaches to categorizing wastes and are demonstrated in table 1 below.

Table 7 Waste categorization approaches

Characterization	Types of waste
Based on physical properties, effects etc	○ **Solid wastes:** Wastes in the form of solid i.e. local, commercial, and industrial waste. ○ **Liquid wastes:** Wastes in the form of liquid or watery. i.e. oils, chemicals, polluted water from ponds or rivers etc
Based on the biological properties of wastes:	○ Biodegradable wastes Non-biodegradable wastes
Based on the effects of waste on human health and environment:	○**Hazardous wastes:** Dangerous substances emitted from the commercial, industrial and agriculture or economical use, which are unsafe to use for further purpose. ○**Non- hazardous wastes:** Safe wastes emitted from the commercial, industrial and agriculture or economical use, considered harmless to use for further purpose

The most known type of waste, which will be focused on during this text will be Municipal Solid Waste as it accounts for most of the waste outputted to dumpsites and has a high potential to be managed. Municipal solid wastes (MSW) include commonly known trash, and consists of daily use items, which we throw away after use such as batteries,

paints, appliances, newspapers, food scraps, bottles, clothing, furniture, and packaging.

As for its sources, MSW is generated from industries, hospitals, schools, and houses. MSW is a biomass waste type consisting of glass, food wastes, metals, textiles, wood, plastics, and paper. The methods most commonly used for management of MSW are open dumping and landfilling. Both methods have side effects such as environmental contamination, methane gas generation which promote global warming and labor issues.

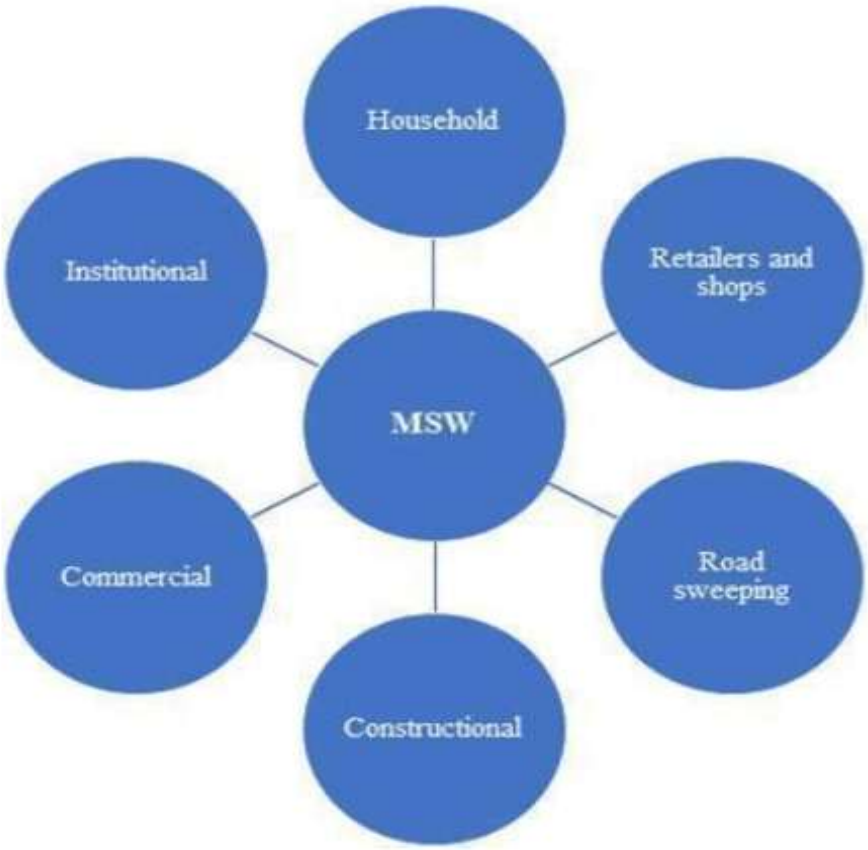

Figure 9 Sources of MSW

The presence of chemical bonding between C–H–O, MSW allows for energy generation whenever these bonds are broken, this characteristic presented the potential for extracting methane from the biodegradable

components in MSW, and further use it for the purpose of generating electricity.

In 2016, urban population generated 2.01 billion tons solid waste with each person contributing approximately 0.74 kg/day. With increasing urbanization, the annual generation of wastes is expected to increase by 70% from 2016 to 2050. The waste generation is expected to increase from around 2 billion tons from 2016 to 3 billion tons by 2050 (World Bank, 2019). Annually, 1.9 billion tons of MSW is generated with each person contributing 218 kg MSW to this grand total. This shows the great potential of putting MSW into use, rather than using traditional landfilling and dumping approaches.

4. Waste Management Principles and Procedures:

This chapter will introduce some of the administrative guidelines that govern the different processes involved in waste management. These guidelines will be translated in later chapter into technical measures for the design and assessment of waste management plans.

These guidelines will be based on the different approaches that are used in environmental science planning and auditing, which are known as the Beat Environmental Management Practice BEMP. BEMP represents the techniques, measures and actions that allow organizations to minimize their impact on the environment in all aspects under their direct control. These practices

involve multiple disciplines, including waste management. To begin with, for any facility that generates waste, there are two main practices to look for:

- Establishing waste management priorities throughout the operations and activities of the implementing facility. And this should be based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts while in parallel, considering waste generation and its consequences.
- Establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, and finally disposal of wastes.

The practices demonstrated in this text should be conducted following set procedures which conform to the 3Ra of waste management and the waste management hierarchy, and they include:

- Avoiding or minimizing the generation waste materials is the most preferable approach.
- Where waste generation cannot be avoided, we always look for ways minimize it.
- Wherever it cannot be minimized we look for ways to recovering and reusing it.
- wherever waste cannot be recovered nor reused. We must ensure that we either properly recycle it or dispose of it in an environmentally sound manner.

BEMPs and waste management practices have been recently increasingly linked to the concept of Zero Waste, which can be implemented within our waste management structure. Zero Waste is an approach that at managing waste in in a way where none of the wastes generated from our facility would be sent for disposal such as landfilling, open dumping or incineration. Rather than that, it is either reused or inputted into other processes.

After establishing the basis of our waste management practices, we start designing a specific waste management model that addresses issues linked to waste minimization, generation, transport, disposal, as well as the required monitoring process needed to ensure proper implementation of our plans.

In this model we identify how facilities that generate waste should characterize their waste according to: composition, source, types of wastes produced, generation rates, in addition to any local regulatory requirements.

Additionally, the effective planning and implementation of waste management strategies should include the following six key focus areas, which are:

- Review of new waste sources during planning, siting, and design activities, including during equipment modifications and process alterations, to identify expected waste generation, pollution prevention opportunities, and necessary treatment, storage, and disposal infrastructure.

- Collection of data and information about the process and waste streams in existing facilities, including characterization of waste streams by type, quantities, and potential use.
- Establishment of priorities based on a risk analysis that takes into account the potential Environmental, Health and Safety risks during the waste cycle and the availability of infrastructure to manage the waste in an environmentally sound manner.
- Definition of opportunities for source reduction, as well as reuse and recycling.
- Definition of procedures and operational controls for onsite storage.

- Definition of options / procedures / operational controls for treatment and final disposal

Finally, it is integral as we have said to incorporate a consistent planning criterion in the waste management plans design phase. We have until now covered how this process needs to be initiated.

In this chapter, we will start with identifying the phases of waste management, starting from its generation up until disposal, this will include:

Section 1: Generation, Collection and Storage.
Section2: Transport, Treatment, and Disposal.
Section3:Monitoring and Evaluation.

✓**Generation, Collection, and Storage**:

In this section, we will tackle three integral stages of the waste management hierarchy, which are:

1. Generation
2. Collection
3. Storage

Waste Generation Prevention Processes should be designed and operated to prevent, or minimize, the quantities of wastes generated, and hazards associated with the wastes generated in accordance with the following strategy:

- Substituting raw materials or inputs with less hazardous or toxic materials, or with those where processing generates lower

waste volumes. An example of this would be the replacement of toxic cleaning materials with sustainable and safe ones. For example, Using Certified Green Seal products, which is a labeling for environmentally friendly cleaning products.

- Secondly, we can also minimize hazardous waste generation by implementing strict waste segregation to prevent the mixing of non-hazardous and hazardous waste during storage. Because any contact between nonhazardous and hazardous waste results in contamination, thus increasing the amount of hazardous waste which need to be properly managed and processed.

Which is surely considered a losing bargain.

- Applying manufacturing process that convert materials efficiently, providing higher product output yields, including modification of design of the production process, operating conditions, and process controls. An example of this would Be in the form of reducing wasted materials in production line for fabric cutting through certain design solutions.
- Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off specification, contaminated, damaged, or excess to the facility's needs

- Instituting procurement measures that recognize opportunities to return usable materials such as containers. Which respectively prevents the over ordering of materials. This can be utilized in reusing packaging materials, and containers for compatible materials as well as furniture.

As for waste collection, methodologies differ inside a facility but in most cases, they are based on three main levels, they are:

Level 1: Station Collection (per office / room / workstation / single production line).

Level 2: Level Collection (per floor / Apartment / Zone).

Level 3: Facility Collection and Storage (within a building).

The design for each of these levels will be further in chapter six which will tackle the design and assessment of waste management plans.

Moving on to storage, waste should be stored in a manner that prevents the mixing or contact between incompatible wastes and allows for inspection between containers to monitor leaks or spills. Examples include sufficient space between incompatibles or physical separation such as walls or containment curbs, and there are a few guidelines to be kept in mind when we design storage plans:

- Store waste in closed containers away from direct sunlight, wind, and rain, and consider the wind profile for the area of storage in case it was exposed.
- Secondary containment systems should be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment.
- Secondary containment should also be included wherever liquid wastes are stored in volumes greater than 220 liters. Keeping in mind that the available volume of secondary containment should be one of two. Either at least 110 percent of the largest storage container, or 25 percent of the total storage capacity

(whichever is greater in that specific location).

- Provide adequate ventilation where volatile (hazardous) wastes are stored. Hazardous waste storage activities should also be subject to special management actions, which should be conducted by employees who have received specific training in handling and storage of hazardous wastes.

The waste management plans should also take into consideration the following parameters whenever hazardous waste streams are present in a facility:

- Provision available information on chemical compatibility to employees,

including labeling each container to identify its contents.

- Limiting access to hazardous waste storage areas only allowing employees who have received proper training while clearly identifying (label and warning signs) in the area, including documentation of its location on a facility map or a site plan.
- Conducting periodic inspections of waste storage areas and documenting the findings.
- Preparing and implementing spill response and emergency plans to address any accidental release.
- Avoiding underground storage tanks and underground piping of hazardous waste. Due to its high risk of contamination.

✓ Transport, Treatment And Disposal

On-site and Off-site transportation of waste should be conducted to allow for processing, as well as preventing or minimizing spills, releases, and exposures to employees and the public. All waste containers designated for off-site shipment should be secured and labeled with the contents and associated hazards, be properly loaded on the transport vehicles before leaving the site and be accompanied by a shipping paper (manifest) that describes the load and its associated hazards.

In conjunction with the waste collection levels inside facilities, transportation begins with municipal waste collection. In this regard

we see that Municipal waste handling is mostly based on 4 main levels, they are:

Level 1: Collection Center.

Level 2: Distribution Center.

Level 3: Treatment.

Level 4: Disposal.

These levels need to be taken into consideration when following up on the transportation of waste from handling services.

Next, the treatment of waste. This could be in the form of Recycling and Reuse In addition to the implementation of waste prevention strategies, the total amount of waste may be significantly reduced through the implementation of recycling plans within

our waste treatment approaches, which should consider the following elements:

- Evaluation of waste production processes and identification of potentially recyclable materials.
- Identification and recycling of products that can be reintroduced into the manufacturing process or industry activities within the area of operation.
- Investigation of external markets for recycling by other industrial processing operations located in the neighborhood or region of the facility (e.g., waste exchange).
- Establishing recycling objectives and formal tracking of waste collected for processing.

- Providing training and incentives to employees in order to meet objectives of proper Treatment and Disposal If waste materials are still generated.
- Finally, we need to ensure that the waste handling service should be properly equipped to treated and dispose of waste in a manner that ensures meeting sustainable goals set in our plans.

For the waste handling service provider, we need to keep in mind that Selected management approaches should be consistent with the characteristics of the waste and local regulations, and may include one or more of the following:

– On-site or off-site biological, chemical, or physical treatment of the waste

material to render it nonhazardous prior to final disposal.

– Treatment or disposal at permitted facilities specially designed to receive the waste. Examples include composting operations for organic non-hazardous wastes; properly designed, permitted, and operated landfills or incinerators designed for the respective type of waste; or other methods known to be effective in the safe, final disposal of waste materials such as bioremediation.

Commercial or Government Waste Contractors, as waste managers we need to validate that they represent the best option for us to achieve our waste management plan

goals, this is done by ensuring that they have two main things, they should:

- Have the technical capability to manage the waste in a manner that reduces immediate and future impact to the environment.
- Have all required permits, certifications, and approvals, of applicable government authorities.

Finally, waste managers should consider Installing on-site waste treatment or recycling processes in case no proper waste handling service is available and as a final option, const-ruct facilities that will provide for the environmental sound long-term storage of wastes on-site or at an alternative appropriate location up until external commercial options

become available. An example of this would be nuclear power generation waste storage.

✓ **Monitoring**

There are several guidelines that you need to be sure to follow during the implementation of any waste management plan, and most of them will be greatly utilized in the assessment stage for existing waste management plans .

Monitoring of activities associated with the management of hazardous and non-hazardous waste should include many stages of observation of active waste management operations and includes inspection, audits, tracking and characterization of waste management operations. These include:

- Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labeled and stored.
- Regular audits of waste segregation and collection practices as seen in our plans.
- Tracking waste generation trends by (type and amount of waste generated) preferably by facility departments for us to be able to assess the achievement of different goals.
- Adapt to new inputs through Characterizing waste at the beginning of generation of a new waste stream, and periodically documenting the

characteristics and proper management of the waste.

- Keep manifests or other records that document the amount of waste generated and its destination, to allow for assessment and comparison between different conditions of operations.

Accordingly, whenever significant quantities of hazardous wastes are generated and stored on site, monitoring activities should include:

- Inspection of vessels for leaks, drips, or other indications of loss.
- Identification of cracks, corrosion, or damage to tanks, protective equipment, or floors

- Verification of locks, emergency valves, and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied).
- Documenting results of testing for integrity, emissions, or monitoring stations (air, soil vapor, or groundwater).
- Documenting any changes to the storage facility, and any significant changes in the quantity of materials in storage.

As for Monitoring records for hazardous waste collected, stored, or shipped should contain Name and identification number of the material(s) collected, stored, or shipped. This includes three things:

- Name and identification number of the material(s) composing the hazardous waste, including**::**
  - physical state (be it solid, liquid, gaseous or a combination of one).
  - Quantity (in kilograms or liters, and number of containers).
- Strict Waste shipment tracking documentation that includes:
  - quantity and type.
  - date dispatched, date transported.
  - date received, as well as the.
  - record of the generation facility.
  - handling and processing service provider.
- Document Method and date of storing, repacking, treating, or disposing at the facility, cross-referenced to specific

manifest document numbers from the WMP.

You might feel that these administrative guidelines are not relevant to your facility's requirement in specific, and therefore you need to keep it mind that by the end of this text, you should be able to design the proper waste management plan for your specific facility in focus, and from there decide on the proper regulation with regard to each stage of the

hierarchy from generation to disposal.

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