UNIT 12 STORAGE LOSSES AND PREVENTION

Structure

12.0 OBJECTIVES

After completing this Unit, you will be able to:

- assess the key variables that influence the storage life and eating quality of produce;
- identify the essential factors for the development and maintenance of produce during the post-harvest stages;
- analyze the major causes of deterioration during storage;
- examine the extrinsic and intrinsic factors that contribute to microbial growth and enzymatic activity in post-harvest stages; and
- discuss the insurances for losses and damages caused by deterioration.

12.1 INTRODUCTION

Storage refers to the process of keeping goods, materials, or data in a designated space for future use while ensuring their preservation and protection. In the context of physical commodities, storage involves maintaining optimal conditions such as temperature, humidity, and cleanliness to prevent spoilage, damage, or deterioration. Effective storage ensures accessibility, inventory accuracy, and security, and it plays a crucial role in supply chain management and resource conservation. For agricultural products, it involves specialized facilities like cold storage or silos designed to retain the quality and quantity of produce over time. General methods are used to reduce the risk of spoilage associated with the storage of produce from time of harvest to time of sale. Harvested fruits and vegetables remain biologically active during the post-harvest stage, continuing to respire by inhaling oxygen and releasing carbon

dioxide, heat, and moisture. They also lose water during this phase. After harvesting, agricultural commodities undergo self-decomposition and microbial spoilage, leading to both qualitative and quantitative losses across various stages of post-harvest handling. The percentage of losses varies across different stages, including production, handling and storage, processing, distribution, marketing, and consumption. The handling and storage stage alone accounts for a significant portion of food losses, contributing approximately 6% to 36% of the total post-harvest food losses in different corners of the globe (*Flanagan, et al.*, 2019)

Table 12.1: Category wise Losses in Physical Quantity and Monetary Value

Produce Category	Quantity Loss (Million Metric Tonnes)	Monetary Loss (In Rs. Cr)	% Contribution to Total Monetary Loss
Cereal	12.49	26000.79	17.02
Pulses	1.37	9289.21	6.08
Oilseeds	2.11	10924.97	7.15
Fruits	7.36	29545.07	19.34
Vegetables	11.97	27459.08	17.97
Plantation Crops	30.59	16412.56	10.74
Livestock (Milk, Meat and Fish)	3.01	29871.41	19.55

Source: NABCONS (2022). Study to determine post-harvest losses of agri-produces in India. MOFPI. GOI. Study_report_of_post_harvest_losses.pdf (mofpi.gov.in)

In 2023, according to the NABCONS study, India experienced substantial post-harvest losses, with fruits losing 6.02%-15.05%, vegetables 4.87%-11.61, cereals 3.9%-6.0%, and oilseeds and pulses up to 10.1% due to inadequate infrastructure, insufficient cold storage facilities, and pest infestations. The study also estimated that the country incurs an annual loss of Rs. 1.53 trillion (USD 18.5 billion) due to post-harvest losses (PHL) of crops and allied agricultural produce during 2020-2022 (Table 12.1).

During the post-harvest stage, produce relies on its own energy and water reserves to survive. Each type of produce exhibits varying abilities to maintain its post-harvest quality, influenced by factors such as water loss and metabolic rates. As a result, different types of produce require specific storage conditions to preserve their quality. For instance, produce with high metabolic rates and significant water loss requires cool and humid storage conditions, while produce with lower metabolic rates and minimal water loss can be stored for longer periods without the need for cold storage.

This Unit focuses on key variables that impact the storage life and eating quality of produce, the major causes of deterioration during storage, technical methods for reducing deterioration, and the extent of coverage provided by insurance companies for loss and damage caused by deterioration.

12.2 DETERIORATION IN STORAGE

The produce continues to develop during the post-harvest stage and this development is hindered if the storage and handling conditions essential for development are not maintained. Excess heat or cold can inactivate the essential enzymes that facilitate development, resulting in a loss of quality in the produce.The following factors are crucial for maintaining the right storage and handling conditions post-harvest and also support the development of the produce in the post-harvest stage.

- **Knowledge of Physical Characteristics:** It is highly essential to understand the metabolic rates and rates of water loss for each kind of produce in the post-harvest stage for maintaining optimal storage conditions throughout the supply chain, thereby reducing quality losses due to deterioration.
- **Temperature:** It is a key factor that determines the rate of chemical reactions within the produce. It is not always true that maintaining low temperatures can extend storage lives, as maintaining the wrong temperature, rather than the optimal one, can lead to irreversible damage.
- **Relative Humidity:** Fresh produce tends to lose its moisture content throughout the post-harvest stage, so maintaining high relative humidity levels during storage can minimize the loss of water content from the produce. Therefore, it is crucial to design the cooling facilities to maintain the appropriate humidity levels required for storage.
- **Atmospheric Composition:** Modification of the composition of the gases in the atmosphere that comes into contact with the produce can have an in the impact on the metabolic rates. Increasing the carbon-dioxide content and reducing the oxygen content can slow down the respiration process. However, altering atmospheric compositions needs to be combined with temperature modifications and maintenance in order to avoid negative impacts.
- **Ethylene Exposure:** Exposure to ethylene accelerates the development of the produce. Therefore, minimizing ethylene exposure is necessary to increase the storage life of the produce.
- **Pest & Disease Control:** Pests and diseases would damage the tissues within the produce as a result the damaged tissues tend to emit ethylene, which accelerates deterioration rate and even result in spreading the infection to the other stored produce. Thus, proper hygiene needs to be maintained for post-harvest treatment of produce for control of pests and diseases.

Therefore, the freshness and quality of the goods stored depends on numerous factors, such as:

- The condition of the goods at the time of receipt;
- The length of the time from the point of harvest to the point of storage;
- Storage conditions used while transporting the goods from point of harvest to point of storage;

- Maintenance of temperature levels at the storage locations;
- Maintenance of humidity levels at the storage locations;
- The composition of gases in the atmosphere that comes in contact with the produce;
- Exposure to sources of Ethylene; and
- The type of container or packaging used for storage.

Activity 12.1:

Identify the conditions required for an onion or potato to sprout and try to identify the right temperature and humidity levels to avoid sprouting in onions or potatoes.

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Check Your Progress 12.1

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1. Briefly explain why pest and disease control is essential for maintaining the quality of produce.

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2. Briefly explain how altering the composition of atmospheric gases helps increase the storage life of the produce.

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12.3 FACTORS RESPONSIBLE FOR DETERIORATION

Deterioration can be defined as a deviation from a normal state that is unacceptable for consumption by humankind or for Industrial usage. Deviations from the normal state include changes in nutrition value (decomposition of proteins, carbohydrates and vitamins) & changes in organoleptic features such as color, flavor, taste, odor, consistency, sight etc. These deviations result out of improper sanitation; reactions resulting out of enzymatic and chemical changes; physical changes resulting out of changes in temperature, mechanical effects, inappropriate storage and handling methods; microbiological and macrobiological factors.

1. **Enzymatic Changes:** Deterioration also results from the action of enzymes present in the produce. These enzymes are organic catalysts found in living cells, which accelerate chemical changes leading to the loss of color, flavor, and texture. While they remain relatively inactive during the pre-harvest stage, they become activated after harvesting. Once activated, these enzymes often accelerate the breakdown of components and tissues within the produce through processes such as oxidation, browning, or ripening. The destruction caused by enzymatic activity within the food is referred to as **autolysis**.
    - ***Oxidation:*** Itis a chemical process often initiated by exposure to oxygen and results in fats to turn rancid and destruction of nutrition values. Loss of nutrients such as vitamins A & C and thiamin often result due to oxidation of produce. This process also produces undesirable changes in color, flavor and nutrition contents. Exposure to light also leads to oxidation of fats within the produce.
    - ***Browning*****:** Results in browning of surfaces exposed to air due to the activity of enzymes present on the surface exposed to air.
    - ***Ripening*****:** Enzymes present in the produce can also activate the process of conversion of starch into sugars resulting in ripening of the produce.
2. **Microbiological factors:** Enzymatic activity within the produce would often facilitate microorganisms responsible for deterioration to enter the produce. These microorganisms, or microbes, include bacteria and fungi also tend to grow rapidly with favorable conditions of moisture and temperature.

The typeand number of microorganisms present depends on the type of the produce and the degree of microbial contamination. Extrinsic factors such as temperature, humidity and oxygen levels in the atmosphere that comes in contact with the produce and intrinsic factors such as pH levels, nutrition/ moisture content within the produce as well as structure of produce such as self-coverage of the produce tend to impact the growth of the microorganisms. In addition to the general microflora present within the produce, microbial contamination also leads to addition of microorganisms at each stage of handling. The kind & number of organisms present determines the quality and extent of spoilage of the produce.The growth of the microorganisms also

depends on the extent of moisture and pH levels within the produce. High moisture levels favor bacterial growth and low moisture levels favour mold growth.

Also, external conditions such as favorable temperatures enable the growth of bacteria and availability of oxygen enable the growth of molds.

- ***Bacteria*:**These are minute single celled and variously shaped organisms that are most widespread among the produce. These occur in various shapes and can be classified as coccus (spheroidal), bacilli (cylindrical) or spirillae (spirillar) based on the shape seen under the microscope. These are smaller than yeasts and molds and are visible only under a microscope. These often multiply rapidly with favourable conditions of temperature and moisture levels. These tend to produce enzymes that break down the cell walls and aid them to obtain nutrients for growth from the produce. Increase in the number of bacteria increases the enzymatic activity resulting in loss of flavor, texture and colour. Some kind of bacteria grow in the presence of oxygen, these are called as aerobic bacteria and some kind of bacteria grow without the presence of oxygen and are called as anaerobic bacteria.
- **Yeasts:** These are single celled fungi that reproduce through budding. In warm and moist conditions and with the presence of sugars within the produce, yeasting results in the fermentation of the produce. These are not visible to the naked eye but are visible through a microscope. During the fermentation process the produce is broken to form alcohol and carbon-dioxide.
- **Molds:** Molds are fungi that have *multicellular* structures that are visible to the naked eye. These tend to grow by producing spores and can be seen on the surface of the produce. These tend to germinate at favorable conditions of temperature and moisture levels and produce a fluffy growth colored white or grey or sometimes bluish-green, red, orange, etc. depending on the type of the mold.

3. **Macro Biological Factors:**The presence of insects and their excreta in packaged foods leads to economic losses as the produce losses the quality essential for sale. It also leads to reduction in nutrition quality, production of non-acceptable flavors and acceleration of the decay process resulting from the increase in temperature and moisture levels within the package. Infestation may be detected by the presence of webs, clumps and holes in packages. Rodents also require food for survival and damage the produce making it more vulnerable for deterioration. Produce often gets damaged and contaminated by pests including termites (*mist*), beetles, locusts, cockroaches, flies and rodents such as rats and mice. Pests result in damage of the produce and also contaminate the produce in various ways, such as boring/tunnelling into the produce and thus feeding into the same.
4. **Mechanical Effects:** Physical damages such as bruises or cracks on the produce tend to facilitate the growth of microorganisms. Bruises on protective outer layer of the produce often facilitate the entry of microorganisms.

5. **In appropriate Storing & Handling Methods:** In appropriate storage and handling cause microbial contamination, leading to deterioration of the produce. Basic kinds of deterioration include changes in:

   - **Appearance:**Where in the produce lacks its quality with reference to its looks caused by microbial growth i.e. formation of molds on the surface; browning of surfaces & color changes due to chlorophyll break down.
   - **Textural Changes:** Where in the produce lacks its quality with reference to its feel caused by slime formation due to accumulation of microbial cells & tissue softening resulting from enzymatic degradation.
   - **Taste & Odor:** Where in the produce lacks its quality with reference to its taste & odor due to the development of nitrogenous compounds, sulfides and acids.

Deterioration in foods is caused due to changes in microbiological, biochemical, physical and chemical conditions such as:

- Accelerated growth of microorganisms such as bacteria, molds and yeast;
- Activities resulting from enzymes present in food leading to chemical reactions and changes in color, texture and flavour;
- Unfavourable temperature levels;
- Unfavourable moisture levels;
- Oxidative reactions resulting out of exposure to oxygen and light;
- Bruising resulting out of physical damages; and
- Damage resulting from pests, insects and rodents.

Activity 12.2:

Visit a nearby vegetable market and try to collect pictures of deterioration from enzymatic changes.

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Check Your Progress 12.2

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1. Brief on deterioration due to microbiological factors.

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2. Brief on deterioration due to macrobiological factors.

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12.4 PREVENTIVE MEASURES

Being knowledgeable about predominant factors responsible for deterioration; conditions that favor deterioration and rates of deterioration that are specific to each kind of produce is highly essential to prevent deterioration of the produce and curb economic losses. Knowledge of the above parameters is highly essential to maintain the nutritional values and organoleptic properties of the produce from the time of harvest to the time of sale.

Preservation of produce is essential to save the excess production for future consumption. Also preservation is needed to make the produce available to meet off-season and multi-location demand requirements. Fresh produce also needs to be preserved to save its nutritional values for longer periods. The produce has to be protected from deterioration caused by microbial growth; enzymatic actions within the produce; non-enzymatic reactions such as oxidation; mechanical damages such as bruises/cuts and damage from rodents and insects. Preservation can be temporary wherein the microbial growth is retarded for shorter time frames and it can be permanent wherein the microbial growth is permanently retarded.

12.4.1 Principles of Preservation

The preservation methods are based on general principles to inhibit spoilage caused by microbial decomposition, enzymatic/non-enzymatic chemical reactions, mechanical damages and damages from insects and rodents.

1. Retardation or inhibition of microbial growth on a temporary or permanent basis.

- Keeping the microbes away from the produce (asepsis).
- Removal of microbes through filtration.
- Curbing the growth of microbes through lowering temperatures, drying mechanisms, maintenance of anaerobic conditions and through addition of chemicals.
- Killing of microbes through the use of heat or radiations.

2. Preventing self-decomposition within the produce.
   - Destruction/inactivation of enzymatic action through blanching.
   - Delaying/prevention of the oxidation processes through the usage of antioxidants.
3. Avoidance of damage caused by mechanical abuse, insects and rodents.

Application of heat for shorter durations can aid in killing the undesirable microbes that cause deterioration of the produce. The action of microbes can be delayed by the usage of special protective packaging to avoid the entry of air or water essential for microbial growth, reduced temperature levels can also aid in delaying the microbial growth and addition of preservatives such as sodium benzoate can also delay the microbial growth.Enzymatic action can be stopped by blanching wherein the produce is provided with a mild heat treatment.

12.4.2 Methods of Preservation

Methods of preservation commonly used include- exposure to low temperatures, exposure to high temperatures, addition of preservatives and dehydration processes.

1. **Exposure to Low Temperatures:** Exposure to low temperatures inhibits microbial growth and enzymatic action and thus helps preserve the produce for longer periods.
   - **Freezing:**It helps in preserving the produce for longer durations as the produce is stored well below its freezing temperature. Freezing helps in preventing the microbial growth but enzymatic action can be prevented by blanching the produce prior to freezing.
   - **Dehydrofreezing:** Here the produce is reduced to 50% by weight and volume prior to freezing.The duration for which the foods can be preserved by freezing depends on the type of produce. Refrigeration and cold storage are other means of exposure to low temperatures that are used for storage of produce for shorter time frames.
2. **Exposure to High Temperatures:**The microbes and enzymes are destroyed by exposure to high temperatures. Pasteurization and sterilization are common methods used to apply high temperatures.
   - **Pasteurization:** It is a process wherein the produce is heated to high temperatures and then suddenly cooled. The exposure to sudden changes in temperatures leads to the destruction of microbes to some extent.
   - **Sterilization:** Here the produce is exposed to high temperatures to destroy all kinds of microbes present in the food.

3. **Usage of Preservatives:** Chemicals that are added to extend the shelf life of the produce are called as preservatives. These preservatives aid in keeping the produce fresh for longer durations. Some of the natural preservatives include salt, sugar, lemon juice, vinegar oil and spices. Discoloration of light-coloured fruits can be minimized by the usage of antioxidants, such as ascorbic acid or citric acid, before freezing.
4. **Dehydration:** Removal of excess moisture and water levels from foods also aids in increasing the shelf life of the produce.
5. **Other Methods:** Other methods generally used for preservation of produce are canning, vacuum packing, pickling, combined treatments and radiation etc.
    - **Canning:** It involves application of high temperatures essential for destruction of all microbes present and then placement of the produce in air tight sealed sterilized containers for prevention of re-contamination and for preservation of the freshness of the produce. The degree of heat and length of heating depends upon the kind of the produce and also the kind of microbes present in the produce.
    - **Radiation:** it is a new method sometimes used for pasteurization and sterilization.
    - **Vacuum Packing:** Vapor-proof packaging aids in keeping the air out to reduce oxidation problems. Packaging of foods in cans, jars, cartons, plastics or paper also aids in ensuring food safety as it helps in keeping the food intact and also provides protection against the entry of microorganisms, dust, dirt, insects, chemicals and foreign material.
    - **Pickling**: It aids in varying the pH levels essential for microbial development.

Finally, to reduce the number of microbes, fresh produce should always be washed to physically remove as many microorganisms as possible. Gentle handling of food items would also facilitate maintenance of food quality and safety for longer durations.

12.5 INSURANCE COVERAGE FOR LOSS OR DAMAGE DUE TO DETERIORATION

Deterioration insurance is designed to provide indemnity against damage or loss from deterioration of produce stored under controlled atmospheres. When the produce is stored under controlled environment, there is always a risk of damage to the stock from failure of power supply units, impact damage caused by material handling equipment and breakdown of equipment essential for providing the controlled atmosphere for storage. The policy would generally cover for damages resulting from variation in temperatures due to equipment breakdown, accidental damage to the refrigeration equipment, non-operation of controlling equipment, losses from refrigerant leakages and accidental failure of public electricity supply. Such Insurance coverage policies are highly essential for businesses which store perishable goods. Sometimes these policies also cover for costs of cleanup and disposal of damaged produce. Sometimes deterioration of stock policies might insist on machinery break down policies

to be in force at all times and sometimes Deterioration of Stock (DOS) policies are issued in combination with machinery breakdown policies.

The premiums to be paid for coverage from losses are calculated based on the value of the produce stored within, age and condition of refrigerating machinery, location and construction of the storage facility, nature and type of risk involved based on the kind of product stored, storage handling experience, previous record of losses incurred within the storage facility, etc.

The policy is subjected to certain exclusions and it does not cover for losses resulting from wars, acts of terrorism, damage arising from the use of nuclear weapons, radioactive contamination, damages arising from improper storage and packing methods used negligence of the insured and their representatives, pre-existing faults or defects, willful/deliberate acts, etc.For availing the benefits covered by the DOS policies the below information has to be provided to the insurance provider.

- Number and kind of cold storages used i.e. kinds of freezers and chillers;
- Type of produce being stored;
- The value of produce being stored either at cost or sale prices;
- The age of the storage facility along with the preventive maintenance schedules being used;
- The size of the facility;
- The availability of backup refrigeration or power generation;
- The frequency of logging the temperature checks and levels; and
- The availability of temperature alarms and signals at the facility.

Check Your Progress 12.3

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1. Briefly explain the principles of preservation.

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2. Briefly explain how exposure to high temperatures aids in preservation.

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3. Briefly explain the general coverage provided by the DOS policies.

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Activity 12.3 :

1. Visit your kitchen and try to identify the foods wherein lime juice is used as a preservative.

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2. Visit a storage facility in your neighborhood and;
   - Identify the kind of perishable products being stored at the facility.
   - Describe the types of cold storage facilities available.
   - Find out what kind of insurance is in place to mitigate the risk of loss due to deterioration.

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12.6 LET US SUM UP

The store manager needs to take care of all the factors required for maintaining the freshness and quality of goods such as condition of the goods at the time of receipt, length of the time from the point of harvest to the point of storage, storage conditions used while transporting the goods from point of harvest to point of storage, maintenance of temperature levels at the storage locations, maintenance of humidity levels at the storage locations, composition of gases in the atmosphere that comes in contact with the produce, exposure to sources of ethylene, type of container or packaging used for storage, type

of produce being stored, competence on metabolic rates and rate of water loss for each kind of produce in the post-harvest stage and maintenance of hygiene throughout the post-harvest treatment of the produce. He also needs to ensure provision of controlled storage environments to reduce deviations from normal state that include changes in nutrition value (decomposition of proteins, carbohydrates and vitamins) and changes in organoleptic features such as color, flavour, taste, odor, consistency, sight, etc., which result out of improper sanitation; reactions resulting out of enzymatic and chemical changes; physical changes resulting out of changes in temperature, mechanical effects, inappropriate storage and handling methods; microbiological and macro biological factors, etc.

The store manager also needs to take up preservation methods based on general principles to inhibit the spoilage caused by microbial decomposition, enzymatic/non-enzymatic chemical reactions, mechanical damages and damages from insects and rodents. He/she needs to insure the storage facility to mitigate risks for damages resulting from variation in temperatures due to equipment breakdown, accidental damage to the refrigeration equipment, non-operation of controlling equipment, losses from refrigerant leakages and accidental failure of public electricity supply.

12.7 KEY WORDS

Autolysis : Destruction of cells through the action of enzymes.

Asepsis : A state of being free from deterioration-causing contaminants such as bacteria, fungi, parasites, etc.

Bacilli : Rod-shaped bacteria.

Blanching : A process wherein a food particle is plunged into boiled water prior to cold storage.

Boring : A process of enlarging a hole.

Chlorophyll : Molecules within plants that absorb sunlight and use its energy to synthesize carbohydrates from carbon dioxide and water.

Coccus : Round-shaped bacteria.

Enzymes : Compounds produced by living organisms that act as biochemical catalysts.

Ethylene : A small hydrocarbon gas that occurs naturally and also results from combustion.

Extrinsic : Conditions or factors operating from outside.

Fermentation : A process that converts sugars into acids, alcohol, or gases.

Hygiene : Conditions and practices that promote and preserve health.

Indemnity : An obligation for a person to provide compensation for a loss incurred by another person.

Intrinsic : Conditions or factors operating from inside.

Macrobiology : Study of large living organisms.

Metabolism : Life-sustaining chemical changes/reactions occurring within the cells of living organisms.

Microbes : Single-celled organisms not visible to the naked eye.

Microbiology : Study of very minute living organisms.

Nuclear : Refers to deriving energy from the nucleus of an atom through fusion and fission processes.

Organoleptic : Properties exhibited by foods that can be experienced by taste, touch, smell, and sight.

Radiation : Energy that comes from a source and is transmitted in the form of waves through space or materials.

Radioactive : Relates to materials that emit radiation energy in the form of alpha, beta, and gamma particles.

Rancid : Deals with rancidification, *i.e.*, oxidation of fats, fatty acids, and edible oils.

Rodents : Mammals characterized by a single pair of constantly growing incisor teeth in the upper and lower jaws.

Spirilla : Elongated spiral-shaped bacteria.

Tunneling : A process of making a hole.

12.8 SUGGESTED FURTHER READINGS/ REFERENCES

- *All India Tariff on Deterioration of Stock Insurance- Tariff Advisory Committee DOS/1-1-01.*
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- H.J. Heinz-*Principles & Practices for the Safe Processing of Foods*, 1991- Butterworth-Heinemann, ISBN-13**:** 978-1483132921
- Mircea EnacheseuDauthy-*Fruit & Vegetable Processing*, 1995- FAO Agricultural Services Bulletin No 119, Food and Agricultural Organization of the United States, Rome. ISBN: 92-5-103657-8.
- NABCONS (2022). Study to determine post-harvest losses of agri-produces in India. MOFPI. GOI. Study_report_of_post_harvest_losses.pdf (mofpi.gov.in)
- Preservation of Food-Home Science in Daily Lives-Module I

12.9 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 12.1

1. Pests and diseases damage the tissues within the produce; as a result the damaged tissues tend to emit ethylene and thus increase the deterioration rate and even result in spreading the infection to the other stored produce. Therefore, proper hygiene must be maintained for post-harvest treatment of produce for control of pests and diseases.
2. Modification of the composition of the gases in the atmosphere that comes in contact with the produce can have an impact on metabolic rates. Increasing the carbon dioxide content and reducing the oxygen content can slow down the respiration process. However, alteration of atmospheric compositions should be combined with temperature modifications and maintenance in order to avoid negative impacts.

Check Your Progress 12.2

1. Microbial activity accelerates produce deterioration, with bacteria and fungi thriving under favorable moisture and temperature conditions. The type and extent of microbial presence depend on intrinsic factors like pH, moisture, and structure, as well as extrinsic factors like temperature, humidity, and oxygen. Contamination increases at each handling stage, influencing spoilage. High moisture favors bacterial growth, while low moisture supports molds, with temperature and oxygen further affecting microbial proliferation.
2. The presence of insects and their excreta in packaged foods leads to economic losses as the produce losses the quality essential for sale. It also leads to reduction in nutrition quality, production of non-acceptable flavors and acceleration of the decay process resulting from the increase in temperature and moisture levels within the package. Infestation can be detected by the presence of webs, clumps and holes in packages. Rodents also require food for survival and damage the produce making it more vulnerable for deterioration. Produce often gets damaged and contaminated by pests including termites (*mist*), beetles, locusts, cockroaches, flies and rodents such as rats and mice. Pests result in damage of the produce and also contaminate the produce in various ways like boring/tunnelling into the produce and thus feeding into the same.

Check Your Progress 12.3

1. The preservation methods are based on general principles to inhibit spoilage caused by microbial decomposition, enzymatic/non-enzymatic chemical reactions, mechanical damages and damages from insects and rodents.

   Retardation or inhibition of microbial growth on a temporary or permanent basis

   - Keeping microbes away from the produce (asepsis)
   - Removal of microbes through filtration

- Curbing the growth of microbes through lowering of temperatures, drying mechanisms, maintenance of anaerobic conditions and through addition of chemicals.
- Killing of microbes through usage of heat or radiations

2. The microbes and enzymes are destroyed by exposure to high temperatures. Pasteurization and sterilization are common methods used for exposure to high temperatures.

   Pasteurization: It is a process wherein the produce is heated to high temperatures and then suddenly cooled. The exposure to sudden changes in temperatures leads to the destruction of microbes to some extent.

   Sterilization*:* Here the produce is exposed to high temperatures for destruction of all kinds of microbes present in the food.

3. Deterioration insurance is designed to provide indemnity against damage or loss from deterioration of produce stored under controlled atmospheres. When the produce is stored under controlled environment, there is always a risk of damage to the stock from failure of power supply units, impact damage caused by material handling equipment's and break down of equipment's essential for providing the controlled atmosphere for storage. The policy would generally cover for damages resulting from variation in temperatures due to equipment break down, accidental damage to the refrigeration equipment, non-operation of controlling equipment, losses from refrigerant leakages and accidental failure of public electricity supply.

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MAM-063

PROCUREMENT AND MATERIALS MANAGEMENT IN AGRIBUSINESS

Block

4

INVENTORY MANAGEMENT

BLOCK 4 INVENTORY MANAGEMENT

Effective Inventory Management plays a vital role in ensuring a company's financial stability and smooth operations. Organizations strive to maintain an optimal inventory level to prevent excessive stockpiling, which can lead to higher holding costs, or stock shortages, which may disrupt production and sales.

Managing inventory requires constant monitoring, strategic planning, and seamless coordination between procurement, production, and finance departments to align inventory levels with business needs.

Given the vast number of inventory items in manufacturing and trading organizations, tracking and controlling each item individually can be complex and costly. To address this challenge, companies employ selective inventory control techniques such as Pareto analysis, which helps prioritize high-value and high-impact items.

This approach is based on the principle that a small percentage of inventory items contribute to a significant portion of the total value, allowing businesses to allocate resources effectively. By focusing on critical inventory components, companies can enhance operational efficiency, minimize unnecessary costs, and ensure a steady supply of essential materials, leading to better profitability and overall business success.

Selective Inventory Control, based on Pareto's analysis and the principle of management by exception, helps companies manage their inventories effectively and efficiently. Since manufacturing and trading organizations deal with thousands of inventory items, it is neither practical nor cost-effective to monitor all items closely.

Instead, selective control techniques allow businesses to focus on the most critical inventory items, optimizing costs and ensuring smooth operations. By classifying inventory based on its value, usage frequency, and importance, organizations can allocate resources efficiently, reduce wastage, and minimize holding costs. This approach helps in prioritizing high-value and fast-moving items while applying less stringent controls on low-value or slow-moving stock.

Effective implementation of selective inventory control enhances inventory turnover, prevents stockouts, and avoids excess stock accumulation. Additionally, it enables better coordination between procurement, production, and finance departments, leading to improved decision-making, cost savings, and overall operational efficiency.

The material provided in this Block is supplemented with various *examples* and activities to make the learning process simple and interesting. We have also provided Check Your Progress questions for the self-test at a few places of these Units which invariably lead to possible answers to the questions set in those exercises. What perhaps you ought to do, is to go through Units and jot down important points as you read, in the space provided in the margin. This will help you in assimilating the content. A list of reference books has been provided at the end of each Unit for further detailed reading.

UNIT 13 INTRODUCTION TO INVENTORY MANAGEMENT

Structure

13.0 OBJECTIVES

After completing this Unit, you will be able to:

- describe the concept and importance of inventory;
- discuss the need for inventories and the factors that affect inventories;
- explain inventory management;
- differentiate between centralized and decentralized purchase, inventory management and stores;
- discuss the concept and importance of purchase management;
- explain logistics management and demand system; and
- state the importance of procurement-vendor selection and negotiations.

13.1 INTRODUCTION

Inventory management is the art and science of planning, procuring, storing and providing the appropriate materials of right quality and right quantity, at the right place and at the right time.It is concerned with planning, organizing and controlling the flow of inventories/materials from their initial purchase through internal operations to the service point through distribution. This ensures maximization of the use of the firm's resources to provide the required level of customer service. Acquisition of raw materials or products includes more than just the purchase price from a supplier. It can also include transportation and freight costs and discounts. Manufacturing firms can include costs related to overhead and labor. Service organizations can include intangible inventories for work in process that has not yet been billed to the customer. From this Unit, we can understand how the inventory management encompasses various aspects essential for efficient operations. Inventory acquisition involves procuring necessary materials while accounting for costs like ordering, carrying, and storage. Purchase management highlights the scope, objectives, and importance of efficient procurement processes to optimize resources and reduce costs. Logistics management focuses on planning and managing material flow and demand to meet customer needs effectively, addressing different types of logistics and their objectives. Additionally, procurement involves selecting reliable vendors and negotiating terms to secure quality products and services at competitive rates.

13.2 INVENTORY: IMPORTANCE AND FUNCTIONS

13.2.1 Concept of Inventory

Inventory is needed for the definitive consumption/demand of materials and to manage the uncertainty involved in the usage or availability of the materials. The decoupling function of the inventory allows various dependent operational stages in any production/operation process can act independently of each other. The monetary value of inventories serves as a guide to indicate the size of investment required to achieve operational convenience. Inventories are physical stocks of items that a manufacturing or service organization

holds in stock or for the efficient running of activities.Inventory can also be considered as an idle resource of any kind that holds economic value.

Definitions:

"Inventory is an idle stock of physical goods that holds economic value, and is held in various forms by an organization in its custody awaiting packing, processing, transformation, use or sale at a future point of time".

Any organization which is in the production, trading, sale and service of a product will necessarily hold stock of various physical resources to aid in future consumption and sale. While inventory is a necessary evil of any such business, it may be noted that the organizations hold inventories for various reasons, which include speculative purposes, functional purposes, physical necessities, etc.

"*In functional terms, inventory is defined as the sum of the value of raw materials, fuels, lubricants, spare parts, maintenance consumables; semi-processed materials and finished goods stock at any given point of time".*

"*The operational definition of inventory would be the amount of raw materials, fuel and lubricants, spare parts and semi processed material to be stocked for the smooth running of the plant".*

Inventories are maintained basically for operational smoothness by uncoupling successive stages of production.The monetary value of inventory serves as a guide to indicate the size of investments made to achieve operational convenience.

13.2.2 Reasons for Inventory

Let us understand the reasons for a firm maintains inventory that is often more than the quantity required for day-to-day operations.

Meet Demand: In order to stay in business, it must have the products that the customer wants available when the customer wants them. If the customer can get the goods from some other source, they would go to other sources. Hence, in many instances, if a good is not in inventory, a sale is lost forever.

Keep Operations Running: A manufacturer must have certain purchased items (raw materials, components, or subassemblies) in order to manufacture its product. Running out of even one item can prevent a manufacturer from completing the production of its finished goods. Inventory between successive dependent operations also serves to decouple the dependency of the operations. If a supply of work-in-process inventory is kept between each work center, then each machine can maintain its operations for a limited time, hopefully until operations resume the original center.

Lead Time: Lead time is the time that elapses between the placing of an order (either a purchase order or a production order issued to the shop or the factory floor) and actually receiving the goods ordered. If a supplier (an external firm or an internal department or plant) cannot supply the required goods on demand, then the client firm must keep an inventory of the needed goods. The longer the lead time, the larger the quantity of goods the firm must carry in inventory.

Hedge: Inventory can also be used as a hedge against price increases and inflation. Salesmen routinely call purchasing agents shortly before a price increase goes into effect. This gives the buyer a chance to purchase material, in excess of current needs, at a price that is lower than it would be if the buyer waited until after the price increase occurs.

Quantity Discount: Often, firms are given a price discount when purchasing large quantities of a good. This also frequently results in inventory in excess of what is currently needed to meet demand. However, if the discount is sufficient to offset the extra holding cost incurred as a result of the excess inventory, the decision to buy the large quantity is justified.

Smoothing Requirements: Sometimes, inventory is used to smooth demand requirements in a market where demand is somewhat erratic.

Check Your Progress 13.1

Note: a) Use the spaces given below for your answers.

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

1. What is Inventory?

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2. Indicate the different types of inventories.

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3. Give the reasons for maintaining inventories.

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13.2.3 Factors Influencing Inventory

There are various factors that influence inventory. These include:

a) Demand Related Factors:

- Size and frequency of orders;
- Uniformity or predictability of sales;
- Service requirements or allowed delays in filling orders;
- Physical and economic structure of the distribution network;
- Accuracy, frequency and detail of sales forecasts;
- Costs associated with failure to meet demand.

b) Process Related Factors:

- Form of production organization-Regular production, job shop, project;
- Number of process stages;
- Degree of specialization and differentiation at specific stages;
- Physically required process times, batch sizes and specific stages;
- Time required to respond to (lead time) changes in production plans;
- Production process capability and flexibility;
- Capacity of production and warehouse stages;
- Types of process-batch or continuous;
- Quality requirements, shelf life, obsolescence and risks.

c) Organizational Factors:

- Organization structure;
- Information system;
- Systems and procedures;
- Data processing capabilities-speed, volume and cost;
- Amount of capital available.

13.2.4 Functions of Inventory

The various functions of inventory are as follows:

- Maintaining a rate of flow through a process;
- Covers gaps in discontinuous process;
- Allowing purchase or production in economic lots;
- Allowing portions of a system or process to operate at different rates, at least temporarily;
- Meeting fluctuations in supply, process or consumption;
- Modifying and storing perishable commodities;
- Speculation against anticipated changes in costs or availability.

Check Your Progress 13.2

Note: a) Use the spaces given below for your answers.

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

1. What are the functions of inventory?

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2. Indicate the factors that influence the inventory system.

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13.3 INVENTORY MANAGEMENT

Inventory management is primarily about specifying the shape and percentage of stocked goods. In agricultural sector the inventory management is the need of the hour, as resources are limited and need to be utilized efficiently. It is required at different locations within a facility or within many locations of a supply network to support the regular and planned course of production and stock of materials. The scope of inventory management concerns the fine lines between replenishment lead time, carrying costs of inventory, inventory forecasting and related aspects. Balancing these competing requirements leads to optimal inventory levels, which is an ongoing process as the business needs shift and react to the wider environment.

There are Three Basic Reasons for Keeping an Inventory:

1. **Time :** The time lags present in the supply chain, from supplier to user at every stage, require that you maintain certain amounts of inventory to use in this "lead time." The **lead time** refers to the total time taken from the initiation of a process to its completion.
2. **Uncertainty :** Inventories are maintained as buffers to meet uncertainties in demand, supply and movements of goods.
3. **Economies of Scale :** Ideal condition of "one unit at a time at a place where a user needs it, when they need it" principle tends to incur high costs in terms of logistics. So, bulk buying, movement and storing brings in economies of scale, thus justifying inventory.

13.3.1 Inventory Acquisition

Acquisition of inventory usually involves a high volume of transactions and represents sizable expenditures for most businesses, whether retailers or manufacturers. For these businesses inventory is the most dynamic asset, and is usually a significant proportion of current assets. The cost of goods sold is typically the largest expense of these businesses. In agriculture, inventory acquisition involves procuring essential inputs like high-quality hybrid seeds from certified suppliers before the planting season. This ensures availability, accounts for lead time, and requires proper controls to verify quality, manage costs, and maintain records for optimal productivity. Given the significance of inventory and property, plant and equipment, internalcontrols over the acquisition of these assets are particularly important.

BOX 13.1: Internal Control Procedures for the Acquisition of Inventory Should Address the Following Points:

1. Are orders properly authorized?
2. Were all invoiced goods actually ordered by us?
3. Were all invoiced goods actually received (and of correct quantity and type and at the agreed price)?
4. Is payment made only if the above conditions are satisfactorily met?
5. Is the handling and storage of inventory secure?

There are five categories of procedures generally used to achieve control over acquisition of inventory:

1. Proper authorization
2. Segregation of duties
3. Documents and records
4. Access controls
5. Independent checks.

These procedures should be an integral part of the process for purchasing and paying for inventory and other goods and services. However, specific internal procedures are tailored to a business's needs. *For example*, a small business may not implement all of these procedures. Risk may be reduced for a small business if management is hands-on and directly involved in the day-to-day operations.

These procedures should be an integral part of the inventory purchasing function which involves the following six steps:

1. **Requisitioning Goods and Services:** A purchase requisition is an internal document requesting the purchasing department to buy goods or services. It usually originates from those departments directly involved with the control of inventory, *for example*, a retail department in a shop or the inventory warehouse.

2. **Preparation of Purchase Orders:** The purchasing department receives the purchase requisition from the operating department. A purchasing officer will raise a purchase order, which is the written offer sent to a supplier for the purchase of goods and/or services requested in the requisition. The purchasing officer has the authority to issue a purchase order only upon the receipt of a properly approved purchase requisition.

3. **Receiving of Goods:** There should be a central receiving section or department that is separate from the other functions (requisitioning, purchasing, storage and accounting). The goods receiving department receives one copy of the purchase order from the purchasing department. This order authorizes the receiving clerk to accept goods delivered by the supplier. The goods received should be compared with the description on the purchase order, the quantity should be checked and items inspected for damage.

4. **Storage of Goods:** The inventory warehouse receives goods together with a copy of the receiving report from the receiving department. Inventory should be stored in secure areas with restricted access. Employees responsible for custody of inventory should not be involved in the other purchasing functions. These procedures reduce the risk of unauthorized purchases, inefficient usage (wastage) and theft of goods.

5. **Verification and Approval for Payment:** The accounts payable department receives the supplier's invoice and matches it with the related copy of the purchase order and receiving report received from the other departments. The accounts payable clerk checks that the details on the supplier's invoice agree exactly with the purchase order and receiving report. This is a crucial procedure, as this check should confirm that:

   - Goods invoiced were in fact ordered by the business
   - Goods invoiced were actually received by the business.

The accounts payable clerk checks the supplier's invoice for mathematical accuracy. If all is in order, the supporting documents (purchase order, receiving report and supplier invoice) are attached to a pre-numbered payment voucher. This voucher is coded with the account or accounts to be debited (usually assets and expenses).

6. **Recording the Liability:** The accounting department receives the purchases journal or voucher register from accounts payable and uses this for posting the specified accounts in the general ledger. An accountant should check the appropriateness of account classifications prior to posting.

13.3.2 Inventory Acquisition Costs

Inventory acquisition costs refer to those costs that are necessary to bring the inventory to a condition that is ready for sale. A manufacturing firm incurs the freight and shipping costs that the merchandising firm also deals with, as well as the other costs referred to above. However, the inventory cost reported by the manufacturing firm includes the cost of converting the raw materials to finished goods. The cost of goods sold for a manufacturing firm

includes all the costs of a merchandising firm, plus the conversion costs of goods sold during the period. The manufacturing firm indicates the extent to which its inventory costs are progressing through three inventory accounts: raw materials, work-in-process and finished goods.

There are Four Basic Issues Concerning Inventory are:

1. The costs included in the acquisition cost
2. The valuation basis used for items in inventory
3. The frequency with which inventory computations occur, perpetual or periodic.
4. The cost flow assumption used to trace the movement of costs into and out of inventory, which doesn't necessarily represent physical flow of inventory.

Inventory Costs:

- Costs associated with ordering too much (represented by carrying costs);
- Costs associated with ordering too little (represented by ordering costs);
- These costs are opposing costs, i.e., as one increases the other decreases.

This cost behaviour is the basis for answering the first fundamental question: How much to order? It is known as the Economic Order Quantity (EOQ).

Balancing Ordering cost and Inventory carrying cost is shown in Fig.13.1

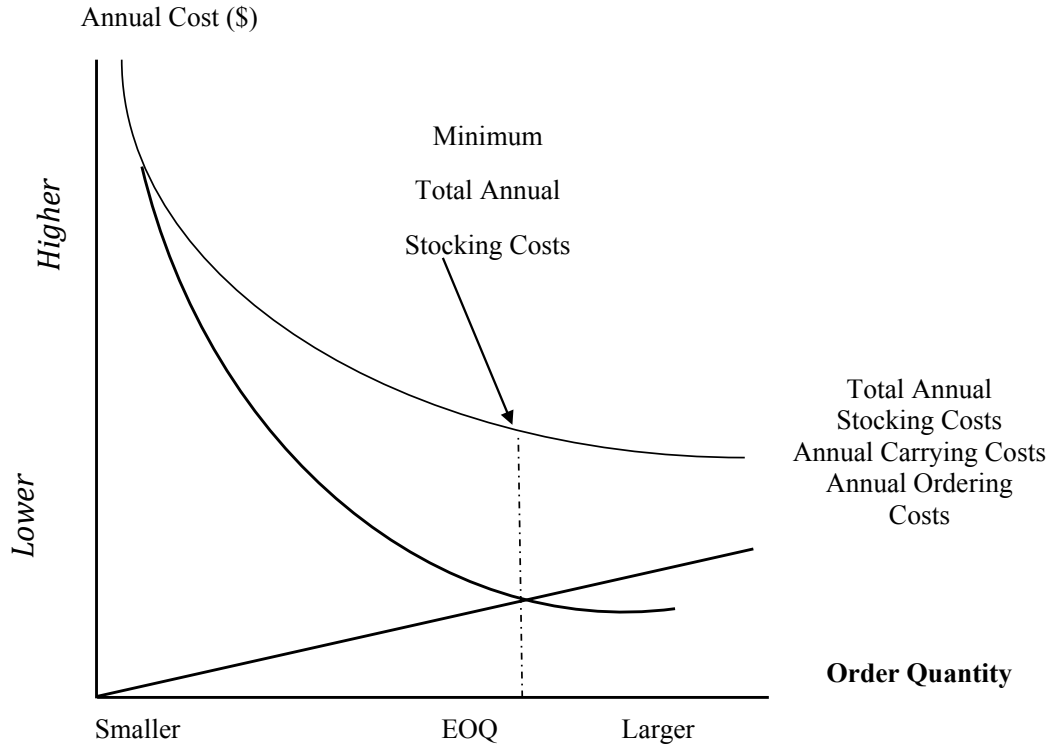

Fig.13.1: Balancing Carrying and Ordering Costs

Fixed Order Quantity Systems Consists:

- Behaviour of Economic Order Quantity (EOQ) Systems
- Determining Order Quantities
- Determining Order Points

Behaviour of EOQ Systems: As demand for the inventoried item occurs, the inventory level drops.When the inventory level reaches a critical point (the order point), the ordering process is triggered. The amount ordered each time an order is placed is fixed or constant.

Economic Order Quantity (EOQ): Annual Demand (D), Carrying Cost (C) and Ordering Cost (S) can be estimated by,

Average Inventory Level = Fixed Order Quantity (Q) / 2.

Annual Carrying Cost = (average inventory level) × (carrying cost) = (Q/2)C

Annual Ordering Cost = (average number of orders per year) × (ordering cost) = (D/Q)S

Total Annual Stocking Cost (TSC) = Annual Carrying Cost + Annual Ordering Cost = (Q/2)C + (D/Q)S

The order quantity where the TSC is at a minimum (EOQ) can be found using calculus (take the first derivative, set it equal to zero and solve for Q)

$$EOQ = 2\sqrt{\frac{DS}{C}}$$

Economic Order Periodic System: As demand for the inventoried item occurs, the inventory level drops. When a prescribed period of time (EOP) has elapsed, the ordering process is triggered, i.e., the time between orders is fixed or constant. At that time, the order quantity is determined using the formula:

Order Quantity = Upper Inventory Target − inventory level + EDDLT (Expected Demand During Lead Time).

After the lead time elapses, the ordered quantity is received, and the inventory level increases. The upper inventory level may be determined by the amount of space allocated to an item. This system is used where it is desirable to physically count inventory each time an order is placed.

Optional Replenishment Model: This model is similar to the Fixed Order Period model, except that if the inventory has not dropped below a prescribed level when the order period has elapsed, no order is placed.This approach avoids placing very small orders. It is especially attractive when review and ordering costs are high.

Base Stock Model: Start with a certain inventory level and whenever a withdrawal is made, an order of equal size is placed which ensures that inventory maintained at an approximately constant level and appropriate for very expensive items with small ordering costs.

Single Period Inventory Model: The order quantity decision covers only one period. This model is appropriate for perishable items, e.g., fashion goods, certain foods, magazines. Payoff tables may be used to analyze the decision under uncertainty.

Dynamics of Inventory Planning includes:

- Continual review of ordering practices and decisions;
- Modifications to fit the firm's demand and supply patterns;
- Constraints, such as storage capacity and available funds, can impact inventory planning;
- Production planning and control systems are changing to support lean inventory strategies;
- Computers and information technology are extensively used in inventory planning.

Cost of Inventory: However, inventory values should also include any incidental costs incurred to bring inventory to the sales location and into a saleable condition including:

- Freight-in, storage and insurance costs
- Costs to prepare, condition and assemble inventory for sale.

Many firms rely on both the materiality and the cost-benefit concepts to argue that the incidental inventory acquisition costs of freight, storage, insurance, etc. are not material and that the cost of appropriately assigning these costs to items of inventory outweigh any benefits received. As a result, many firms justify recording inventory costs using invoice prices only.

Methods Used to Determine which Cost to Expense Include:

- Specific Identification
- Weighted Average
- Last in First Out (LIFO)
- First in First Out (FIFO)

Specific Identification expenses as Cost of Goods Sold the actual costs incurred to purchase the exact inventory item sold.

This may be impractical when inventory includes a large number of items that are difficult to match to the actual cost paid without considerable effort.

If identifying the specific cost paid for an item of inventory is excessive, these methods may be used:

- LIFO – Last in First Out
- FIFO – First in First Out
- Weighted Average

LIFO method expenses the most recent inventory costs first

FIFO method expenses the oldest inventory costs first

Weighted average method expenses the average of all inventory costs incurred for the category.

Check Your Progress 13.3

Note: a) Use the spaces given below for your answers.

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

1. Fill the following blanks:
   a) In centralization, reservation of decision-making power is at .....
   b) Centralized purchasing will cause .....
   c) Three reasons for keeping inventory are ....., ... and .....
   d) Purchase order is a step of .....
   e) Economic Ordering Quantity (EOQ) balances ..... and ..... costs.
2. Mark the following statements as True or False:
   a) In decentralization system delegation of authority is to the lowest levels. ( )
   b) In centralized stores, cost of internal transport is high. ( )
   c) Inventory acquisition steps involve verification but not approval for payment. ( )
   d) Acquisition cost of inventory include freight and shipping costs. ( )
   e) When to place a purchase order is not a part of inventory acquisition. ( )

13.4 CENTRALIZATION VS DECENTRALIZATION

Centralization refers to the process in which decision-making power is concentrated in a few hands, typically at the top levels of management. In a centralized organization, all important decisions and actions at lower levels require approval from top management. According to Allen, "Centralization is the systematic and consistent reservation of authority at central points in the organization."

Key Implications of Centralization:

1. Decision-making power is reserved at the top level
2. Operating authority is retained by middle-level managers
3. Operational actions are carried out at the lower level, under the direction of top management.

Under centralization, the important and key decisions are taken by the top management and the other levels are involved in implementations as per the directions of top-level management.

On the other hand, decentralization is a systematic delegation of authority at

all levels of management and throughout the organization. In a decentralization concern, authority is retained by the top management for taking major decisions and framing policies concerning the whole concern. The rest of the authority may be delegated to the middle level and lower level of management.The degree of centralization and decentralization depends upon the amount of authority delegated to the lowest level.

13.4.1 Centralized vs Decentralized Purchasing

Whether purchasing should be centralized or decentralized, is a question to be decided with reference to a particular situation prevailing in an organization. If, in the case of a concern, the function of buying direct materials, indirect materials and capital nature, is entrusted to a single person or at a single place like head office, buying is said to be 'centralized'. However, if this function is performed by the other managers of the same or different managerial hierarchy besides the purchase manager, and if a factory has a number of divisions or branches, and in each division, there is a purchase manager, the purchasing function is said to be 'decentralized'.

Advantages of Centralized Purchasing:

1. Employing skilled professionals ensures efficient material purchasing.
2. Bulk buying enables favourable terms, such as trade discounts and transport savings.
3. Records are centrally maintained, streamlining management and access.
4. Vendors benefit from dealing with a single purchase officer, reducing complexity.
5. Centralized control minimizes reckless buying.

Disadvantages of Centralized Purchasing:

1. Miscommunication between branches and the purchasing department can lead to incorrect orders.
2. Delays may occur as branches relay requirements to the purchasing department for processing.
3. Branches miss out on localized purchasing benefits.
4. Establishing a central purchasing department involves high initial costs.

Decentralized Management of Inventory Purchases:

There are various advantages and disadvantages of inventory purchases such as:

Advantages of Decentralized Purchasing

Local inventory control ensures awareness of local factors, special promotions, and customer plans. It also fosters a sense of ownership and control among local managers.

Disadvantages of Decentralized Purchasing

Local managers may lack inventory management skills, overreact to transient events, and favor highly visible inventory, ignoring stock in transit or central warehouses.

13.4.2 Centralized vs Decentralized Stores

In business, about 80-90% of capital may be invested on the materials. So, severe losses may have to be suffered by the industries, unless the stores are efficiently managed. The main objectives that must be fulfilled while managing the stores efficiently are mentioned below:

1. Smoothly receiving and issuing materials;
2. To maintain stocks at desired levels; and
3. To protect stock from pilferage, theft, evaporation, deterioration, sublimation, etc.

Depending on the type of industry, size of the business, location and policy of the management, stores may be of three types:

a) Centralized stores *i.e.*, materials are supplied to all departments by one store.

b) Decentralized stores *i.e.*, for each department there is a separate store.

c) Centralized stores with sub-stores, *i.e.*, there is one central store which holds the stocks in general stock, with separate sub-stores for each department which get supplies from the central stores.

From the receiving department, the materials are received by the stores and then materials are supplied to the production and service departments. So near the receiving department should be the location of the store and at the same time, it should also be near the departments which requires supply from it. For the location and layout of stores the factors to be considered are: (i) highest efficiency, (ii) lowest cost of internal transport and (iii) easy accessibility to all departments which require materials.

Merits and Demerits of Centralized Store

Merits:

1. Better control.
2. High technical skill and better supervision,
3. Less storage space is needed because stocks should be kept as low as possible.
4. Replenishment is quicker.
5. As record maintenance of the same material is not required in different departments, less clerical work, stationery and other costs are involved.
6. Better facility for store audits.
7. Stock taking is easier.
8. Insurance cost is lower.

Demerits:

1. Cost of internal transport is higher.
2. In the flow of materials to production, possibility of bottle-neck is there.
3. Risk of obsolescence is greater.
4. Any disturbance affects all production departments.

Merits &Demerits of Decentralized Store

Merits:

1. Cost of internal transport are avoided.
2. Production is not affected by disturbance in the central store.
3. Delays in receiving materials can be avoided.
4. The chance of obsolescence is lower.

Demerits:

1. Organizational and space costs increase due to separate stores for each department.
2. Departmental heads, in addition to their regular duties, must maintain the store.
3. The availability of technical skill is lower.

Centralized Store with Sub-Stores

In this case, a central store is located near the receiving department and each department has a sub-store with it. Materials are received by the sub-store from the central store using the imprest system and issues to the department are made accordingly.

When the central store is located far from work sites, this system becomes essential. It helps avoid bottlenecks in the supply of materials for production. However, this system is more expensive than a purely centralized store.

13.5 PURCHASE MANAGEMENT

The process of 'purchasing'– which is the acquisition of a desired object or commodity in exchange for something else accepted as being of equal value is certainly not a "modernphenomenon".A widely accepted definition of the modern purchasing function for organizations and which is often referred to as 'organizational purchasing' is as follows:

"The function responsible for procuring (obtaining) by purchase, lease or other legally acceptable means, those products - materials, supplies, services and equipment which are required by an organization for use in 'production' to ensure its smooth functioning and its continuous and uninterrupted operations, and to achieve the purposes for which it was established."

The ability of any particular product to satisfy wants is called its 'utility'. Utility expresses the relationship between a possible purchaser and a product.

If a product has utility, then we understand that the purchaser needs that product in order to satisfy a want or a need.

Purchasing management directs the flow of goods and services in a company and handles all data relating to contact with suppliers. Effective purchasing management requires knowledge of the supply chain, business and tax laws, invoice and inventory procedures, and transportation and logistics issues. Sourcing reliable suppliers is a crucial part of purchasing management. Purchasing professionals meet with potential suppliers in their plants whenever possible.

13.5.1 Scope and Objectives of Purchasing Function

The fundamental objective is "To purchase the right quality of materials, at the right times,in the right quantities, from the right sources, at the right prices."

We can consider the scope and objectives of the "modern" purchasing function as set out in the following sections.

- **Continuity of Supply**

  The purchasing function must ensure that there is "continuity of supply"; interruptions in the smooth "inwards" flow of materials can result in loss of production, in loss of sales, in loss of customers – and in loss of profits.Forecasting the probable future purchasing requirements of the organization is also very important.

- **Economy**

  It is incumbent on the purchasing function to buy efficiently and wisely, and to obtain by ethical means the "best value" for all monies which are spent on procurements on behalf of the organization. However, quality and reliability must not be sacrificed in the quest to cut costs; a "balance" between quality/reliability and cost must be maintained.

- **Stock and Inventory Control**

  The purchasing function whether it is under the control of the stores/ inventory function, or whether it controls the stores/inventory function - must act to ensure, as far as is practicable, that the quantity of each required material "held in stock" at any one time is neither too low nor too high.

  Too low stock or inventory of an item can result in 'shortages' or even worse to 'stock-outs' leading to interruptions in and loss of production, to loss of sales, to loss of customers - and to loss of profits. On the other hand, excess (too high) stock or inventory of items results in money being tied up unnecessarily; when that money might be required to purchase other needed goods and/ or materials, or for other purposes. Excess stock/inventory can also lead to problems, especially as storage of materials, particularly as "storage space" - in storehouses and/or stock yards - is generally limited.

- **Cooperation and Coordination**

  An organization's purchasing function cannot operate in isolation; its purpose is to provide an efficient service to other sections/departments of the organization. In order to be able to provide that service, the purchasing function must receive information from other sections/ departments based on their needs. It clearly follows that those who are responsible for the purchasing function must maintain regular and cooperative relationships with the executives and staff of other sections/ departments of the organization, to assist in the effective coordination of the efforts of the organization as a whole towards achieving its goals.

- **Structure**

  To achieve its objectives, a suitable structure for the purchasing function needs to be developed. It must be staffed with trained and efficient personnel, and suitable policies and procedures must be established. Depending on the size and activities of an organization, its purchasing function might be an independent section or department. In some organizations the purchasing function might be part of the production department. In some organizations the purchasing department might encompass the stores/inventory control function, or alternatively it might be a section within the stores/inventory department.

13.5.2 Importance of Purchase Management

The importance of purchase management is that it is a fundamental function in an industrial establishment:

1. **Core Function in Industrial Enterprises**: Facilitates the conversion of raw materials into finished products by ensuring the timely and adequate supply of materials.
2. **Major Cost Component**: Materials account for over 50% of total costs, and efficient purchasing can significantly impact profitability, with a 1% saving equating to a 10% increase in turnover.
3. **Optimization of Working Capital**: Purchasing ties up a significant portion of earnings and working capital in inventories, making efficient procurement crucial for financial stability.
4. **Reliance on Specialized Suppliers**: Advanced manufacturing depends on automatic machines and outsourced components, increasing interdependence among manufacturers.
5. **Support for Import Substitution**: By exploring alternatives to imports, purchasing helps save foreign exchange and foster innovation, leveraging executives' broad industry knowledge.
6. **Critical to Project Success**: Mismanagement in purchasing can lead to costly delays and interruptions in industrial projects, causing significant economic and social repercussions.

13.5.3 Purchase Process

Purchasing is the formal process of buying goods and services. The purchasing process can vary from one organization to another, but there are some common key elements.

The process usually starts with a demand or requirement - this could be for a physical part (inventory) or a service. A requisition is generated, which details the requirements (in some cases providing a requirements specification) and prompts the procurement department to take action. A request for proposal (RFP) or request for quotation (RFQ) is then raised. Suppliers send their quotations in response to the RFQ, and a review is undertaken where the best offer (typically based on price, availability and quality) is given the purchase order.

Purchase orders (PO) can be of various types, including:

- Standard - a one-time buy;
- Planned - an agreement on a specific item at an approximate date; and
- Blanket - an agreement on specific terms and conditions; date, quantity and amount are not specified.

Purchase orders are normally accompanied by terms and conditions which form the contractual agreement of the transaction. The supplier then delivers the products or service and the customer records the delivery (in some cases, this includes a goods inspection process). An invoice is sent by the supplier which is cross-checked with the purchase order and documents specifying which goods have been received. The payment is then made and transferred to the supplier.

Eight-Step Purchase Process:

The purchasing process for companies breaks down into eight clear steps are as follows;

1. Identify Need;
2. Select Specific Product;
3. Appoint Purchase Team;
4. Specify Technical Specifications
5. Budget for Purchase;
6. Research Potential Suppliers
7. Solicit Bids; and
8. Execute/Award Contract.

Check Your Progress 13.4

Note: a) Use the spaces given below for your answers.

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

1. Fill the following blanks :
   a) Purchase management professionals must be good .....
   b) Purchase must ensure ..... of supply
   c) RFQ means ....., ..., ...

2. Mark the following statements as True or False:

   a) Sourcing suppliers is crucial part of purchase management. ( )

   b) Purchasing is not concerned with import substitution. ( )

   c) Lead Time for procurement is important in purchase. ( )

Activity 13.2:

Visit a nearby manufacturing plant and discuss the objectives with the operations manager. Try to relate their goals and practices to the concepts discussed above. Make a brief note on your understanding.

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13.6 LOGISTICS MANAGEMENT AND DEMAND SYSTEM

Logistics is the management of the flow of resources between the point of origin and the point of consumption in order to meet certain requirements, *for example*, of customers or corporations.Logistics involves the integration ofinformation, *transportation*, inventory, *warehousing*, *material handling* and *packaging*, and often *security*. It is a part of the *supply chain* which adds the value of time and place utility.

13.6.1 Definition and Objectives of Logistics

"Logistics/Supply Chain is a collection of functional activities (transportation, inventory control, etc.) which are repeated many times throughout the channel through which raw materials are converted into finished products and moved to consumer".

"Supply Chain Management (SCM) is the management of an inter-connected or interlinked network of businesses, channels and nodes involved in the provision of product and service packages required by the end customers in a supply chain. SCM spans the movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption."

The objectives of logistics can be divided into performance-related and cost-related categories. These objectives include high due-date reliability, short delivery times, low inventory level and high-capacity utilization. However, when decisions need to be made, there is always a trade-off between these targets. This is what makes being a logistician both challenging and interesting.

13.6.2 Types of Logistics

Based on the services performed by logistics, one can distinguish the main fields as follows:

- Procurement Logistics
- Production Logistics
- Distribution Logistics
- Disposal Logistics

1. Procurement Logistics consists of activities such as market research, requirements planning, make or buy decisions, supplier management, ordering, and order controlling. The targets in procurement logistics might be contradictory to maximize the efficiency by concentrating on core competences, outsourcing while maintaining the autonomy of the company, and minimization of procurement costs while maximizing the security within the supply process.
2. Production Logistics connects procurement to distribution logistics. The main function of production logistics is to use the available production capacities to produce the products needed in distribution logistics. Production logistics activities are related to organizational structure, layout planning, production planning and control.
3. Distribution Logistics has, as main tasks, the delivery of the finished products to the customer. It consists of order processing, warehousing, and transportation. Distribution logistics is necessary because the time, place and quantity of production differs from the time, place and quantity of consumption.
4. Disposal Logistics' main function is to reduce logistics costs, enhance services and conserve natural resources. Supply Chain Management (SCM) approaches are being extensively used in planning logistics to meet the customer's requirements in terms of time, cost and quality.

13.6.3 Logistic Management and Demand

Logistics is the part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of raw materials, in-process inventory, finished goods, services and related information from point of origin to point of consumption (including inbound, outbound, internal and external movements) for the purpose of conforming to customer requirements. (Coyle *et. al*.)

Demand Management

Companies must match the supply of their products with the demand for their products. On average, a company may succeed and deliver the right amount at the right time to the right place, but frequently something goes wrong: wrong quantity, wrong time, wrong place. The economic consequences for a company may range from lost customers to bankruptcy. The root cause is often that demand varies, but supply does not. Logistics and supply chain management helps companies to overcome this challenge by finding ways to best match their supply with demand.

Demand management is the supply chain management process that balances the customers' requirements with the capabilities of the supply chain. With the right process in place, management can proactively match supply with demand proactively and execute the plan with minimal disruptions. The process is not limited to forecasting. It includes synchronizing supply and demand, increasing flexibility, and reducing variability.

Characteristics of Demand Management

- Smooths production after master production schedules have already been released to internal production and external suppliers.
- Functions as a process (versus a bounded business function) that requires the utmost in coordination and communication between the responsible parties.
- Includes contingency plans developed with supply chain members to allow modification of short-term schedules when necessary.
- Balances total costs of not meeting demand against the total costs of adding additional resources required to meet demand.
- Failure to accurately estimate demand and share information among supply chain entities can result in bloated inventory levels due to the cumulative effect of poor information cascading up through the supply chain.

The SCM Triangle covering supply management, demand management, logistics management provides the foundation for effective SCM.

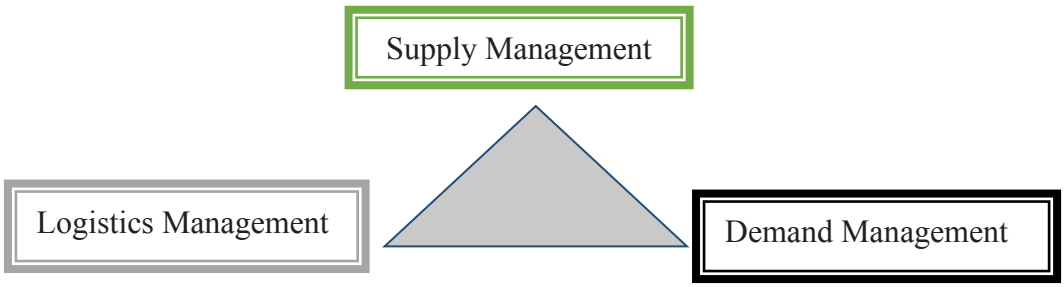

Fig. 13.2: Supply Chain Management Triangle

Demand management typically fits within either supply management or SCM organizationally.

Supply professionals manage the relationships in the supply chain; therefore, they are in a critical position to facilitate the high levels of communication and trust that are required in Strategic Demand Management.

13.7 PROCUREMENT-VENDOR SELECTION AND NEGOTIATIONS

Procurement involves the strategic process of acquiring goods and services, where vendor selection and negotiations play a critical role. Identifying the right vendor and negotiating effectively ensures value for money, quality, and long-term partnership benefits.

13.7.1 Vendor Selection

- One of the most important processes performed in organizations today is the evaluation, selection and continuous measurement of suppliers.
- Selecting a vendor is now as important a process as developing new products.

Importance of Supplier Selection Includes:

- Supplier selection is a multi-criteria problem, which includes both qualitative and quantitative factors.
- Purchasing commands a significant position in most organizations since purchased parts, components, and supplies typically represent 40 to 60 percent of the sales of their end products.
- Thus relatively small cost reductions gained in the acquisition of materials can have a greater impact on profits.
- Suppliers have a large and direct impact on the cost, quality, technology and time-to-market of new products.
- An organization's ability to produce a quality product at a reasonable cost and in a timely manner is heavily influenced by its suppliers'capabilities.
- Supplier selection is one of the key issues of SCM because the cost of raw materials and component parts constitutes the main cost of a product management.
- A sound supplier selection decision today canreduce or prevent a host of problems tomorrow.

Steps in Supplier Selection Process:

– Evaluating Needs and Defining Objectives;

– Gathering a Limited Pool of Vendors;

– Interviewing Vendors; and

– Selecting and Applying the Method;

The Supplier Should Have:

- Sound business sense and attitude;
- A good track record in supplying the market in which the buyer operates (or similar);
- A sound financial base;
- A suitable technical capability with modern facilities;
- A total quality orientation;
- Cost-effective management;
- Effective purchasing, acquisition and control;
- Good morale among the workforce;
- Effective logistical arrangements; and
- A customer service mentality.

Vendor Rating

The vendors also like to be given priority by the purchaser if they constantly improves its selling performance, which from a purchaser's point of view is mainly its offered price, quality and punctuality in delivery.

For the purchaser, there shall always be a need to continuously monitor and update their registered vendor base so that the organization continues to have the most competent and competitive vendors in its list of vendors. For this purpose, the efforts are made to monitor supply performance of the vendors and rate them objectively.

The major factors usually considered for such vendor rating are the competitiveness of vendor are price, quality of supply and delivery adherence.

Vendor rating may also be used for removing a vendor from registered vendor list and also in the selection of vendors.

13.7.2 Negotiations

Negotiation is a dialogue between two or more people or parties, intended to reach a common understanding, resolve points of difference, or gain advantage. It is a problem-solving process in which two or more people voluntarily discuss their differences and attempt to reach a joint decision on their common concerns. Negotiation requires participants to identify issues about which they differ, educate each other about their needs and interests, generate possible settlement options and bargain over the terms of the final agreement. Successful negotiations generally result in some kind of exchange or promise being made by the negotiators to each other. The exchange may be tangible (such as money, a commitment of time or a particular behaviour) or intangible (such as an agreement to change an attitude or expectation, or to make an apology).

Negotiations in Procurement/Purchase Function:

Negotiation in the purchasing process covers the period from when the first communication is made between the purchaser and the supplier through to the final signing of the contract. Negotiation can be as simple as trying to obtain a discount on a case of safety gloves, or as complex as major capital purchases. A purchasing professional must aim to be successful in their negotiations with suppliers to obtain the best price with the best conditions for every item that is purchased.

The negotiation process has become a more important sector in the supply chain process as companies look to reduce their expenditure whilst increasing their purchasing power. This means that purchasing professionals have to negotiate increasingly better rates with suppliers whilst maintaining or increasing quality and service. This offers companies the ability to negotiate significantly lower prices for items that they were purchasing from a number of separate vendors.

Negotiation Objectives

Purchasing staff must enter negotiations with clear, flexible objectives to avoid conceding on price, quality, or service. Negotiators should stay focused on their objectives and avoid discussing areas where objectives are undefined, such as quality, unless they are prepared. Negotiation is a vital skill for purchasing professionals and proper training enhances their effectiveness.

Vendors as Partners

Negotiation now emphasizes building partnerships with fewer vendors to secure the best price, quality, and service rather than focusing solely on the lowest price. Long-term contracts foster collaborative relationships, encouraging vendors to improve quality and service for continued business, benefiting both parties.

Check Your Progress 13.5

Note: a) Use the spaces given and fill your answers.

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

1. Fill in the blanks:
   a) Logistics is the management of the flow of goods between the _____ and the _____ in order to meet the requirements.
   b) The main targets of logistics can be divided into_____ and _____ related.
   c) Supply Chain Management approaches are used in logistics to meet the customers' requirement of _____ and _____
   d) Negotiation is a _____ between two or more parties.
   e) Objective of negotiation is to provide _____
2. Mark the following statements as True or False:
   a) Production logistics connect procurement to distribution logistics. ( )
   b) In demand management companies pay attention only to supply. ( )
   c) Evaluation criteria are fundamental to the choice of a supplier. ( )
   d) Negotiation is not concerned with problem solving. ( )
   e) Vendors today are considered as partners in business. ( )

Activity13.3 :

Visit a nearby manufacturing plant and discuss with operations manager about their objectives. Try to assimilate the concepts discussed above. Make a brief note on your understanding.

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13.8 LET US SUM UP

Inventory management is concerned with planning, organizing and controlling the flow of materials from their initial purchase through internal operations to the service point through distribution.Inventory acquisition deals with a wide range of activities covering procurement, inventory control, costs, purchase, logistics and demand management. It is a critical function that ensures the efficient flow of materials through planning, procurement, storage, and distribution. It encompasses inventory acquisition, cost-management and balancing ordering and carrying costs. Centralized and decentralized systems have their unique advantages and challenges in managing purchasing and inventory. Effective logistics management, purchase processes, and vendor selection contribute to achieving organizational goals while optimizing resources and costs.

13.9 KEY WORDS

Perpetual	**:**	Continues, everlasting, unending.
Transaction	**:**	Deal, business, contract.
Expenditure	**:**	Spending, expenses, cost.
Inventory	**:**	List, record, stock.
Centralization	**:**	A process where the concentration of decision-making is in a few hands.
Decentralization	**:**	Devolution, delegation, transference.
Acquisition	**:**	Gaining, achievement, attainment.
Segregation	**:**	Separation, isolation.
Depreciation	**:**	Reduction, decrease, decline.
Fixtures	**:**	Fittings, equipment.
Logistic	**:**	The detailed organization of large and complex operations.
Procurement	**:**	The act of obtaining or acquiring goods and services.

13.10 SUGGESTED FURTHER READINGS/ REFERENCES

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13.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 13.1

1. Inventories are physical stocks of items that a manufacturing or service organization holds in stock for the efficient running of activities.

   Inventory is an idle stock of physical goods that contain economic value and are held in various forms by an organization in its custody awaiting packing, processing, transformation, use or sale at a future point of time.

2. Meeting demand, keeping operations running, lead time, hedging, quantity discounts and smoothing requirements.

Check Your Progress 13.2

1. Functions of inventory:

   Maintaining a rate of flow through a process, covering gaps in discontinuous process, allowing purchase or production in economic lotsallowing parts of a system or process to operate at different rates, at least temporarily meeting fluctuations in supply, process, or consumption,modifying and storing perishable commodities and speculating against anticipated changes in costs or availability.

2. Factors affecting inventory cover demand-related factors, process-related factors and organizational factors.

Check Your Progress 13.3

Q1	a	b	c	d	e
	top level	delay	time, uncertainty, economies of scale cost of internal failure	inventory acquisition	ordering, inventory carrying
Q2	a	b	c	d	e
	F	T	F	T	F

Check Your Progress 13.4

Q1	a	b	c
	good negotiators	continuity	request, for quotation
Q2	a	b	c
	T	F	T

Check Your Progress 13.5

Q1	a	b	c	d	e
	point of origin, point of use	Performance, cost	time, cost	dialogue	clarity
Q2	a	b	c	d	e
	T	F	T	F	T

UNIT 14 INVENTORY MANAGEMENT TECHNIQUES

Structure

14.0 OBJECTIVES

After studying this Unit, you should be able to:

- explain the concept and importance of Inventory Turnover Ratios;
- discuss various solutions of inventory problems;
- describe the concept and importance of inventory control systems and selective Inventory control;
- explain the concept and importance of various classifications like ABC Analysis, VED, HML, XYZ, FSN Analysis,etc.;
- illustrate the steps involved in various types of analysis; and
- indicate the unique features of Agribusiness for applying different classifications for inventory control.

14.1 INTRODUCTION

Dear learners, in the previous chapter you have already studied about the inventory management. It is all about knowing what is on hand, where it is in use, and how much finished product results from it. Inventory management is the process of efficiently overseeing the constant flow of units into and out of an existing inventory. This process usually involves controlling the transfer of units in order to prevent the inventory from becoming too high, or dropping to levels that could put the operation of the company at risk. In this Unit we will study inventory turnover ratios, various solutions to inventory problems and related techniques. For effective inventory management, it seeks to control the costs associated with maintaining the inventory. It logically covers the need for inventory, the types of inventories, the relevant costs and the selective inventory control approaches for effective and efficient control of inventories in organizations. Inventories are physical stocks of items that a manufacturing or service organization holds in stock for the efficient running of activities.

There are Four Different Types of Inventories:

- Raw Material Inventory
- Work In Process
- Finished /Brought Out parts
- Finished Goods

Though inventories are necessary for the efficient running of the activities of the organization, they cost money in terms of storage, personnel, insurance, the space that is required for their storage and most importantly the cost of capital incurred in acquiring the stocks.

On the other hand, it is necessary to maintain sufficient inventories to avoid the stock-outs cost, cost of idle wages of labor, the cost of idle machines and also the loss of business opportunities.The most important asset of the organization is its material (stock), if you analyze any company's balance

sheets, you will observe that 45 to 90% of the capital is tied up in inventories. If this area can be managed properly the profit margin of the company can be increased. One of the international surveys revealed that in manufacturing firms, on average companies lose one percent of the profit due to the non-availability of inventories despite of high investment in inventories.

There are several techniques of inventory control and one of the techniques used for this is Selective Control of Inventories.

14.2 INVENTORY MANAGEMENT

Inventory management is expected to provide the operational convenience with a minimum possible investment.

1 **Raw Material:** Raw material and production components are purchased from external suppliers/vendors and the reason for their existence is to uncouple the purchasing function from the production function.

The size of this inventory is dependent upon factors such as availability, lead time for purchase, supplier lead time, government policies (especially for imports), etc.

2. **Work in Process (WIP):** WIP inventory might exist merely because of the production cycle time or could be maintained for decoupling successive manufacturing operations. The size of this inventory depends upon production cycle time and availability of production machines.

3. **Finished Goods Inventory:** Finished goods inventory is maintained to assure a free flow of products to the customers. The marketing department of the organization prefers substantial finished goods inventory. The size of the inventory depends upon the ability of the marketing department to push products, the shelf life of products and the warehousing capacity. All inventories are geared for future requirements and the factors that influence the inventories of all types depend on the details and accuracy of the forecasting system.

The norms for the inventory are normally given by the top management of the company.

4. **Inventory for Normal Consumption:** The inventory that takes care of normal consumption is called normal inventory. Inventories for normal consumption requirements depend upon the average consumption rate and the average lead time for procurement/manufacture of the material, inventories are kept at the appropriate times.

5. **Safety Stock or Buffer Stock:**The inventory that handles uncertainty is called the safety stock or buffer stock inventory.

6. **Other Categories of Inventories:**There are various other categories of inventories mentioned such as “Anticipatory inventory”,“Transit Inventory” or the “Pipe line inventory”. But these are basically modified versions of normal inventory or safety stock.Inventory is working capital and therefore the control of inventories is an important aspect of materials management.

Check Your Progress 14.1

Note: a) Use the spaces given below for your answers.

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

1. What is work in process?

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2. What is safety stock/Buffer Stock?

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14.3 INVENTORY TURNOVER RATIOS

These are also known as inventory Indices. These ratios are quite important in evaluating the performance of inventory management. Intra-firm comparison and inter-firm comparison of these ratios help in evaluating the competitive position of the company in the market. These ratios also help the management in formulating the policies and guidelines for effective inventory management.

14.3.1 Inventory Ratios Commonly Used

BOX 14.1: The Inventory Ratios are as follows:

Inventory Turnover Ratio (Finished Goods) = Annual Sales/Average Inventory

Inventory Turnover ratio (Raw Material) = Annual Consumption/Average Inventory

Priority of Importance Index (Number) = No. of A-class Inventory items/Total No. of items

Priority of Importance Index (Value) =Value of A-class inventory items/Total Inventory

Weekly Inventory on Hand Ratio=Material in Stock/Weekly consumption

Weekly Inventory on Order=Materials on order/Weekly consumption

Out of Stock Index=No. of items out of stock/No. of items requisitioned

Production Loss Due to Stock-outs=Hours of production lost due to non-availability of materials/Total scheduled production

Work in Progress Index = Average work in progress (WIP)/Total production value annually

Spare Parts Index= Value of Spare parts inventory/Value of capital goods

Spare Parts Turnover Index = Spare parts consumed/Spare parts inventory

14.3.2 Return On Investment (ROI)

Materials form an important part of the current assets in any organization. The Return on Investment (ROI) depends a great deal on the efficient utilization of materials.

ROI = Profit/Sales x Sales/ (Fixed Assets + Current Assets)

Fixed assets constitute capital already committed and the only scope for improving the Return on Investment (ROI) lies in the efficient utilization of materials which constitute the bulk of current assets.ROI will be helpful for top management of the company in formulating policies for inventory management.

14.3.3 Rate of Return (ROR)

Inventory problems require consideration of the use of capital.Capital differs from expenses in that it represents cash that is tied up and is expected to be recovered eventually. The cost of capital is therefore not the capital loss but the cost of having capital for use in supporting or financing operations. This cost must be based on either or both of the following:

1. The cost of borrowing funds from banks or the cost of diverting capital from other possible uses (*i.e.*, the cost of foregone opportunities for profitable use). Capital cost is based on out-of-pocketinvestment and a rate charged per rupee of capital invested per unit time.
2. The Rate of Return (ROR) on capital investment is the ratio of additional profit earned as a result of the investment to the additional out-of-pocket investment made. ROR is helpful for top management of the company in formulating policies for inventory management. Investment in inventory may be relatively permanent or short-term.

Check Your Progress 14.2

Note: a) Use the spaces given below for your answers.

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

1. Explain the importance of inventory turnover ratios.

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2. What is inventory turnover ratio for raw material?

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3. What is Return on Investment (ROI)?

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Activity 14.1:

Take the balance sheet of any manufacturing company from books or internet and calculate the relevant inventory turnover ratios.

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14.4 SOLUTION OF THE INVENTORY PROBLEMS

To find appropriate levels of holding, ordering sequence and the quantities so that the total cost incurred is minimized.

In inventory management, the three important parameters to be taken care of are:

- How much inventory should we stock?
- When should a fresh order be placed?
- How much quantity should be procured?

The demand and supply conditions impose certain limitations within which relevant costs are to be optimized *i.e.*, to have a minimum cost so that neither the ordering cost nor the inventory carrying cost increases.

14.4.1 Economic Order Quantity (EOQ)

EOQ is defined as that quantity at which the ordering cost and inventory carrying costs are equal and total cost of the two are minimum. The solution of the inventory problem is to find appropriate levels of holding inventories and ordering sequence and the quantities so that the total cost incurred is minimum.

The important parameters to be considered are:

- How much quantity of inventory should be stocked?
- When a fresh order is to be placed?
- How much quantity to be purchased at a time?

The relevant costs need to be optimized within the constraints of demand and supply conditions. This implies neither that to have a minimum cost so that neither ordering cost nor the inventory carrying cost should increase.

14.4.2 Lead Time

Lead time is defined as the period elapsed between the recognition of the need to its fulfillment.There are various steps involved in the procurement cycle. The cycle involves identifying the need for placing an order, procurement from suppliers, shipping and transport, receipt and inspection. The time taken for these steps is the lead time for procurement.

The lead time can be divided into:

– Internal lead time

– External Lead time

Internal lead time involves:

– Administrative lead time

– Inspection lead time

External lead time comprises of:

– Manufacturing or suppliers lead time

– Transportation lead time

14.4.3 Reorder Level

Reorder level may be defined as the level of inventory at which an order for replenishment quantity is placed with the suppliers to procure inventory. When specific demand is known, the reorder levelcan be set equal to the demand. In practice when the demand is variable or stochastic in nature, it is not possible to predict the exact demand during the lead period.The reorder level (R) is calculated as given below:

Reorder level (R) = Amount of inventory used during the lead time in units
=D x L

Here, D =Rate of demand for inventory during the lead time in units and
L =Lead time

As the inventory level drops to a predetermined level called reorder level an order for fixed quantity is placed. However, in order to avoid stock outs a minimum inventory level known as safety stock is maintained. In this case the reorder level is decided as given below:

Reorder level = Safety stock + Rate of Demand x Lead Time

Or R= B + DL, Where R= Reorder Level, B= Safety stock

If demand per unit time is normally distributed with mean D and standard deviation σ D of demand per unit time, then demand during lead timeperiod L will also be normally distributed with mean D L and Standard deviationσ D √L.

Here reorder level (R) = D L + K σ D √L

Where K is the number of standard deviations required to give the desired level.

Check Your Progress 14.3

Note: a) Use the spaces given below for your answers.

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

1. Explain the concept of Economic Order Quantity (EOQ).

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2. Explain the concept of Lead Time.

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3. What is Reorder level?

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4. What is Service level?

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Activity 14.2 :

Visit a manufacturing unit and find out their experience with EOQ in procurement. Also, find out their experience regarding the problems of lead time in procuring the materials from their suppliers.

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14.4.4 Scientific Inventory Management

Inventory management is an extremely important problem area in the management of materials. It is quite susceptible to control and a very large amount of scientific models are available in the literature to enable us to choose an optimal inventory policy. Buying the optimal quantity can result only from a sound inventory control system which is achieved by judicious reconciliation of conflicting costs and departmental objectives. However, inventory is only an indicator of the performance of the materials management function and not the sole target to cut down inventories.

Remember, we use not only scientific inventory management principles and models but also take long-term measures to reduce inventories through strategies such as variety reduction and standardization, source development and vendor rating, lead-time reduction through improvements in the systems and procedures of procurement. It is obvious that scientific inventory management has to be practiced selectively rather than indiscriminately to make it cost-effective. It is also important to have informational inputs like demand forecast, lead time estimate and other cost estimates to be realistic to make effective use of inventory models

14.4.5 Just-In-Time (JIT)

Just-In-Time (JIT) is a philosophy that advocates the lowest possible levels of inventory. JIT espouses that firms need only keep inventory in the right quantity at the right time with the right quality. The ideal lot size for JIT is one, even though one hears the term “zero inventories” used.

The Just-In-Time (JIT) concept has its origin in Japan and US. It is actually a production and materials planning system, where the production and procurement closely follow the actual demand. This system is carried down the line from the final product to the basic components/materials. There is no lot size production anywhere and where necessary they are minimized. As and when the item is produced it is conveyed to the next process so that there is no waiting involved at any place. For JIT, the operations at each place are also equalized.

In effect, in JIT:

- There are no waiting times either due to lot-size production or due to unequal production at different work places.
- Conveyance times are also balanced.
- JIT is a combination of single unit production and the conveyor system.
- JIT is used for continuous mass production. It may not be much relevant for intermittent production.

14.4.6 Process for Controlling Inventory

The process for controlling inventory involves five steps given below.

Step 1: Inventory Planning: Inventory control requires inventory planning. It also represents goods that must be in transit for arrival after the goods in the store or plant are sold or used. An ideal inventory control system would arrange for the arrival of new goods just at the same moment the last item has been sold or used.

Step 2: Establish Order Cycles: If demand can be predicted for the product or if demand can be measured on a regular basis, regular ordering quantities can be setup that takes into consideration the most economic relationships among the costs of preparing an order, the aggregate shipping costs, and the economic order cost.

If the business experiences seasonal cycles, it is important to recognize the demands that will be placed on suppliers as well as other sellers.

Step 3: Balance Inventory Levels: Efficient or inefficient management of inventory by a firm is a major factor in distinguishing between healthy profits and operating at a loss. There are both market-related and budget-related issues that must be dealt with in terms of coming up with an ideal inventory balance:

1. Is the inventory correct for the market being served?
2. Does the inventory have the proper turnover?

Step 4: Review Stocks: Items sitting on the shelf as obsolete inventory are simply dead capital. Keeping inventory up to date and devoid of obsolete items is another critical aspect of good inventory control.

Step 5: Follow-up and Control: Periodic reviews of the inventory are essential to detect slow-moving or obsolete stock.Inventory quantities must be organized and measured carefully. Minimum stocks must be assured to prevent stock-outs or the lack of product. At the same time, they must be balanced against excessive inventory because of carrying costs. Careful monitoring, periodic review of reorder points and quantities are a must.

14.5 INVENTORY CONTROL SYSTEMS

There are mainly two types of inventory control systems:

Fixed Order Quantity system – Q System

Periodic Review System – P System

14.5.1 Fixed Order Quantity System-Q System

In this system, which is also called Perpetual Inventory System or Q System, the count of a number of units of inventory is continuously maintained. With lead time less than the reorder cycle (L<t), an order for a fixed quantity, Q is placed,when the inventory drops to a predetermined Reorder Point R. The value of Q should be close to the optimal lot size.Inventory

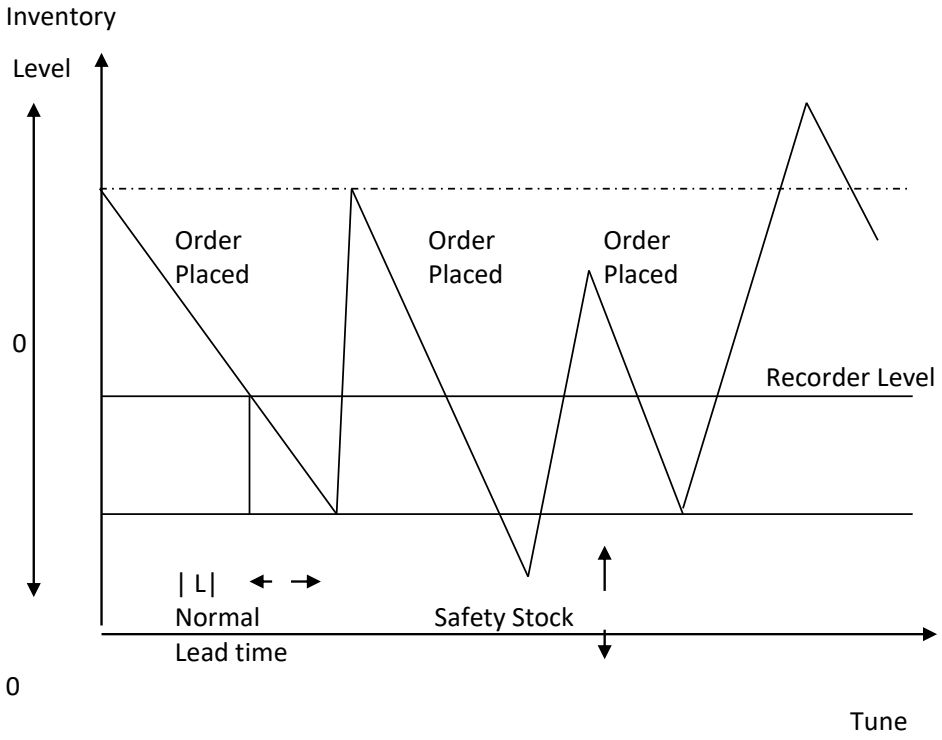

Figure.14.1: Fixed Order Quantity System-Q

As shown in Fig.14.1, the demand rate,D, deviates from its average rate. As a result, the actual lead time demand D varies from the average lead time demand D. However, the quantity ordered, Q remains same at each time. The reorder cycle time also varies according to the demand rate during the previous cycle.

If the lead time becomes more than the reorder cycle time (L>t), then a replenishment order for fixed quantity is placed when the "stock on hand" falls to reorder level. "Stock on hand" means the current stock plus any replenishment orders still outstanding.

Buffer stock/safety stock may be held to guard against fluctuations in demand during the lead time period. The amount of buffer stock held is the amount that the reorder level exceeds the expected demand during lead time.

The reorder level system can be used in a simplified form as the "two bin" system. This system is normally used for C class items. The stock of an item is stored in two bins. One of them usually larger, is the working bin from which demand is currently served without requisitions or paper work. The second bin is opened when the working bin becomes empty. At the same time when the second bin is opened, a replenishment order for the item is released. Clearly, the amount of stock in the second bin materializes the order point. When the order comes, the second bin is refilled first and the excess amount

put into the working bin. This system works well only if there is no more than one order outstanding at any point of time.

It is recommended that the order quantity should last much longer than the replenishment lead time. The order point should be set so as to offer a high service level to compensate for rather lose control.

14.5.2 Periodic Review System - P System

This system involves reviewing stock levels at a fixed interval, review period, and placing replenishment orders at the end of each interval. The replenishment order variable and corresponds to the amount of stock required to bring the stock ordered plus the stock on hand up to a target level S. This system is also known as fixed period system or Replenishment Inventory System or P-System.The optimal review period and target inventory level are determined as indicated below:

Review Period:

It is possible to find a review period that minimizes the annual cost of acquiring and holding stock, although in practice choice of review period is likely to be dominated by other considerations such as type of the item held in the inventory.

Annual running cost of the system = Average inventory carrying cost + Cost of placing order.

Suppose there are r reviews per year. Then average quantity ordered will be D/r.Thus, average stock held will be D/2r +B, where B is the buffer stock.

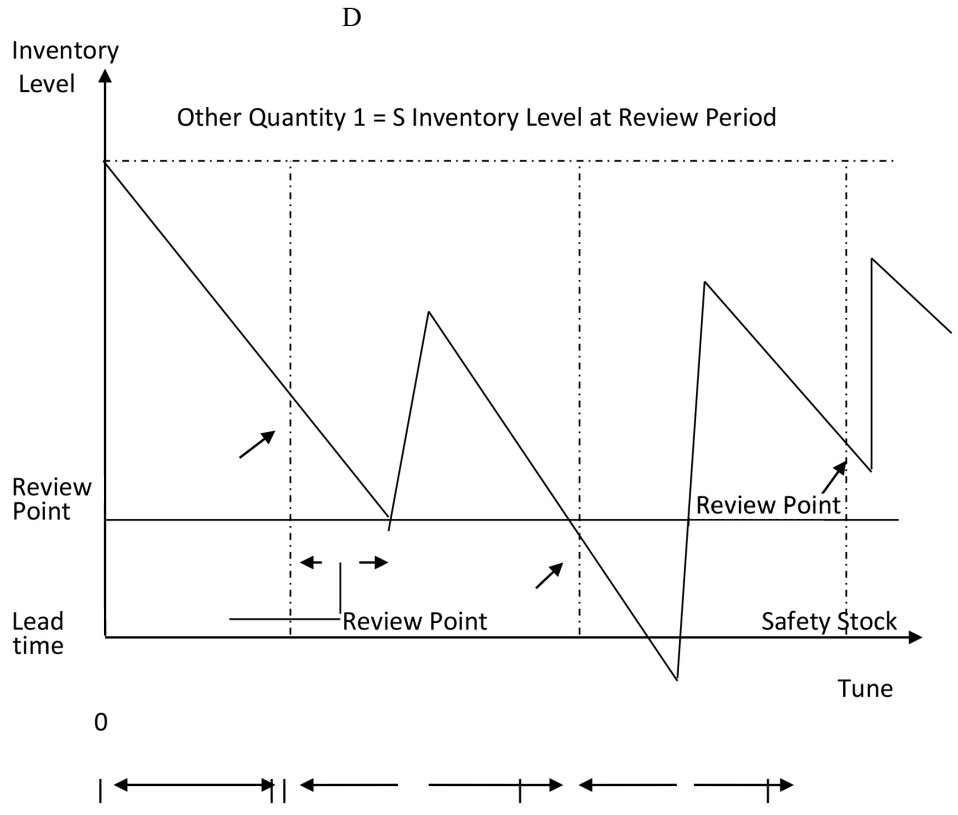

Fig.14.2: Periodic Review – P System

Target Inventory Level:

At the end of each review period, an order is placed so that the stock on hand plus the order placed reaches a target stock level. With the reorder level system,one is only liable to a stock out once the reorder level is reached. Hence, one is only at the risk from a stock out during the lead time period, and it is only necessary to carry buffer stock against demand fluctuations during this period.

Suppose demand is normally distributed with mean demand (monthly) $\bar{D}$ and standard deviation σ_d

Then the expected demand during periodic cycle= $\bar{D}(\bar{R}+\bar{L})$. Bufferstock to be held during this period $= K\,\sigma_d\sqrt{R+L}$

where K is the number of Standard deviations to give the required service level.

Therefore, $S = \sqrt{\bar{D}(\bar{R}+\bar{L}) + K\sigma_d(R+L)}$

Figure 14.2 shows the Periodic Review System - Q

14.5.3 Comparison of Systems

- The reorder level system involves ordering quantities of stock at different periods of time, while the periodic review system involves ordering variable quantities at fixed intervals.
- The reorder level system requires continuous surveillance to ascertain whether the stock level has fallen below the reorder level,while in the periodic review system, it is only necessary to monitor stock levels at the same time as of the periodic review. Hence, the reorder level system may require more administrative effort than the periodic review system, though this may not be difficult, if the system is computerized.
- The periodic review system facilitates orders for goods to be combined to obtain transport economies, to obtain discounts when discounts are based on the total value of the order to meet given production schedules. This is not possible with the reorder level system, where orders are generated at unpredictable intervals. Generally, periodic review system requires a higher average stock level to maintain the same level of customer service as the reorder level system.

14.6 INVENTORY CONTROL RECORDS

Inventory control records are essential to making buy-and-sell decisions. Some companies control their stock by taking physical inventories at regular intervals, monthly or quarterly. Others use a rupee-based inventory record that gives a rough idea of what the inventory may be from day to day in terms of rupees. If your stock is made up of thousands of items, as it is for a convenience type store, rupee-based control may be more practical than physical control. However, even with this method, an inventory count must be taken periodically to verify the levels of inventory by item.

Perpetual inventory control records are most practical for big-ticket items. With such items, it is quite suitable to hand count the starting inventory, maintain a card for each item or group of items, and reduce the item count each time a unit is sold or transferred out of inventory. Periodic physical counts are taken to verify the accuracy of the inventory card.

Check Your Progress 14.4

Note: a) Use the spaces given below for your answers.

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

1. Explain the concept of Just-in-Time.

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2. Indicate the steps involved in inventory control process.

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3. What is Fixed Order Quantity System (Q System)?

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4. Whatis Periodic Review System (P System)?

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14.7 SELECTIVE INVENTORY CONTROL: DIFFERENT TYPES

Selective Inventory Control is the process of identifying items that bring significant benefit through proper management from among hundreds and thousands of items.

14.7.1 Methods

The various methods of selective inventory classification help the manager to effectively control the items selectively. There is no rule of thumb to determine stock levels or to determine the type of strategy to be employed for procuring and stocking. No common procedure can be made applicable for all the items. There would be special peculiarities for each item and as such a special treatment need to be given to overcome the problems or difficulties in respect of each type. The different types of classifications suggested would give the executive a clear idea as to what their implication. This would give them the necessary clues.

The materials executives will have to make the best use for all the methods and should not be guided by "Tunnel Vision" of using only one method.

The method of selective control of inventories is in accordance with Pareto' law of Cause and Effect: According to this law, "20% of the causes are responsible for 80% of the effects and vice versa.In Selective Inventory control the emphasis is on the "Vital Few and Trivial Many".

14.7.2 Criterion Used for Selective Inventory Control

Selective control means variation in control of items on selective basis. The general criteria used for the purpose may include:

- Usage Value
- Unit Price
- Criticality of the item
- Procurement difficulties
- Seasonality
- Issues from Stores
- Inventory investment.

14.7.3 Classification Basis

The classification basis and uses of different types of inventory control are given inTable14.1

Table 14.1: Classification Basis and Uses of Different Types of Inventory Control.

Sl. No	Type of Control	Basis for Classification	Main Use
1.	A BC also known as (Always Better Control or Pareto's law)	Value of consumption of items concerned. (It has nothing to do with the unit value of the item)	To control Raw Materials, Components and Work in process in normal course of business
2.	H M L (High, Medium, Low)	Unit price of material. (This is opposite of A B C analysis; it does not take consumption into account)	Mainly to control purchases
3.	X Y Z	Value of items in storage.	To review the inventories, their uses etc. at scheduled intervals
4.	V E D (Vital, Essential, Desirable)	Criticality of the item	To determine the stocking levels of Spare parts.
5.	F S N (Fast, Slow, Non-moving)	Consumption pattern of items in stores.	To control obsolescence.
6.	S D E (Scarce, Difficult, Easy to obtain)	Problems faced in procurement	Lead time analysis and purchasing strategies.
7.	G O L F (Government, Ordinary, Local and Foreign)	Source of supply of material	Procurement Strategies
8.	S O S (Seasonal and Off-Seasonal)	Nature of supplies	Procurement and holding strategies for seasonal items like agriculture products)

Check Your Progress 14.5

Note: a) Use the spaces given below for your answers.

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

1. What is selective inventory control?

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2. Indicate the criteria used for classification.

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14.8 SELECTIVE INVENTORY CONTROL– IMPORTANT STEPS

- Identify items that bring significant benefit by proper management from among hundreds and thousands of items managed by an organization.
- Determine the importance of items, allowing different levels of control basedon the relative importance of items.
- Deciding Stock-Keeping Units (SKU).
- Management decisions regarding inventories must ultimately be made at the level of an individual item or product.
- The specific unit to be controlled will be called a Stock-Keeping Unit (SKU).
- An SKU will be defined as an item of stock that is completely specified in terms of function, style, size, colour and usually location.

14.9 VARIOUS INVENTORY ANALYSIS

There is various inventory analysis such as:

14.9.1 ABC Analysis

ABC Analysis stands for "Always Better Control".It is a method of selective inventory control based on annual usage value. Figures reveal that a small number of items account for a large portion of material expenditure. ABC Analysis segregates the inventories into three categories:

1. **AItems:** These constitute 5-10% of the items but account for 70-75% ofthe total money spent on materials.These items should be stocked in smaller quantities and procured frequently, with small quantities per order.
2. **B Items:** These represent 15-20% of the items and account for 15-20% of the material expenditure.
3. **C Items:** These make up 70-80 % of the items but account for 5-10% of the total material expenditure.

Conducting ABC Analysis:

The following steps are involved in conducting ABC Analysis:

- Prepare a list of items and estimate their annual consumption (units).
- Determine unit price of each item. Multiply annual consumption with unit price to get the annual consumption in rupees referred as Annual Usage Value (AUV).
- Arrange the items in descending order of their annual usage value (AUV), starting with the highest and ending with the lowest.
- Calculate cumulative usage and express it as a cumulative usage percentage. Also express the number of items as a cumulative item percentage.
- Plot a graph of cumulative usage percentage vs. cumulative item percentage and segregate into three categories as A, B and C items.
- Decide on appropriate control policies for managing these three categories.

The sample graph of the curve is given in Fig.14.3.

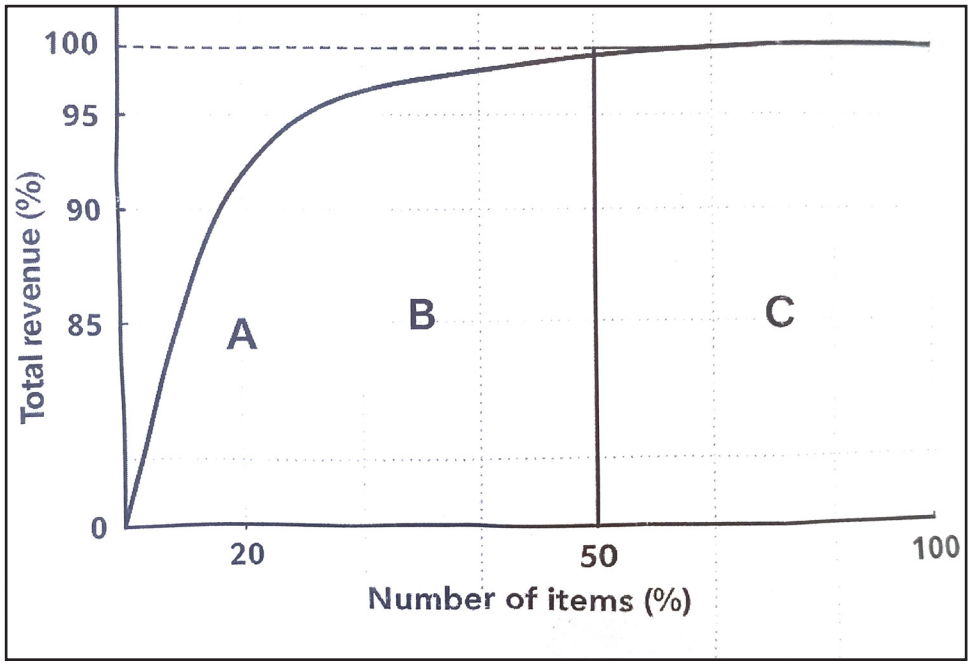

Fig.14.3: Sample Graph of ABC Analysis
(https: //industrialengg.wordpress.com)

- ***Different Controls*:**

Based on classification of items as A, B, C, each class of item needs to be provided different types of controls.

A-Class Items Require:

- High priority

- Tight control
- Complete and accurate record keeping
- Frequent review of inventory status by management
- Frequent review of demand forecast
- Close follow-up and expediting to reduce lead time

B-Class Items Require:

- Medium priority
- Normal control

C-Class Items Require:

- Lowest priority
- Simple control system
- Use of a two-bin system where possible
- Ordering large quantities and carrying sufficient stock
- ***Limitations of ABC Analysis:***

One should note that the ABC Classification depends not only on the value per unit but also on the number of units consumed over the year, because we are considering the annual consumption. If the value of an item were to increase or if the amount of annual consumption of the item were to increase, the annual consumption value of the item would increase. Therefore, the classification of the item may change from say, C class to A class. The point is that the ABC classification is not done once and for all time. The classification need to be monitored periodically and any changes need to be incorporated accordingly.

- ***ABC Analysis Example:***

A company stocks 20 items. Table2 gives the number of items and the annual consumption value of each item. The items are listed in decreasing order of their consumption.

In Table 14.2, Columns no.2 and 6 which give respectively the cumulative percentage of the items and cumulative percentage of the total annual consumption. From Table 2, it may be observed that items no. 1 and 2 account for 70% of the annual consumption value. Hence, these two items can be classified as ‘A’ class items.Items no.8 to 20, which constitute 65% of the items account for only about 6% of the annual consumption value. So, items 8 to 20 can be classified as ‘C’ class items.The remaining items, that is, items no. 3 to 7 can be classified as ‘B’ class items.

Figure 14.2 provides the graphical picture of ABC Analysis for the company.

Table 14.2: Analysis of Data on Inventory Stocked by a Company

Item No.	Cumulative % of items	Annual Consumption Units	Value per Unit (Rs.)	Annual Consumption Value (Rs.)	Cumulative % of Consumption Value
1	5	100	400	40,000	40
2	10	500	60	30,000	30
3	15	200	70	14,000	84
4	20	25	200	5,000	89
5	25	25	100	2,500	91.5
6	30	65	20	1,300	92.8
7	35	50	25	1,250	94.05
8	40	50	20	1,000	95.05
9	45	30	30	900	95.95
10	50	50	14	700	96.65
11	55	20	30	600	97.25
12	60	90	5	450	97.70
13	65	40	10	400	98.10
14	70	35	10	350	98.45
15	75	20	17.50	350	98.80
16	80	50	6	300	99.10
17	85	100	3	300	99.40
18	90	25	10	250	99.65
19	95	20	10	200	99.85
20	100	25	6	150	100.00
Total				1,00,000	

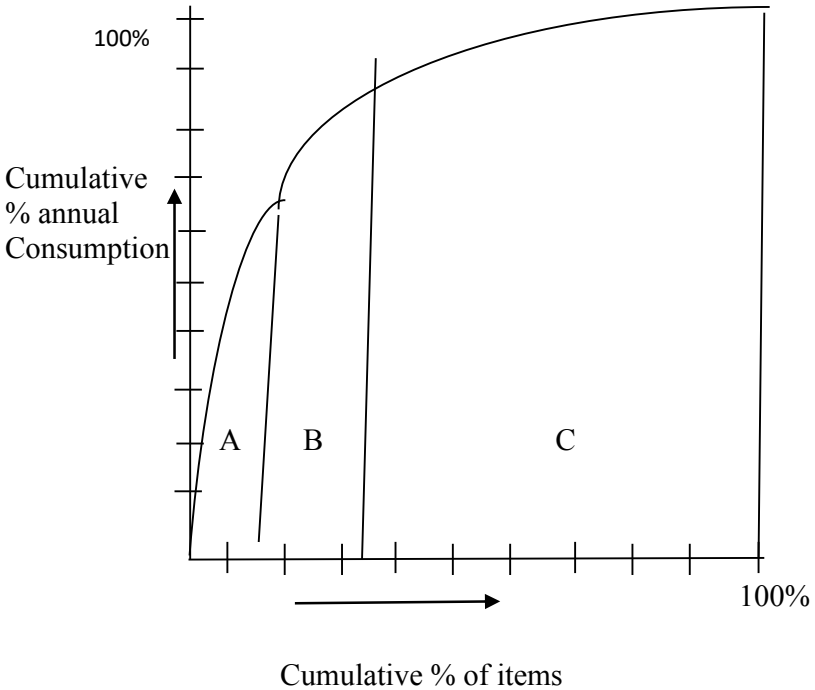

Fig.14.4: ABC Analysis of Problem

Check Your Progress 14.6

Note: a) Use the spaces given below for your answers.

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

1. Indicate the limits for classification of items as A-class, B-class and C-class items.

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2. Indicate the prerequisite for making ABC analysis effective.

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Activity 14.5 :

Visit a supermarket or an industry and collect the details required for ABC Analysis of approximately 25 items and classify them as A-class, B-Class and C-class items.

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14.9.2 HML Analysis

Here items are classified according to the unit price as High, Medium and Low. This analysis isthe opposite of ABC analysis and does not take into account consumption. This analysis is mainly useful in purchasing.

Salient Features of HML Analysis:

- HML Analysis is based on high, medium and low price.
- Cut-off lines are decided by company management.

HML Analysis Helps to:

- Assess storage and security requirements.
- Keep control at the departmental head level
- Determine the frequency of stock verification
- Evolve buying policies to control purchases
- Delegate authority to different buyers to make petty cash purchases.

14.9.3 X Y Z Analysis

This analysis is based on the value of inventory recorded during the closing of annual accounts.

Items are Classified as :

- X: High Value
- Y: Medium Value
- Z: Low Value

XYZ Criterion Employed: Amount invested in the inventory of each item.

XYZ analysis is based upon the value of the stocks held. In other words, the investment made in the inventory of each item assessed.Items whose inventory investments values are high, are called X items. Y items consist of those items whose investment inventory values are moderate,while, Z items are those with low inventory investment values. Normally, XYZ analysis is used along with either the ABC analysis or with HML analysis. When combined with ABC analysis, it is detailed below in Table14.3.

Table 14.3: Combination of ABC and XYZ Analysis

Class of Items	A	B	C
X	Efforts to be made to reduce stock to Z category	Efforts to be made to convert stock to Y category	Steps to be taken to dispose of surplus stocks
Y	Efforts to be made to convert stock to Z category	*	Control on stocks may be further tightened.
Z	*	Stock levels may be reviewed, say, twice a year.	*

14.9.4 VED Analysis

The criterion used in this classification is the criticality of the item. Here, items are classified as: V-Vital, E-Essential, D-Desirable.

- V- Vital items have extreme criticality.
- E- Essential items are of medium importance.
- D- Desirable items are neither critical and essential.

Table 14.4: VED and ABC Analysis Combination

Class	Vital (V)	Essential (E)	Desirable (D)
A	AV	AE	AD
B	BV	BE	BD
C	CV	CE	CD

- **Combination of VED and ABC Analysis:**

This analysis is particularly helpful in spare parts inventory control.

The conventional ABC Analysis and VED Analysis are both important. If both classifications are combined, the joint classification becomes very helpful in inventory control. The combination of VED and ABC Analysis given in Table.14.4.

Inventory control policies can be decided by the company management for nine possible combinations of inventory items.

14.9.5 FSN Analysis

Here the classification is based on the movement of the items.

- F – Fast-moving items
- S – Slow-moving items
- N –Non-moving items

This analysis is frequently used in control of spare parts inventory. Fast-moving items require close and continuous review and control.

Many spare parts come under slow-moving items, which are to be managed by adopting some of the following strategies:

- If spares are required only at a pre-specified time, such as during scheduled maintenance for replacement, then it is desirable not to stock them.
- Place procurement orders sufficiently in advance, considering lead times, so that they arrive just in time.
- If a part gives adequate warning of impending breakdown, the best policy is to place an order the moment the warning is received.
- For items with inadequate warning, some stock needs to be maintained.
- In general, a one-for-one order policy is useful. This means placing an order for one spare when one is consumed.

A combination of FSN and VED analysis will also be quite helpful in laying down policies for controlling especially spare parts inventory. The combined analysis is given in Table 14.5.

Table 14.5: FSN and VED Analysis

Class	Fast-moving (F)	Slow-moving (S)	Non-moving (N)
Vital (V)	VF	VS	VN
Essential (E)	EF	ES	EN
Desirable (D)	DF	DS	DN

Check Your Progress 14.7

Note: a) Use the spaces given below for your answers.

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

1. What is HML analysis and where is it normally used?

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2. What is VED analysis? Where can we use it?

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3. What are the criteria of FSN Analysis?

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14.9.6 SDE Analysis

Here, the analysis focuses on the difficult to obtain the materials. Based on the difficulties involved, the items are classified as:

S- Scarce, D- Difficult, E- Easy to obtain

- **S-Scarce:** Scarce items are short in supply, imported or canalized through government agencies. These items may be normally procured once in a year because of the expenditure and effort involved in imports.
- **D-Difficult:** These items may be available indigenously, but there may be difficulties in procurement.
- **E-Easy to obtain:** These items do not pose any problems.

This analysis deals with:

- Problems of procurement
- Non-availability
- Scarcity
- Longer lead time
- Geographical location of suppliers
- Reliability of suppliers, etc.

14.9.7 GOLF Analysis

This classification uses the criteria G- Government Controlled, O- Ordinarily Available in Open Market, L - Locally Available and F - Foreign/Imported Purchase.

Several items are to be procured through agencies like State Trading Corporation, Metals and Minerals Trading Corporation, etc. While procuring the items through these agencies, companies need to follow numerous procedures stipulated by the government. As such, normal systems of inventory control may not work in these situations. Similarly, for the imported items, procurement need to follow special procedures.For items available in domestic markets, normal procurement procedures may be applicable.

14.9.8 SOS Analysis

This analysis helps in the management of seasonal and off-seasonal inventory items.

S- Seasonal, OS- Off-seasonal.

Factors to be Considered When Using SOS Analysis Include:

- Seasonal items available only for a limited period need to be procured and stocked for the entire year. *Example*: Agricultural products like rice, wheat, mangoes, etc.
- The prices of seasonal items that are available throughout the year are generally lower during the harvest season. The quantities required should be decided considering the savings in procurement cost versus the inventory carrying costs.
- For seasonal items available year-round, inventory control norms will differ.
- For off-seasonal items, inventory quantities are decided based on different considerations.

14.9.9 MUSIC-3D (Multi-Unit Selective Inventory Control–Three Dimensional)

In this analysis, the three dimensions considered are finance, operations and lead time for materials. The model is shown in Table 14.6.

Table 14.6: MUSIC-3 D (Multi-Unit Selective Inventory Control-Three Dimensional)

	HCV			**LCV**
Critical	LLT 1	SLT 2	LLT 5	SLT 6
Non-critical	3	4	7	8

HCV – High Consumption Value
LCV – Low Consumption Value
LLT – Long Lead Time
SLT – Short Lead Time

The MUSIC-3D model provides a sound basis for companies to decide inventory policies effectively.

14.10 AGRIBUSINESS INVENTORY CONTROL

Agribusiness has some unique characteristics which are to be kept in view in Inventory management.The following are some of the unique characteristics of Agribusiness:

- Timely availability of agriculture inputs the season (*Example*: Seeds)
- Agri produce/products available only in specific seasons (*Example*: Crops, Sugarcane, etc.)
- Requirement of large godowns/warehouses for product storage (*Example*: Crops)
- Determination of quality/shelf life during storage (*Example*: Sugarcane, Oilseeds)
- Perishable products (*Example*: Fruits, Vegetables, Flowers)
- Requirement of cold storage (*Example*: Floriculture)
- Requirement of refrigerated transport (*Examples*: Fruits, Flowers)
- Government policies on procurement, subsidies, etc.
- Logistics including transport and communication, especially in rural areas.

All these factors need to be considered in inventory control and particularly in the use of Selective Inventory Control approaches.

Check Your Progress 14.8

Note: a) Use the spaces given below for your answers.

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

1. What is SDE analysis?

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2. What is GOLF analysis?

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3. What is SOS Analysis?

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Activity 14.3 :

Take any agro-based manufacturing or trading organization and understand its operations and inventory management problems. Find out the selective inventory control practices they can follow.

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14.11 LET US SUM UP

Inventory Management is a very important function that determines the health of the Company and the balance sheet. Every organization constantly strives to maintain optimum levels of inventory to meet its requirements and avoid overstocking or understocking, that can impact the financial performance.

Inventory is always dynamic. Inventory Management requires constant and careful evaluation of external and internal factors, along with control through planning and review. Most organizations have a separate department or job function called inventory planning, where inventory planners continuously monitor, control and review inventory while coordinating with the production, procurement and finance departments.

In any manufacturing and trading organization, there are thousands of inventory items. These items may range from various raw materials and parts to critical spares and consumables. It will not be possible to exercise close control on all the thousands of items of inventory. The effort and cost involved in controlling every single item would be prohibitive.

Selective inventory control based on Pareto analysis and the principle of management by exception, helps companies manage their inventories effectively and efficiently.

14.12 KEY WORDS

ABC Analysis : Also called Pareto analysis or the 80/20 rule, categorizes inventory items based on value and usage.

AUV : Annual Usage Value.

Backorder : Occurs when demand cannot be met from stock, but the customer waits for restocking.

Consumables : Materials needed for operations but not part of the final product (*e.g.*, oil, paper, cleaners).

Customer : Anyone or anything that creates demand for items.

Cycle Counting : Checking inventory at regular intervals by reviewing small portions at a time.

Demand : The amount of material desired by a customer.

Distribution Centers : Locations in the supply chain for logistics activities like warehousing and stock management.

Economic Order Quantity (EOQ) : Order size that minimizes inventory costs in a simple inventory system.

Finished Goods : Items ready for delivery to customers.

Finite Replenishment Rate : When deliveries are received gradually over time instead of all at once.

Fixed Order Quantity Method : Inventory control method where fixed-size orders are placed at variable time intervals.

Forecast : An estimate or prediction of future demand or activity.

FSN Analysis : Movement analysis classifying inventory into Fast-moving, Slow-moving, and Non-moving items.

GOLF Analysis : Classifies items as Government-controlled, ordinarily available, and foreign-imported.

HML Analysis : High, Medium, Low analysis used for purchase control.

Holding Cost : The cost of holding a unit of an item in stock for a unit time.

Inventory : A list of items held in stock.

Item : A single article kept in stock, one entry in the inventory.

Just-in-Time (JIT) : An approach organizing operations to occur exactly when needed.

Lead Time : The total time between ordering materials and having them available for use.

Lead Time Demand : The demand for an item during its lead time.

Logistics : The function managing material flow within organizations and to customers.

Lost Sales : Occur when demand cannot be met, causing customers to switch suppliers.

Material : Anything kept in stock.

Min-Max System : A hybrid inventory method setting order sizes between fixed order quantity and periodic review.

MRP (Material Requirements Planning) : A system for managing material needs.

MUSIC-3D : Multi-Unit Selective Inventory Control— three dimensions being finance, operations, and lead time.

Order : A request to a supplier for material delivery.

Organization : Any entity (business, government, charity) that holds stock.

Pareto Analysis : Also called ABC analysis or the 80/20 rule, categorizes inventory based on value and use.

Periodic Review Methods : Inventory control methods placing variable-size orders at fixed intervals.

Pipeline Stock : Stock currently being moved from one location to another.

Price : The amount charged by a supplier.

Price Discounts : Stepwise reductions in price for larger orders.

Procurement : The function responsible for acquiring materials needed by an organization.

Pull System : A JIT approach where customer demand triggers material movement.

Purchasing : A part of procurement responsible for buying materials.

Raw Materials : Materials received from suppliers, stored until needed for operations.

Reorder Level : Stock level indicating when to place another order (lead time demand + safety stock - stock on order).

Replenishment : Adding materials to stock to replace used units.

Rule of 80/20 : Also called Pareto or ABC analysis, categorizing inventory by value and use.

Safety Stock : Reserve stock held to cover unexpected demand.

Scientific Inventory Control : Using mathematical models to optimize stock levels and ordering policies.

SDE Analysis : Classifies items by availability— Scarce, Difficult to obtain, Easily available.

Seasonal Stock : Stock used to maintain operations through seasonal demand variations.

Service Level : Measure of customer demand met from stock.

Shortage : When demand cannot be met from stock, causing backorders.

SKU (Stock Keeping Unit) : An alternative name for an inventory item.

Smoothing Constant : A value controlling the sensitivity of a forecasting method.

SOS Analysis : Classifies materials based on seasonality— Seasonal and Off-seasonal.

Spare Parts : Stocked items used as replacements for machinery, equipment, etc.

Stock All goods and materials stored by an organization until needed.

Stock Cycle : The sequence of repeated events in stock management, including replenishments.

Stock Keeping Unit (SKU) : Another term for an inventory item.

Stocktaking : Periodic checks to reconcile recorded and actual stock levels.

Supplier : Anyone or anything that replenishes stock.

Target Inventory : Determines order size in periodic review (order size = target stock - current stock - stock on order).

Two-Bin System : A simple inventory method where one bin stores reorder stock, and another holds the remaining stock.

Uncertainty : Occurs when a value is not exactly known but follows a probability distribution.

Unit : The standard size or quantity of a stock item.

Unit Cost : The cost of acquiring each unit of an item.

VED Analysis : Classifies items as Vital, Essential, and Desirable.

Warehouse : Any location where stocks are held.

Work in Process : Another term for work in progress.

XYZ Analysis : Classifies inventory value at the end of the year— X (High value), Y (Medium value), Z (Low value).

14.13 SUGGESTED FURTHER READINGS/ REFERENCES

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14.14 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 14.1

1. **Work-in-process (WIP):** WIP inventory might exist merely because of the production cycle time or could be maintained for decoupling successive manufacturing operations. The size of this inventory depends on production cycle time and availability of production machines.
2. **Safety Stock or Buffer Stock:** The inventory taking care of uncertainty is called the safety stock or buffer stock.

Check Your Progress 14.2

1. **Inventory Turnover Ratios:** These are also known as Inventory Indices. These ratios are quite important in evaluating the performance of inventory management. Intra-firm comparison and inter-firm comparisons of these ratios help in evaluating the competitive position of the company in the market. These ratios also help the management in providing the policies and guidelines for effective inventory management.
2. **Inventory Turnover Ratio (Raw Material)** = Annual Consumption/ Average Inventory
3. **Return on Investment (ROI):** Materials form an important part of current assets in any organization. The Return on Investment (ROI) depends a great dealon the manner of utilization of materials.

   ROI = Profit/Sales X sales/(Fixed assets + Current assets)

   Fixed assets constitute capital already blocked and the only scope for improving the Return on Investment (ROI) lies in the efficient utilization of materials which constitute the bulk of current assets.

   ROI is helpful for top management of the company in formulating inventory management policies.

Check Your Progress 14.3

1. **Economic Order Quantity (EOQ):** EOQ is defined as that quantity where the ordering cost and inventory carrying costs are equal and the total cost of the two is minimum.
2. **Lead time:** Lead time is defined as the period elapsed between the recognition of the need to its fulfillment.
3. **Reorder level:** The level of inventory at which an order for replenishment quantity placed with the suppliers for procuring inventory.
4. **Service level:** The probability of not running out of stock on any stock

cycle *i.e.*, percent order cycle in which all demand can be supplied from stock.

Check Your Progress 14.4

1. **Just-in-Time (JIT):** A philosophy that advocates the lowest possible levels of inventory. JIT espouses that firms need only keep inventory in the right quantity at the right time with the right quality. The ideal lot size for JIT is one, even though the term "zero inventory" is often used.
2. The process for controlling inventory involves five steps given below.

   Step 1: Inventory Planning

   Step 2: Establish order cycles.

   Step 3: Balance Inventory Levels

   Step 4: Review Stocks

   Step 5: Follow-up and Control
3. **Fixed Order Quantity System-Q System:**Also called the Perpetual Inventory System or Q System the count of a number of units of inventory is continuously maintained. With lead time less than the reorder cycle (L <t), an order for a fixed quantity, Q is placed, when the inventory drops to a predetermined reorder point R. The value of Q should be close to optimal lot size.
4. **Periodic Review System – P System:** This system involves reviewing stock levels at a fixed interval, review period, and placing replenishment orders at the end of each interval. The replenishment order variable and corresponds to the amount of stock required to bring the stock ordered plus the stock on hand up to a target level S. This system is also known as Fixed Period System or Replenishment Inventory System or P-System.

Check Your Progress 14.5

1. **Selective Inventory Control:** A process to identify items, which bring significant benefit by proper management from among hundreds and thousands of items.
2. **The Criteria for SIC Include:** Usage Value, Unit Price, Criticality of item, Procurement difficulties, Seasonality, Issues form Stores and Inventory investment.

Check Your Progress 14.6

1. A-Class items represent 5 to 10% of the items in numbers but account for around 70% of the annual usage value. B-class items will be 15 to 20% in terms of numbers and account for 15 to 20% of annual usage value.C-class items account for 70 to 80% in terms of number of items but account for 5 to 10% of annual usage value.
2. To be effective, the items classified in ABC Analysis need to be frequently reviewed and updated to reflect the changes in prices and annual consumption.