CHAPTER | TWENTY THREE

Inventory Management

Learning Objectives

After reading this chapter, you should be able to:

- Understand the meaning, components and objectives of inventory.
- Discuss the concepts of inventory costs.
- Explain factors influencing inventory management and control.
- Discuss the benefits and the process of inventory management and control.
- Discuss fixed-order quantity and fixed-order period inventory control systems.
- Discuss in detail various inventory control techniques.

The management and control of inventory is a problem common to all organisations in any sector of the economy. The problems of inventory do not confine themselves to profit making business firms. The same type of problems are encountered by social and non-profit organisations too. Inventories are common to besides industries - agriculture, wholesalers, retailers, hospitals, temples, churches, prisons, zoos, universities, and national, state and local governments.

Inventory problems have been encountered by every society, but it was not until the 20th century that analytical techniques were developed to study them. The initial impetus, for analysis expectedly came from manufacturing sector. It was not until after World War II that a concerted effort on risk and uncertainty aspects of inventory was made. In theory, inventory is an area of organisational operation that is well developed. In practice, it is very backward. This gap will narrow as educational institutions integrate materials management into their course structures.

MEANING AND DEFINITION

The term inventory includes raw material, work-in-process, finished goods and stores and spares.

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

The term *inventory* has been defined by several authors. The more popular of them are: *'the term inventory includes materials – raw, in process, finished packaging, spares and others stocked in order to meet an unexpected demand or distribution in the future'.*

Another definition of inventory is that it *'can be used to refer to the stock on hand at a particular time of raw materials, goods-in-process of manufacture, finished products, merchandise purchased for resale, and the like, tangible assets which can be seen, measured and counted... In connection with financial statements and accounting records, the reference may be to the amount assigned to the stock of goods owned by an enterprise at a particular time'.*

Yet another definition is that the term inventory includes the following categories of items:

1. ***Production Inventories :*** Raw materials, parts, and components which enter the firm's product in the production process. These may consist of two general types: *(a)* special items manufactured to company specifications, and *(b)* standard industrial items purchased 'off the shelf'.
2. ***MRO Inventories :*** Maintenance, repair, and operating supplies which are consumed in the production process but which do not become part of the product. (e.g., lubricating oil, soap, machine repair parts).

MRO inventories required for maintenance, repair and operating machinery.

3. ***In-process Inventories :*** Semi-finished products found at various stages in the production operation.
4. ***Finished goods Inventories :*** Completed products ready for shipment.

Merchandise meant for resale is not included in the above classification of inventories. The exclusion of merchandise is justified on the ground that a manufacturing establishment does not buy anything for resale in the same condition. It buys raw materials and other items for their conversion into finished products. A trading concern, however, buys finished goods for resale. The present study is concerned with industrial establishments and not with trading concerns.

OBJECTIVES OF INVENTORIES

Inventory is as old as man. The primitive man's inventory consisted of a few tools; as a shepherd, man had to tend his flocks and herds; later, he had his granaries and warehouses; today, with industrialisation, his inventories cover a very wide range. As man has progressed

and his needs and activities have multiplied, the range of inventory has become larger and more diversified.

As of today inventories include, among others, raw materials, semi-finished goods, finished goods and operating supplies. Each of these serve specific purposes. The raw materials inventories are held for later conversion into semi-finished or finished goods. Raw material inventories must exist because generally it is not always economically feasible either to purchase or to schedule the delivery of raw materials as they are needed in the production process.

Since manufacturing or processing always takes time, there is need for finished goods inventory. In some industries, materials must be processed in lots or batches. In other industries the flow of material may be steady, with the product existing simultaneously in several stages of completion. In still other types of manufacturing it is desirable, from economic considerations, to process or schedule material in lots.

The nature of the product, the nature of the customer demand, and the nature of the manufacturing process determine, to a considerable extent, the need for finished goods inventories. If the customer is willing to wait for the product to be manufactured, there is need for finished goods inventories. Sometimes, the nature of the product prohibits expensive finished goods inventories. Fresh fruits, vegetables and some other foods have limited storage life, so the extensive inventories of these products are not desirable. If the material must be processed in lots or batches, finished goods inventories will usually exist.

Supplies inventories do not directly go into the product. But they exist to facilitate smooth operation of the manufacturing process.

The primary objective of inventory management is to ensure continuous supply of raw materials and facilitate uninterrupted production.

In general, inventory facilitates transit and handling. Materials may be transported thousands of kilometres before they are incorporated into an end product. All the time, materials are in transit, which may be a period of several months. During this transit, materials constitute someone's inventory.

Furthermore, inventories serve to isolate the supplier, the producer and the consumer. Inventories permit the procurement of raw materials in economic lot sizes as well as processing of these raw materials into finished goods in the most economical quantities. Raw material inventories isolate the supplier of raw materials from the user of these raw materials. Finished goods inventories isolate the user from the producer of the goods. In process the inventories isolate the departments within the plant.

Isolating, also called decoupling, of producer from supplier, one production department from another, and consumer from producer is necessary for two reasons. First is to reduce dependencies of one another, and second, to enable each organisation schedule its operations independently of another.

Yet another purpose of holding inventories is to reduce material handling costs. In some manufacturing and service operations, material handling cost can be reduced by accumulating parts between operations. This is particularly true of intermittent systems, since they involve less automation of material handling than do continuous systems. Parts can be accumulated and inventoried into the boxes or baskets and transported by hand-jack dollies or fork-lift trucks much more economically than they can be carried by hand. In continuous manufacturing, automated material handling systems, rather than larger work-in-process inventories, are designed to reduce overall handling costs.

Obtaining a reasonable utilisation of people and equipment is one of the reasons for holding inventories.

Another reason for holding inventories is to obtain a reasonable utilisation of people and equipment.

Finally, inventories are held to facilitate product display and service to customers, batching in production in order to take advantage of longer production runs and provide flexibility in production scheduling.

Box 23.1 depicts the objectives more clearly.

Box 23.1 : Objectives of Inventory Management

1. Ensure a continuous supply raw materials and supplies to facilitate uninterrupted production.
2. Maintain sufficient-finished goods for smoot sales operation and efficient customer service.
3. Inventories permit the procurement of raw materials in economic lot sizes as well as processing of these raw materials into finished goods is the most economical quantity known as "economic lot size".
4. Reduce dependencies of one another and enable, the organisations to schedule its operations independently of another.
5. Inventory management helps to reduce material handling costs.
6. It helps to utilise people and equipment reasonably.
7. It facilitates product display and service to customers.

I INVENTORY COSTS

Inventory costs includes ordering cost plus carrying costs.

Inventories cost money. The cost factor must be considered while taking any decision regarding inventories. Inventory cost includes ordering cost, carrying cost, out of stock or shortage cost, and capacity cost. Each of these comprises several elements as shown below:

1. Ordering Costs

A. Cost of placing an order with a vendor of materials:

1. Preparing a purchase order.
2. Processing payments.
3. Receiving and inspecting the material.

B. Ordering from the plant:

1. Machine set-up.
2. Start-up scrap generated from getting a production run started.

2. Carrying Costs

A. Costs connected directly with materials:

1. Obsolescence
2. Deterioration
3. Pilferage.

B. Financial Costs

1. Taxes
2. Insurance
3. Storage
4. Interest (as the cost of capital borrowed to acquire and maintain the inventories).

Aljian elaborates the carrying costs in greater details as follows:

Capital Costs

Capital cost is the loss of interest on money invested in inventory building and inventory control equipment.

Interest on money invested in inventory.

Interest on money invested in land and building to hold inventory.

Interest on money invested in inventory holding and control equipment.

Storage Space Costs

Rent on building.

Taxes and insurance on building.

Depreciation on building.

Depreciation on warehouse installation.

Cost of maintenance and repairs.

Utility charges, including heat, light and water.

Salaries of security and maintenance personnel.

Inventory Service Costs

Taxes on inventory.

Labour costs in handling and maintaining stocks.

Clerical expenses in keeping records.

Employee benefits for warehouse and administrative personnel.

Handling-equipment Costs

Taxes and insurance on equipment.

Depreciation on equipment.

Fuel expense.

Cost of maintenance and repairs.

Obsolescence and physical deterioration of inventory and losses from pilferage are the inventory risk costs.

Inventory Risk Costs

Obsolescence of inventory.

Insurance on inventory.

Physical deterioration of inventory.

Losses from pilferage.

3. **Out-of-stock Costs**

   A. Back ordering.

   B. Lost sales.

4. **Capacity Costs**

   A. Overtime payments when capacity is too small.

   B. *Lay-offs and idle time when capacity is too large.*

Some of the components of inventory costs are conflicting, ordering costs and carrying costs, for example. If ordering costs are more carrying costs are less and vice versa.

Further, identifying and assessing some items of cost poses difficulty. Stock out cost is one such example. In a seller's market an unsatisfied customer will not be lost as easily as in a buyer's market, and who will say what the cost of not satisfying this customer at this time will be in the long run?

Two approaches have been suggested to overcome the difficulty. It is possible to trace and cumulate the individual costs attributable to individual items and use these for decision making. *For example,* what is the cost of issuing a purchase order for this item? Hopefully, such tracing would be applicable to a class or a number of different items and might, therefore, have a broader applicability.

The second approach would be to forecast the impact of a major change in operations and predict the impact on various cost centres. *For example,* if for half of the `C' items we use systems contracting, what will be the impact on stores operations? Since most inventory models and these are based on finding an optional cost level, weighing carrying costs against ordering costs or stock-out costs, the quality and availability of cost data are relevant considerates.

In practice it is only the carrying costs and ordering costs which are considered for calculating inventory costs. In one of the Bangalore based large industrial undertakings, the carrying cost and ordering cost are calculated as follows:

Calculation of Carrying Cost

	(Rs. in lakhs)
Opening inventory	2974.60
Closing inventory	3004.30
Average inventory	2989.45
Cost of carrying	
Salaries or wages (stores dept.)	24.84
Rent of stores building	7.40
Computer services	15.50
Administration overheads	21.70
Insurance	8.25
Other expenses (power, fuel, etc.)	16.60
Maintenance of transport vehicle used in stores	1.80
Material accounts	1.07
Total	**97.16**
% of carrying cost on average inventory	$\frac{97.16 \times 100}{2989.45} = 3.25\%$
+ Interest charges	= 18.00%
Total inventory carrying cost (%ge)	= 21.25%

Calculation of Ordering Cost

	(Rs. Lakhs)
Salaries or wages of purchasing department	12.96
Receiving and shipping of orders	5.40
Receiving/inspection	2.85
Follow-up costs	0.52
Provisioning	6.80
Audit	0.63
Total	**29.16**
Total number of orders during the year	= 3,600
Ordering cost per order	$= \frac{29,16,000}{3,600} = 810$
Total items ordered during the year	= 10,800
Therefore ordering cost per item	$= \frac{29,16,000}{10,800} =$ Rs. 270.0

Together it is estimated that the carrying and ordering costs came to around 25% to 30% of the total inventory.

INVENTORY MANAGEMENT AND CONTROL

Because of high costs involved in inventories, their proper management and control assume considerable importance. In fact, the management of inventory is given such an importance, that, it is often treated synonymous with materials management. Literature wise, there are more number of books and articles written on inventory management than on materials management.

Inventory management involves the *'development and administration of policies, systems, and procedures which will minimise total costs relative to inventory decisions and related functions such as customer service requirements, production scheduling, purchasing and traffic'*. Viewed in that perspective, inventory management is broad in scope and affects a great number of activities in a company's organisation. Because of these numerous inter-relationships, inventory management stresses the need for integrated information flow and decision making, as it relates to inventory policies and overall systems.

Inventory management involves administration, policies and procedures to reduce in inventory cost.

Inventory control, on the other hand, is defined in a narrower sense than inventory management and pertains *primarily to the administration of established policies, systems and procedures. For example,* the actual steps taken to maintain the stock levels or stock records refer to inventory control.

Factors Influencing Inventory Management and Control

Several factors influence inventory management and control. The principal effects of these factors are reflected most strongly in the levels of inventory and the degree of control, planned in the inventory control system. The factors include type of product, type of manufacture, volume of output and others.

Type of Product

Among the factors influencing inventory management and control, the type of product is fundamental. If the materials used in the manufacture of the product have a high unit value when purchased, a much closer control is usually in order. Jewellers are much more careful of their stock of diamonds than they are with display cases full of low-priced costume jewellery. This same principle holds in manufacturing also.

Type of product refers high unit and low unit value.

If the material used in the product is in short supply or is rationed by the government, this may influence the purchase of this material and its stock maintained.

The manufacture of standard products as compared to custom-made items, will influence inventories. Material needed to manufacture a standard produce is easy to obtain and a close control on the stock is not necessary. Material required to product made-to-order items needs strict control to ensure that no item is lost in the process of manufacture. Such materials and tools are of special and expensive type and a loss of any small part will hold up the production.

Type of Manufacture

Besides type of product, type of manufacture also influences inventory management and control. Where continuous manufacture is employed the rate of production is the key factor. Here inventory control is of major importance and in reality controls the production of the product. The economic advantage of this type of manufacture is the uninterrupted operation of the machines and assembly lines in the plant. It is a major offence on the part of the

inventory personnel to have the plant shut down for the lack of material. Intermittent manufacture, on the other hand, permits greater flexibility in the control of material.

Volume of Production

The volume of product to be made as represented by the rate of production may have little effect on the complexity of the inventory problem. Literally, millions of brass bases for light bulbs are manufactured each month involving the control of only two principal items of raw material inventory. On the other hand, the manufacture of a large locomotive involves the planning and control of thousands of items of inventory. Both the inventory problem and the difficulty of controlling production increase in difficulty with the number of component parts of the product and not with the quantity of products to be made.

The other factors are :

(i) The objectives of the company as they relate to inventories and the level of service to be provided to customers.

(ii) The qualifications of staff personnel who will design and co-ordinate the implementation of the system.

(iii) The capabilities of personnel who will be responsible for managing the system on a continuing basis.

(iv) The nature and size of inventories and their relationship to the other functions in the company, such as manufacturing, finance and marketing.

(v) The capability of present and future data processing equipment.

(vi) The potential savings that might be anticipated from improved control of inventories.

(vii) The current, or potential, availability of data that can be used in controlling inventories.

(viii) The present method for controlling inventories, and for making inventory decisions.

(ix) The degree of commitment by management personnel to the development of a more effective inventory management system and the results they anticipate from such a system.

Benefits of Inventory Management and Control

Ensures an adequate supply of materials and minimises inventory costs.

Proper management and control of inventories will result in the following benefits to an organisation :

1. Inventory control *ensures an adequate supply of materials, stores,* etc., minimises stock-outs and shortages, and avoids costly interruptions in operations.
2. It *keeps down investment in inventories,* inventory carrying costs and obsolescence loses to the minimum.
3. If *facilitates purchasing economies* through the measurement of requirements on the basis of recorded experience.
4. It *eliminates duplication in ordering* or in replenishing stocks by centralising the source from which purchase requisitions emanate.
5. It *permits a better utilisation of available stocks* by facilitating inter-department transfers within a company.
6. It *provides a check against the loss of materials* through carelessness or pilferage.
7. It *facilitates cost accounting activities* by providing a means for allocating material costs to products, departments or other operating accounts.
8. It *enables management to make cost and consumption comparisons* between operations and periods.

9. It *serves as a means for the location and disposition of inactive* and obsolete items of stores.
10. Perpetual inventory values provide a *consistent and reliable basis for preparing financial statements*.

PROCESS OF INVENTORY MANAGEMENT AND CONTROL

As mentioned earlier, inventory management and control refers to the planning for optimum quantities of materials at all stages in the production cycle and evolving techniques which would ensure the availability of planned inventories. Four steps are involved in the process, *viz.*,

Step 1. Determination of optimum inventory levels and procedures of their review and adjustment.

Step 2. Determination of the degree of control that is required for the best results.

Step 3. Planning and design of the inventory control system.

Step 4. Planning of the inventory control organisation.

Step 1. Determination of Optimum Inventory Levels

Determination of inventory that an organisation should hold is a significant but difficult step. Too much of inventory results in locking up of working capital accompanied by increased carrying costs (but reduced ordering costs). Excess inventories, however, guarantee uninterrupted supply of materials and components, to meet production schedules and finished goods to meet customers demand. Too less of inventory releases working capital for alternative uses and reduces carrying costs and increases ordering costs. But there is the risk of stock out costs.

A few suggestion may be offered which might help to overcome this problem. The trend of sales must be watched closely and inventories adjusted in advance of the change in rate of production as determined by actual sales.

The actual level of the inventory may also be improved by a close study of the manufacturing cycle. How long does it take to bring out a road roller or a rail coach or an electric motor from the raw materials stage to the finishing stage? A study in co-operation with the manufacturing function of the ratio of actual processing time to waiting time may be most revealing, and when unnecessary details are eliminated, the work in process inventory can be considerably reduced.

All these and other related factors must be considered to determine a level of inventory which an organisation should hold. An interesting aspect is that the level of inventories is not static. What is the optimum level today may not be so tomorrow. Hence, inventory management must plan for the review of the stock often.

Step 2. Determination of Degree of Control

The second aspect of inventory management is to decide just how much control is needed to realise the objectives of inventory management. The difficulty is best overcome by classification of inventory on the basis of value. Popularly called the ABC classification, this approach is useful in deciding the degree of control. 'A' class items are 'high' in value but 'low' in quantity, 'C' class inventories are the opposite of 'A' group, *i.e.*, 'high' in quantity and 'low' in value. In between are the 'B' group stock which are more or less equal in quantity and value proportion to the total inventory. Tight control is exercised on 'A' category items through accurate records of receipts and issues and by co-ordination of incoming

with production requirements. On the other hand, 'C' class items may simply be ordered in large quantities covering several months' need, no record being made of their issue to manufacturing. More stock is simply requested when the existing stock reaches a reorder point. The 'B' class items receive not so tight control but are not neglected either.

Step 3. Planning and Design of the Inventory System

An inventory system provides the organisational structure and the operating policies for maintaining and controlling goods to be inventoried. The system is responsible for ordering and receipt of goods, timing the order placement, and keeping track of what has been ordered, how much, and from whom.

Further, the system must provide follow up to enable the answering of such questions as: Has the vendor received the order? Has it been shipped? Are the items correct? Are the procedures established for reordering or returning undesirable merchandise.

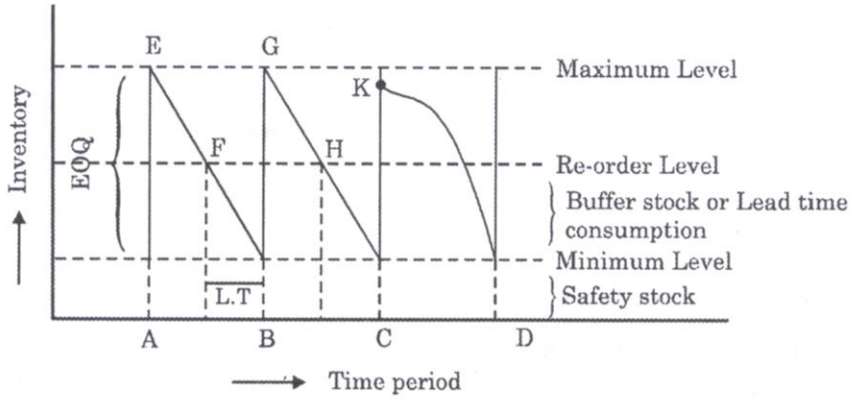
There are two general approaches to inventory systems, *viz.*, *(a)* the fixed order quantity system, and *(b)* the fixed order periodic system (variously known as periodic system, the periodic review system, and the fixed order interval system).

FIXED ORDER QUANTITY SYSTEM OR 'Q' SYSTEM

'Q' system : Fixed quantity of materials ordered whenever stock reaches the reorder point.

In this, a fixed quantity of material is ordered whenever the stock on hand reaches the reorder point. The fixed quantity of material ordered each time is nothing but the economic order quantity (EOQ). When the new consignment arrives, the total stock (existing plus new arrival) shall be within the maximum and the minimum limits. *Exhibit 23.1* illustrates the fixed order quantity system. At A, a supply equal to EOQ is received and the stock reaches point E. Materials are then issued and when the stock reaches F (re-order point) an order is placed and the issues continued. At B, the supplies of order placed at F are received and the stock reaches G. In the further part of the cycle, it should be noted that at C, there is delay in the arrival of supplies and the issues cross minimum (safety) level. Similarly at D, safety stock is touched due to heavy consumption of material.

Exhibit 23.1 : Operation of Fixed Order Quantity System



Advantages of 'Q' System

The fixed order quantity system has certain advantages. The major advantages claimed are that:

1. Each material can be procured in the most economical quantity.

2. Purchasing and inventory control personnel automatically devote attention to the items that are needed only when required.
3. Positive control can easily be exerted to maintain total inventory investment at the desired level simply by manipulating the planned maximum and minimum values.

Disadvantages of 'Q' System

Its disadvantages are that

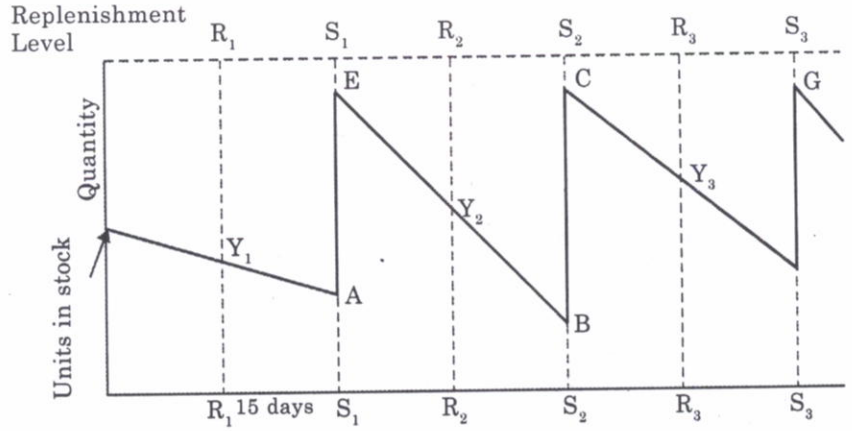
1. The orders are raised at irregular intervals which may not be convenient to the suppliers.
2. In case the lead time is very high, say three months, and the ordering quantity happens to be material supplies for one month, there would be two to three pending orders with the supplier each time and there is every likelihood that he may supply all orders at a time.
3. The items cannot be grouped and ordered at a time since the reorder points occur irregularly.
4. EOQ may give you an order quantity which is much below the supplier minimum (for a good discount), and there is always a chance that the ordering level for an item has been reached but not noticed in which case a stock-out may occur.
5. Further, the system assumes stable usage and definite lead time. When these change significantly, a new order quantity and a new order point should be fixed, which is quite cumbersome.

FIXED-ORDER PERIOD SYSTEM OR 'P' SYSTEM

'P' system : In this inventory is ordered based on fixed period.

In this, the stock position of each item of material is regularly reviewed. When the stock level of a given item is not sufficient to sustain the production operation until the next scheduled review, an order is placed replenishing the supply. The frequency of reviews varies form firm to firm. It also varies among materials within the same firm, depending upon the importance of he material, specific production schedules, market conditions and so forth. Order quantities, likewise, vary for different materials. *Exhibit 23.2* illustrates the periodic review system.

Exhibit 23.2 : Periodic Review System



Suppose we fix review period for an item as two months and the lead time for the item at 15 days. Then the order would be placed every two months, *i.e.*, at ordinate of R_1, R_2, R_3 etc., and the supplies would be received at ordinates S_1, S_2, S_3, etc., (15 days after R_1, R_2, R_3 etc.).

At R_1 let us assume that the stock available to be Y_1, then this stock together with the quantity ordered at R_1 (supplies received at S_1) should be sufficient to last till the next supplies are received at S_1 *i.e.,* to last a total period of 2½ months (review + lead time).

In addition, some buffer stock would also be necessary to take care of any increased consumption or increase in lead time.

Advantages of 'P' System

'P' systems help to have attractive discounts from supplier.

This system has some distinct advantages.

1. The ordering and inventory costs are low. The ordering cost is considerably reduced though follow-up work for each delivery may be necessary.
2. The suppliers will also offer attractive discounts as sales are guaranteed.
3. The system works well for materials which exhibit an irregular or seasonal usage and whose purchases must be planned in advance on the basis of sales estimates.

Disadvantages of 'P' System

The system has certain limitations also.

1. It compels a periodic review of all items; this in itself makes the system somewhat inefficient. Because of differences in usage rates, supplies may not have to be ordered until the succeeding review. Conversely, the usage of some items during the period may have increased to the point where they should have been ordered before the current review date. Consequently, this system must be augmented with a minimum balance figure which signals the need for an early reorder in the case of a sharp usage increase.
2. Equally important, the system demands the establishment of rather inflexible order quantities in the interest of administrative efficiency. Theoretically, there exists an optimum economic order quantity for each item, depending upon its price structure, its rate of usage and attendant internal costs. However, because all items must fit reasonably well into a limited number of ordering cycles under this system, actual order quantities may deviate substantially from the optimum.

Periodic review system tends to peak the purchasing work around the review dates.

3. The periodic review system tends to peak the purchasing work around the review dates. For the mathematical approach to the design of 'Q' System and 'P' System, refer to Annexure-D.

Table 23.2 : Distinction between 'Q' System and 'P' System

Point of Difference	Q System	P System
1. Initiation of order.	1. Stock on hand reaches to reorder point	1. Based on fixed review period and not stock level
2. Period of order.	2. Any time when stock level reaches to reorder point.	2. Only after the predetermined period.
3. Record keeping.	3. Continuously (perpetual system) each time a withdrawal or addition is made.	3. Only at the review period.
4. Order quantity.	4. Constant the same quantity ordered each time.	4. Quantity of order varies each time order is placed.
5. Size of inventory.	5. Less than the 'P' system.	5. Larger than the Q system.
6. Time to maintain.	6. Higher due to perpetual record keeping.	6. Less time due to only at the review period.

Mathematical Approch to the Design of 'Q' System and 'P' System

1. Design of 'Fixed-order-quantity' system or 'Perpetual Review' system or 'Q' system:

How much to order:

Let Annual demand (units) = D

Ordering cost per order = C_o

Inventory carrying cost as a percentage Of value of the item per unit per year = C_i

Unit price of the item = p

$$\text{Order Quantity} = EOQ = Q = \sqrt{\frac{2DC_o}{pC_i}}$$

(a) Safety stock to meet the demand during the extension of lead time at normal consumption rate is calculated as below:

(i) Maximum safety stock Without taking any risk of stock out = (Normal Consumption rate) × (Maximum extension of lead time)

(ii) Safety stock with some risk of stock out = (Normal consumption rate) × (Maximum extension of lead time) × (Cumulative probability of that extension of lead time)

(b) Calculation of reserve stock to meet the increased demand due to increase in consumption rate during the normal lead time:

The level of reserve stock depends on the criticality or importance of the item and the service level to be maintained.

A service level of 99% for vital, 90% for essential and 50% for desirable items may be used.

Variation in consumption rate during normal lead time may follow either normal distribution pattern or poisson distribution pattern.

Depending on the service level desired, value of service level constant 'K' or 'Z' is found from Annexure 'C'.

Reserve stock for normal distribution pattern of consumption during normal lead time (L) = $K\sigma_L$ or $Z\sigma_L$

Where $\sigma_L = \sigma\sqrt{L}$, where σ is the standard deviation for time period (i.e., day, week, month etc.) and L is normal lead time in same time period, i.e., week or month.

Reserve stock when the consumption during normal lead time follows Poisson distribution pattern = $K\sqrt{D_L}$ or $Z\sqrt{D_L}$

Where D_L = Normal consumption during normal lead time period.

(c) Calculation of buffer stock or normal lead time consumption.

$$\text{Buffer stock} = \left(\begin{matrix}\text{Normal}\\ \text{consumption rate}\end{matrix}\right) \times \left(\begin{matrix}\text{Normal}\\ \text{lead time}\end{matrix}\right)$$

When to order : Order is placed for supply of a quantity equal to EOQ when the inventory level falls to a level known as Re-order Level (ROL).

$$\text{Re-order Level} = \text{Safety} + \text{Reserve Stock} + \text{Buffer Stock}$$

2. Design of 'Fixed-order-cycle' system or 'Periodic Review' system or 'P' system:

(a) Calculation of Review Period :

$$\left.\begin{matrix}\text{Number of orders}\\ \text{per year}\end{matrix}\right\} N = \frac{\text{Annual Demand (units)}}{\text{EOQ}} = \frac{D}{Q}$$

$$\left.\begin{matrix}\text{Review period or Interval}\\ \text{between two successive orders}\end{matrix}\right\} R = \frac{12}{N} \text{ months}$$

$$= \text{or } \frac{52}{N} \text{ weeks or } \frac{365}{N} \text{ days}$$

How much to order : The decision to whether to order or not is taken by reviewing the inventory level at the review periods. If at any review period, the virtual stock (VS), i.e., physical stock plus pipe line inventory is found to be less than the desired inventory level set (i.e., DIL) an order for a quantity which equals the difference between DIL and virtual stock is placed. i.e., Order Quantity = DIL – VS if positive.

(b) Calculation of desired inventory level:

$$\text{D.I.L.} = \text{S.S.} + \text{R.S.} + \text{S.S.}$$

$$\text{Safety Stock (S.S)} = \left(\begin{matrix}\text{Normal}\\ \text{consumption}\\ \text{rate}\end{matrix}\right) \times \left(\begin{matrix}\text{Maximum}\\ \text{extension}\\ \text{of lead time}\end{matrix}\right) \times \left(\begin{matrix}\text{Cumulative}\\ \text{probability of}\\ \text{that extension of}\\ \text{lead time}\end{matrix}\right)$$

Reserve Stock (R.S)

(i) Under normal distribution pattern of variation, R.S. = $K\sigma_{L+R}$ or $Z\sigma_{L+R}$

Where K or Z = Service level constant ;

σ_{L+R} = Standard deviation during lead time plus review period

$\sigma_{L+R} = \sigma \times \sqrt{L+R}$,

Where, σ = Standard deviation; L = Normal lead time; R = Review period

(ii) Under Poisson distribution pattern of variation,

$$\text{R.S.} = K\sqrt{D_{L+R}} \text{ or } Z\sqrt{D_{L+R}}$$

$$\text{Where } D_{L+R} = \left(\begin{matrix}\text{Normal}\\ \text{consumption rate}\end{matrix}\right) \times \left(\begin{matrix}\text{Lead time +}\\ \text{Review period}\end{matrix}\right)$$

(iii) $$\text{Buffer stock} = \left(\begin{matrix}\text{Normal}\\ \text{consumption rate}\end{matrix}\right) \times \left(\begin{matrix}\text{Lead time +}\\ \text{Review period}\end{matrix}\right)$$

Step 4. Determining Organisational Arrangement Structure

The last aspect of inventory management and control is to determine an organisation structure to handle inventory. Organisationally speaking, inventory control function is assigned to materials management, or production planning and control.

Attaching inventory control to materials management activity is feasible in organisations where integrated materials management is in practice. There is a strong justification for such an arrangement as inventory control is part of materials activity and all materials functions must be integrated into one group.

Assigning inventory control function to production planning and control, however, has advantages. Production planning and control department will be in a better position to plan its production schedule with the knowledge of inventory under its control. Besides, the production planning and control department will be able to issue timely requisitions for replenishment of stocks used in the production operation. And logically speaking, it is the production department which is the user of inventories and the same department must be held responsible for controlling them.

Actually, the nature of a firm's production operation, its product, and the type of market in which it operates determine the preference for assigning inventory function to production. An engineering oriented company producing specialised technical products on a job-shop basis might well choose to emphasise production considerations as long as an analysis of total costs justifies such a decision. Hence, inventory may report to the production division. On the other hand, a mass producer of electric motors might well find itself in just the opposite situation and be compelled by relative cost considerations to integrate inventory control with purchasing.

Whatever the consideration, it may be pointed out that any inventory control system is not 'once set, goes automatic' type but needs to be reset from time to time as the conditions such as lead time, consumption pattern etc., keep changing.

INVENTORY CONTROL TECHNIQUES

Inventory control techniques are employed by the inventory control organisation within the framework of one of the basic inventory models, *viz.*, fixed order quantity system or fixed order period system. Inventory control techniques represent the operational aspect of inventory management and help realise the objectives of inventory management and control.

Several techniques of inventory control are in use and it depends on the convenience of the firm to adopt any of the techniques. What should be stressed, however, is the need to cover all items of inventory and all stages, *i.e.*, from the stage of receipt from suppliers to the stage of their use. The techniques most commonly used are the following:

Always better control (ABC) classification.

High, medium and low (HML) classification.

Vital, essential and desirable (VED) classification.

Scarce, difficult and easy to obtain (SDE).

Fast moving, slow moving and non-moving (FSN).

Economic order quantity (EOQ).

Max-Minimum system.

Two bin system.

ABC ANALYSIS

One of the widely used techniques for control of inventories is the ABC (always better control) analysis. The objective of ABC control is to vary the expenses associated with maintaining appropriate control according to the potential savings associated with a proper

ABC analysis : Is also called as PVA or SIM technique.

level of such control. *For example,* an item having an inventory cost of Rs. 1,00,000 such as sheet steel, has a much greater potential for saving expenses related to maintaining inventories than an item with a cost of Rs. 100. The ABC approach is a means of categorising inventory items into three classes 'A', 'B' and 'C' according to the potential amount to be controlled.

Once inventory is classified, we have a firm base for deciding where we will put our effort. Logically, we expect to maintain strong controls over the 'A' items taking whatever special actions needed to maintain availability of these items and hold stocks at the lowest possible levels consistent with meeting demands. At the other end of the scale, we cannot afford the expense of rigid controls, frequent ordering, expediting, etc., because of the low amounts in this area. Thus, with the 'C' group we may maintain somewhat higher safety stocks, order more months of supply, expect lower levels of customer service, or all the three. It is for this selective approach, ABC analysis is often called the *Selective Inventory Control Method (SIM).*

ABC inventory control technique divides inventory into three categories A, B and C based on their annual consumption value.

The inspiration behind the ABC analysis has been drawn from Vilfredo Pareto, an Italian economist and sociologist (1842-1923) who generated some highly debatable concepts of economics and sociology. One that is most interesting to a student of inventory management is the concept known as "Pareto's Laws". Pareto arrived at the general conclusion that income distribution patterns were basically the same in different countries and in different historical periods. Pareto's studies showed that a very small percentage of total population always seemed to receive the bulk of the income. He concluded that there was a natural economic law in existence which would always establish the shape of the income distribution and could not be overridden by any political or sociological reforms.

Extending Pareto's principle to inventory, it is always possible and necessary to separate "vital few" from "trivial many" of the stock items for their effective control. Separating vital few from trivial many is what is precisely done in ABC analysis.

Pareto's principle was brought to the attention of people concerned with inventory management by H. Ford Dickie, who applied Pareto's law to inventory and developed the general concept of ABC analysis. Like so many ideas, however it has not been completely understood. Many people refer to the ABC system or the ABC technique. The idea of distribution of value for inventory stratification is neither a system nor a technique, it is a fundamental management principle with universal application potential.

The following procedure is suggested for developing an ABC analysis:

1. List each item carried in inventory by number or some other designation.
2. Determine the annual volume of usage and rupee value of each item.
3. Multiply each item's annual volume of usage by its rupee value.
4. Compute each item's percentage of the total inventory in terms of annual usage in rupees.
5. Select the top 10 per cent of all items which have the highest rupee percentages and classify them as 'A' items.
6. Select the next 20 per cent of all items with the next highest rupee percentages and designate them 'B' items.
7. The next 70 per cent of all items with the lowest rupee percentages are 'C' items.

Table 23.1 is a typical illustration of the above procedure.

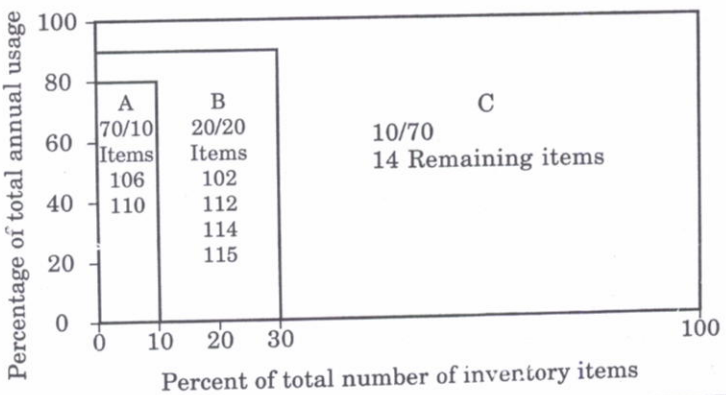
Table 23.1 : Example of ABC Inventory Analysis

	Inventory Item	Annual Use (in Rs.)	Percentage of total Inventory Usage	
	101	3,000	0.3	
B	102	40,000	4.0	B
	103	2,000	0.2	
	104	10,000	1.0	
	105	5,000	0.5	
A	106	4,00,000	40.0	A
	107	7,000	0.7	
	108	9,000	0.9	
	109	8,000	0.8	
A	110	3,00,000	30.0	A
	111	1,000	0.1	
B	112	50,000	5.0	B
	113	15,000	1.5	
B	114	20,000	2.0	B
B	115	90,000	9.0	B
	116	8,000	0.8	
	117	7,000	0.7	
	118	11,000	1.1	
	119	9,000	0.9	
	120	5,000	0.5	
Total	20 items	Rs. 10,00,000	100.0	

Items A	Items B	Items C
106 110 10% of 20 items 70% of Rs. 10,00,000	102 112 114 115 20% of 20 items 20% of Rs. 10,00,000	All 14 remaining items 70% of 20 items 70% of Rs. 10,00,000

The same information is shown graphically in *Exhibit 23.3.*

Exhibit 23.3 : ABC Analysis



Once ABC analysis has been done, the following broad policy guidelines can be established in respect of each category:

A items	B items	C items
1. Very strict control	1. Moderate control	1. Loose control
2. No safety stocks (or very low)	2. Low safety stocks	2. High safety stocks
3. Frequent ordering or weekly deliveries	3. Once in 3 months	3. Bulk ordering once in 6 months
4. Weekly control statements	4. Monthly control statements	4. Quarterly reports
5. Maximum follow-up and expediting	5. Periodic follow-up	5. Follow-up in exceptional cases
6. Rigorous value analysis	6. Moderate value analysis	6. Minimum value analysis.
7. As may sources as possible for each item	7. Two or more reliable sources	7. Two sources for each a item
8. Accurate forecasts in materials planning	8. Estimates based on past data	8. Rough estimates
9 Minimisation of waste, obsolete, and surplus (review every 15 days)	9. Quarterly review	9. Annual review
10. Individual postings	10. Small group postings	10. Group postings
11. Central purchasing and storage	11. Combination purchases	11. Decentralised purchasing.
12. Maximum efforts to reduce lead time	12. Moderate	12. Minimum efforts
13. To be handled by senior officers.	13. To be handled by middle management.	13. Can be fully delegated.

HML Classifications

The High, Medium and Low classification follows the same procedure as is adopted in ABC classification. Only difference is that in HML classification unit value is the criterion and not the annual consumption value. The items of inventory should be listed in descending order of unit value and it is up to the management to fix limits for three categories. *For example,* the management may decide that all units with unit value of Rs. 2,000 and above will be H items, Rs. 1,000 to 2,000 M items and less than Rs. 1,000, L items.

The HML analysis is useful for keeping control over consumption at departmental levels, for deciding frequency of physical verification, and for controlling purchases.

VED Classification

While in ABC, classification inventories are classified on the basis of their consumption value and in HML analysis unit value is the basis, criticality of inventories is the basis for vital, essential and desirable categorisation.

The VED analysis is done to determine the criticality of an item and its effect on production and other services. It is specially used for classification of spare parts. If a part is vital, it is given 'V' classification, if it is essential, then it is given 'E' classification and if it not so essential, the part is given 'D' classification. For 'V' items, a large stock of inventory is generally maintained, while for 'D' items minimum stock is enough.

SDE analysis : Divides units based on availability scarce, difficulty and easy.

SDE Classification

The SDE analysis is based upon the availability of items and is very useful in the context of scarcity of supply. In this analysis, 'S' refers to 'scarce' items, generally imported, and

those which are in short supply 'D' refers to difficult items which are available indigenously but are difficult items to procure. Items which have to come from distant places or for which reliable suppliers are difficult to come by, fall into 'D' category. 'E' refers to items which are easy to acquire and which are available in the local markets.

The SDE classification, based on problems faced in procurement, is vital to lead time analysis and in deciding on purchasing strategies.

FSN Analysis

FSN stand for fast moving, slow moving and non-moving. Here, classification is based on the pattern of issues from stores and is useful in controlling obsolescence.

To carry out FSN analysis, the date of receipt or the last date of issue, whichever is later, is taken to determine the number of months which have lapsed since the last transaction. The items are usually grouped in periods of 12 months.

FSN analysis is helpful in identifying active items which need to be reviewed regularly and surplus items which have to be examined further. Non-moving items may be examined further and their disposal can be considered.

SOS Analysis

'S' stands for Seasonal items and 'OS' stands for Off-Seasonal items. It may be advantageous to buy seasonal items at low prices and keep inventory or buy at high price during off seasons. Based on the fluctuation in prices and availability, suitable decision has to be taken regarding how much to purchase and at what prices.

XYZ Analysis

This classification is based on the value of inventory of materials actually held in stores at a given time (usually during stock checking annually or half-yearly). XYZ analysis helps to control average inventory value by focussing efforts to reduce the inventory of 'X' items which are usually 10% of the number of items stored, but accounting for 70% of the total inventory value. Similarly, 'Y' items are 20% of the number of items stored and account for 20% of the total inventory value. The remaining 70% of the items accounting for 10% of the total inventory value are 'Z' items. The XYZ classification is done in the same way as ABC analysis, the difference being the actual inventory value of items in stores instead of their estimated annual consumption value.

GOLF Analysis

This stands for Government, Open market, Local or Foreign source of supply. For many items, imports are canalised through government agencies such as State Trading Corporations, Mineral and Metals Trading Corporations, Indian Drugs and Pharmaceuticals etc.

For such items, the buying firms cannot apply any inventory control techniques and have to accept the quota allotted by the Government. 'Open market' category are those who form bulk of suppliers and procurement is rather easy. 'L' category includes those local suppliers from whom items can be purchased off-the-shelf on cash purchase basis. 'F' category indicates foreign suppliers. Since an elaborate import procedure is involved, it is better to buy imported items in bigger lots usually covering the annual requirements.

Economic Order Quantity

EOQ - is the level of inventor order of which inventory cost is minimum.

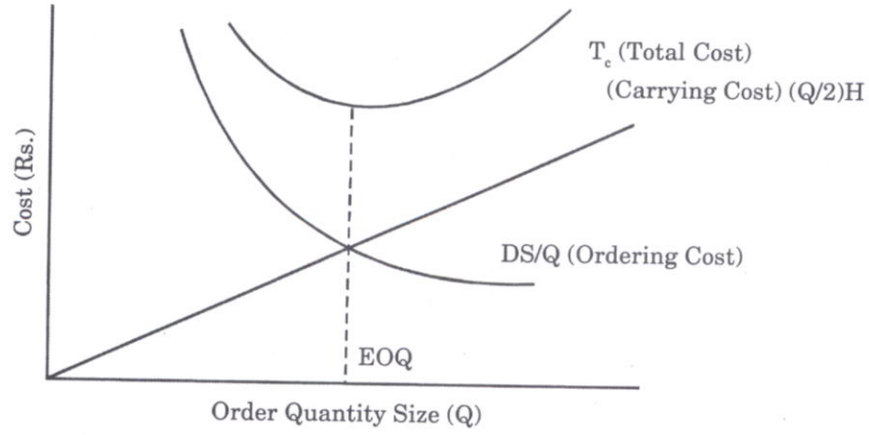
As was explained earlier, under the fixed order quantity system of inventory management, an order for supplies is placed when the existing stock reaches reorder point. The relevant question now is – What should be the size of the order? Buying in large quantities has its

virtues, but, one of the problems associated with bulk buying is the high carrying cost. Similarly, buying in small quantities reduces holding cost but adds to ordering cost. Consequently, the materials manager is torn between a desire to keep inventories low by ordering in small quantities and a desire to reduce cost by buying large quantities.

Economic order quantity (EOQ) is the technique which solves the problem of the materials manager. EOQ or Q Opt (Optimum Quantity) is the order size at which the total cost, comprising ordering cost and plus carrying cost, is the least. *Exhibit 23.4* illustrates the EOQ graphically.

Graphing the two costs, *viz.*, carrying costs and ordering costs show exactly, where the total cost curve is at its lowest point. An examination of the two curves reveals that the carrying cost curve is linear *i.e.*, the more the inventory held in any period, greater will be the cost of holding it. Ordering cost curve, on the other hand, is different. Ordering in small quantities means more acquisition and higher ordering costs. The ordering costs decrease with increase in order sizes.

Exhibit 23.4 : Graphic Presentation of EOQ



A point where the carrying cost curve and the ordering cost curve meet represent the least total cost which incidentally is the economic order quantity or optimum quantity.

Assumptions

EOQ assumes ordering costs are constant per order.

EOQ can be carrying with the help of a mathematical formula. Following assumptions are and implied in the calculation:

1. Demand for the product is constant and uniform throughout the period,
2. Lead time (time from ordering to receipt) constant,
3. Price per unit of product is constant,
4. Inventory holding cost is based on average inventory,
5. Ordering costs are constant, and
6. All demands for the product will be satisfied (no back orders are allowed).

In constructing any inventory model, the first step is to develop a functional relationship between the variables of interest and the measure of effectiveness. As we are concerned with cost here, the following equation would pertain:

$$\text{Total Annual Cost} = \text{Annual Purchase Cost} + \text{Annual Ordering Cost} + \text{Annual Holding Cost}$$

$$TC = DC + \frac{D}{Q}S + \frac{Q}{2}H$$

Where, TC = Total cost

D = Annual Demand

C = Purchase cost per unit

Q = Quantity to be ordered (the optimum amount is termed the EOQ or Q opt).

S = Cost of placing an order

H = Holding cost per unit of average inventory per annum. [C × percent carrying]

I = Cost of carrying inventory as percentage.

Annual demand is known and constant for a year.

On the right hand side of the equation, DC is the annual purchase cost for the units, (D/Q)S is the annual ordering cost (the actual number of orders placed, D/Q, times the cost of each order, S), and (Q/2) H is the annual holding cost (the average inventory, Q/2, times the cost per unit for holding and storage, H). These cost relationships are shown graphically in *Exhibit 23.4*.

The second step in the model development is to calculate order quantity Q, for which, the total cost is the minimum. In the basic model, this may be done by simple algebra if we recognise that DC is not a decision variable and hence not a factor in the ordering decision. Then, with reference to *Exhibit 23.4,* total cost is minimum at the point where, the cost of ordering is equal to the cost of carrying, or

$$\frac{D}{Q}S = \frac{Q}{2}H$$

Which in turn is solved as follows :

$$DS = \frac{Q^2}{2}H \quad \text{or} \quad 2DS = Q^2H \quad \text{or} \quad Q^2 = \frac{2DS}{H}$$

$$Q \text{ (optimum) or EOQ} = \sqrt{\frac{2DS}{H}}$$

When more complex cost equations are involved, this single algebraic approach will not suffice and different calculus must be employed.

EOQ technique is highly useful in as much it answers the question of how much to order and in so doing establishes the frequency with which orders are placed. EOQ is applicable to both single items and to any group of stock items with similar holding and procurement costs. Its use causes the sum of the two costs to be lower than under any other system of replenishment.

Weaknesses of EOQ Formula

1. ***Erratic Usages :*** The formulae we have used assume that usage of materials is both predictable and evenly distributed. When this is not the case, the formulae are useless. Different and far more complex formulae can be developed for wide swings in usage, so long as these swings can be predicted. But if usage varies unpredictably, as it often does, no formula will work well.

2. ***Faulty Basic Information :*** EOQ calculations are only as accurate as the order cost and carrying cost information in which they are based. It is no easy job to calculate order cost. In practice, order cost varies from commodity to commodity. Carrying cost can vary with the company's opportunity cost of capital.
3. ***Costly Calculations :*** It is not easy job to estimate cost of acquisition and cost of possession accurately. This requires hours of work by skilled cost accountants. Actual calculation of EOQ can be time-consuming even when the simple formulae for steady usage are used. More elaborate formulas are even more expensive. In many cases, the cost of estimating, cost of possession and acquisition and calculating EOQ exceeds the savings made by buying that quantity.
4. ***No Formula is Substitute for Commonsense :*** It is therefore desirable to include a number of modifiers. The formula may suggest that we order six years supply, based on the assumption that we will continue to require the item at the same rate for the next six years. The modifier is a 'maximum', limit, not more than one year's supply, or two year's supply perhaps. It may suggest that we order every week, for these volumes we would adopt a different ordering method. It may suggest that we order very small quantities, unacceptable to the supplier or penalised by small quantity extras. The modifier here would be 'minimum' limit. Some items are best ordered jointly from a single source, if they are bought out, or ordered at the same time from the works in the case of made-in items to save on set-up time or for some other reason. *'Order with'* would be the modifier.
5. ***EOQ Ordering Must be Tempered with Judgement :*** Certain corporate operating goals must be followed in managing an inventory. Sometimes, the guidelines provide a conflict in ordering. Where an order strategy conflicts with an operating goal, order strategy restrictions should be developed to permit honouring the goal. EOQ restrictions might include the following:
   - Items purchased to order, and items subject to rapid product improvement will be restricted from EOQ use.
   - Shelf life items (those goods only for a specific length of time) should be restricted to a quantity not greater than one fourth of their age limitation.
   - Items with unusual sales will be identified, with annual sales reduced by appropriate quantities, prior to calculating EOQ.
   - Critical supply items (those having most effect on customer's service), will be ordered in greater than normal quantities. The time supply quantities selected will over-ride EOQ.

Order Point Problem

After determination of EOQ, then at what level should the order be placed? If the inventory level is too high it will be unnecessary blocks the capital, and if the level is too low, it will disturb production by frequent stock out and also involves high ordering cost. Hence, an efficient management of inventory needs to maintain optimum inventory level, where there is no stock out and the costs are minimum. The different stock levels are *(a)* Minimum level (safety stock), *(b)* Reorder level, *(c)* Maximum level, *(d)* Average stock level, and *(e)* Dangers level.

Minimum stock level that need to be maintained for smooth production.

(a) Minimum Level : Minimum stock is that level that must be maintained always for smooth production. How to fix minimum level? While determination of minimum stock level, lead time, consumption rate, material nature must be considered.

- *Lead-time* is the taken to receive the delivery after placing order with the supplier. In other wards, the number of days required to receive the inventory from the date of placing order. Lead time also called as procurement time of inventory.
- *The average quantity of raw materials consumed daily*. The consumptions rate is calculated based on the past experience and production plan.
- *Requirement of materials for normal or regular production or special order production*. If the material is required for special order production, then the minimum stock level need not maintain.

Formula for Calculation Minimum Stock Level

Minimum stock level = Re-order level – [Normal usage × Average delivery time]
(sabet, stak)

(b) Reorder level : Reorder level is that level of inventory at which an order should be placed for replenishing the current stock of inventory. Generally the reorder level lies between minimum stock levle and maximum stock level.

Reorder level : Is the stock level at which an order should be place.

Re-order point = Lead time (in days) × Average Daily usage

The above formula is based on the assumption that consistent daily usage and fixed lead-time.

Safety stock : Prediction of average daily usage and lead-time is difficult. Raw materials may vary from day to day or from week to week, it is the case for lead-time also. Lead-time may be delayed if the usage increases, than the company faces problem of stock out. To avoid stock out firm may require to maintain safety stock. Formula (under uncertainity of usage and lead time).

Re-order point = Lead time (in days) × Average usage) + Safety stock

(c) Maximum level : Maximum level of stock, is that level of stock beyond which a firm should not maintain the stock. If the firm stocks inventory beyond the maximum stock level it is called as overstocking. Excess inventory (overstock) involves heavy cost of inventory because it blocks firms funds in inventory, excess carrying cost, wastage, obsolescence and theft cost. Hence, firm should not stock above the maximum stock level. Safety stock is that minimum additional inventory to serve as a safety margin or better or buffer or cushion to meet an unanticipated and increase in usage resulting from an unusally high demand and or an uncontrollable late receipt of incoming inventory.

Maximum level : The level of stock beyond which a firm should not maintain the stock.

Maximum stock level = Reorder-level + Reorder quantity
– (Minimum usage × Minimum delivery time)

(d) Average stock level :

Average stock level = (Minimum level + Maximum level)/2

Minimum-Maximum Technique

The minimum-maximum system is often used in connection with manual inventory control systems. The minimum quantity is established in the same way as any re-order point. The maximum is the minimum quantity plus the optimum lot size. In practice, a requisition is initiated when a withdrawal reduces the inventory below the minimum level, the order quantity is the maximum minus the inventory status after the withdrawal. If the final withdrawal reduces the stock level substantially below the minimum level, the order quantity will be longer than the calculated EOQ.

The effectiveness of a minimum-maximum system is determined by the method and precision with which the minimum and maximum parameters are established. If these parameters are based upon arbitrary judgements with a limited factual basis, the system will

be limited in its effectiveness. If the minimum are based on an objective rational basis, the system can be very effective.

Two-Bin Technique

Two-bin technique, in which order is placed when one bin inventory is used.

One of the oldest systems of inventory control is the two-bin system which is mainly adopted to control 'C' group inventories. In the two-bin system, stock of each item is separated into two bins. One bin contains stock, just enough to last from the date a new order is placed until it is received in inventory. The other bin contains a quantity of stock enough to satisfy probable demand during the period of replenishment. To start with the stock is issued from the first bin. When the first bin is empty an order for replenishment is placed, and the stock in the second bin is utilised until the ordered material is received.

Such a method is appropriate to ideal conditions in which rate of consumption is fairly constant and for items lead time of which is fairly established and regular.

Although the system itself possesses a high degree of automacy, in practice, we need to allow for variations in the rate of consumption as well as lead time. However, for such a system the most desirable quantity to re-order is the EOQ. Since the quantity to re-order is fixed in advance, initiation of replenishment action can be delegated to lower level staff and there is need to take physical count of inventory also.

A possible disadvantage of the system in some case is the requirement of additional storage facilities and perhaps some practical difficulty in keeping the two stocks properly separated.

MEASUREMENT OF THE EFFECTIVENESS OF INVENTORY MANAGEMENT

Like purchasing and stores, the performance of inventory management should be measured to ensure that the functions of inventory management are effectively carried on. Traditional indicators, like the number of months' holdings in stores as compared to budgeted consumption, or number of months' finished goods inventory *vis-a-vis* budgeted sales, serve as broad, over-all signals for bankers or top management, but are not adequate for functional managers, who are most concerned with sorting out day-to-day problems of co-ordination in respects of materials, and matching production or despatch schedules with commitments. So, in addition to the traditional methods, there is the felt need for developing a further set of indicators, which relate organisational goals to departmental goals. The following are some of the performance indicators of inventory management.

1. Overall inventory turnover ratio $= \dfrac{\text{Cost of goods sold}}{\text{Average inventory at cost}}$

2. Raw materials inventory turnover ratio $= \dfrac{\text{Annual consumption of raw materials}}{\text{Average raw materials inventory}}$

3. Work - in - process inventory turnover ratio $= \dfrac{\text{Cost of manufacture}}{\text{Average w - i - p inventory at cost}}$

4. Finished goods inventory turnover ratio $= \dfrac{\text{Cost of goods sold}}{\text{Average finished goods inventory at cost}}$

5. Week's inventory of raw materials on hand $= \dfrac{\text{Raw materials inventory on hand}}{\text{Weekly consumption of raw materials}}$

6. Week's raw material on order $= \frac{\text{Raw materials on order}}{\text{Weekly consumption of raw materials}}$

7. Week's inventory of finished goods on hand $= \frac{\text{Finished goods inventory}}{\text{Weekly sale of finished goods}}$

8. Average age of raw materials in inventory $= \frac{\text{Average raw materials inventory at cost}}{\text{Average daily purchase of raw materials}}$

9. Average age of finished goods inventory $= \frac{\text{Average finished goods inventory at cost}}{\text{Average cost of goods manufactured per day}}$

10. Out of stock index $= \frac{\text{Number of times out of stock}}{\text{Number of times requisitioned}}$

11. Spare parts index $= \frac{\text{Value of spare parts inventory}}{\text{Value of capital equipment}}$

SOLVED PROBLEMS

1. *A company's books of accounts revealed the following*

Staff salaries of purchase department = *Rs. 2,50,000*

Expenses incurred in ware-house personnel salaries = *Rs. 2,75,000*

Cost of security for ware house = *Rs. 80,000*

Travelling and purchase follow up expenses = *Rs. 80,000*

Taxes and insurance = *1.0% p.a.*

Interest rate on inventory value = *20% p.a.*

Cost of bills payment = *Rs. 30,000*

Cost of materials handling in store = *Rs. 1,50,000*

Obsolence and pilferage = *Rs. 20,000*

Cost of inwards inspection = *Rs. 48,000*

The company has an average inventory of Rs. 60 lakhs and has placed 3,400 orders in the year of review. Calculate the cost per order and inventory carrying the cost as percentage based on the above costs. What would be the EOQ, if the annual demand of an item is 12,000 numbers and unit price is Rs. 60 per unit.

Solution :

In order to calculate the ordering cost/acquisition cost per order and the inventory carrying cost as a percentage of the value of average inventory, it is necessary to bifurcate the various items of cost data under two heads *viz.*, ordering cost and inventory carrying cost as below.

Ordering Cost (Rupees)		**Inventory Cost (Rupees)**	
(a) Staff salaries of purchase department	2,50,000	(a) Expenses incurred in warehouse personnel salaries	2,75,000
(b) Travelling & purchase follow up expenses	80,000	(b) Cost of security for wareshouse	80,000

(c) Cost of bills of payment = 30,000

(d) Cost of in-ward inspection = 48,000

Total 4,08,000

$$\text{Ordering cost per order } (C_0) = \frac{\text{Total ordering cost}}{\text{No. of orders per year}}$$

$$= \frac{4,08,000}{3,400}$$

$$= \textbf{Rs. 120}$$

(c) Taxes and insurance @1% $= \frac{1}{100} \times 60,00,000$

$= 60,000$

(d) Interest @20% of the value of average inventory $= \frac{20}{100} \times 60,00,000$

$= 12,00,000$

(e) Cost of materials handling in store $= 1,50,000$

(f) Obsolescence and handling in store $= 20,000$

Total inventory carrying cost $= 17,85,000$

$$\text{Inventory carrying charges } (C_i) = \frac{17,85,000}{60,00,000} \times 100$$

$$= \textbf{29.75\%}$$

Calculation of E.O.Q. :

Annual demand (D) = 12,000 units

Unit price (P) = Rs. 60

$$\text{E.O.Q.} = \sqrt{\frac{2 \times \text{Annual demand (units)} \times \text{Ordering cost per order}}{\text{Unit price} \times \text{Inventory carrrying charges (as \%)}}} = \sqrt{\frac{2DC_o}{PC_i}}$$

$$= \sqrt{\frac{2 \times 12,000 \times 120}{60 \times 0.2975}} = 401.67 = 402 \text{ units}$$

2. *An auto industry purchases spark plugs at the rate of Rs. 25 per piece. The annual consumption of spark plug is 18,000 no's. If the ordering cost is Rs. 250 per order and carrying cost is 25% p.a, what would be the EOQ? If the supplier of spark plugs offers a discount of 5% for order quantity of 3,000 no's per order, do your accept the discount offer?*

Solution :

(a) Calculation of EOQ :

Annual demand (D) = 18,000 nos.

Unit price (C) = Rs. 25

Ordering cost per order (S) = Rs. 250

Carrying charges (as %) (O) = 25%

$$\text{EOQ} = \sqrt{\frac{2DS}{C \cdot i}} = \sqrt{\frac{2 \times 18,000 \times 250}{25 \times 0.25}}$$

$$= \sqrt{\frac{90,00,000}{6.25}} = 1,200 \text{ units}$$

(b) Decision regarding discount offer for Q = 3000

(i) EOQ option :

$$\left.\begin{matrix}\text{Total cost of materials plus}\\ \text{cost on materials per annum}\end{matrix}\right\} = DP + \frac{D}{Q}S + \frac{Q}{2}C \cdot i$$

$$= 18,000 \times 25 + \frac{18,000}{1,200} \times 250 + \frac{1,200}{2} \times 25 \times \frac{25}{100}$$

$$= 4,50,000 + 3,750 + 3,750$$

$$\text{Total cost } TC_{(EOQ)} = \text{Rs. } 4,57,500$$

(ii) Discount option :

Discount offered for order qty. (Q_1) of 3,000 nos. = 5% of unit price

New price after discount, $P_1 = 25 \times 0.95 = \text{Rs. } 23.75$

$$\left.\begin{matrix}\text{Total cost of materials plus}\\ \text{cost on materials } TC_{(Discount)}\end{matrix}\right\} = DP_1 + \frac{D}{Q_1}S + \frac{Q_1}{2}C_1 \cdot i$$

$$= 18,000 \times 23.75 + \frac{18,000}{3,000} \times 250 + \frac{3,000}{2} \times 23.75 \times 0.25$$

$$= 4,27,500 + 1,500 + 8,906.25$$

$$TC_{(Discount)} = \text{Rs. } 4,37,906.25$$

(iii) Decision rule :

If TC (Discount) $\leq$ TC (EOQ) $\rightarrow$ Accept discount

If TC(Discount) $>$ TC(EOQ) $\rightarrow$ Reject discount offer

5% discount offer on unit price for ordering 3,000 nos. per order is acceptable.

Since $TC_{(Discount)}$ (*i.e.*, 4,37,906.25) is less than TC_{EOQ} (*i.e.*, 4,57,500).

3. *The ABC Fun novelty company buys 80,000 shipping container per year. Price of each container is Rs. 0.40. Cost of purchase Rs. 80 per order, cost of holding one container per year Re. 0.10. Bank rate of interest 15% including a charge for taxes and insurance. Find*

(i) the economic order quality and time between orders based on 220 working days per year.

(ii) the minimum variable cost per year.

(iii) if the company had been following a policy of quarterly ordering, what would have been the increase in the variable cost?

Solution :

Annual demand (D) = 80,000 units

Unit price (C) = Re. 0.40

Ordering cost per order (S) = Rs. 80

Holding cost per item per year = Re. 0.10

$$\left.\begin{matrix}\text{Bank rate of interest including}\\ \text{charge for taxes and insurance}\end{matrix}\right\} = 15\% \text{ of unit price}$$

$$= \frac{15}{100} \times 0.40 = \text{Re. } 0.06$$

$$\left.\begin{matrix}\text{Inventory carrying cost}\\ \text{per item per year}\end{matrix}\right\} C_c = 0.10 + 0.06 = \text{Re. } 0.16$$

Calculation of EOQ :

$$(i)\ \text{EOQ} = \sqrt{\frac{2DS}{C \cdot i}} = \sqrt{\frac{2 \times 80{,}000 \times 80}{0.16}} = 8944.27 = 9{,}000 \text{ nos.}$$

Calculating of time between orders based on 220 working days per year:

$$\left.\begin{matrix}\text{Time between order}\\ \text{(in days)}\end{matrix}\right\} = \frac{\text{No. of working days per year}}{\text{No. of orders per year (N)}}$$

$$\left.\begin{matrix}\text{No. of orders per}\\ \text{year (N)}\end{matrix}\right\} = \frac{\text{Annual demand (D)}}{\text{EOQ (Q)}}$$

$$N = \frac{D}{Q} = \frac{80{,}000}{9{,}000} = 8.88 = 9 \text{ orders}$$

$$\text{Time between order} = \frac{220}{9} = 24.44 \text{ days} = 24 \text{ days}$$

(ii) Calculation of minimum variable cost per year :

Variable cost comprises ordering cost per year and inventory carrying cost per year and this would be minimum when the order qty. equals economic order qty. (*i.e.,* EOQ).

$$\left.\begin{matrix}\text{Miniumum variable}\\ \text{cost per year}\end{matrix}\right\} = \begin{matrix}\text{Ordering cost}\\ \text{per year}\end{matrix} + \begin{matrix}\text{Inventory carrying}\\ \text{cost per year}\end{matrix}$$

$$= \begin{pmatrix}\text{No. of}\\ \text{orders}\end{pmatrix} + \begin{pmatrix}\text{Ordering}\\ \text{cost per order}\end{pmatrix} + \begin{pmatrix}\text{Average}\\ \text{inventory}\\ \text{units}\end{pmatrix} + \begin{pmatrix}\text{Inventory}\\ \text{carrying cost /}\\ \text{unit / year}\end{pmatrix}$$

$$= (9 \times 80) + \left(\frac{9{,}000}{2}\right) \times 0.16 = 720 + 720 = \text{Rs. } 1{,}440$$

(iii) Policy of quarterly ordering (ordering once in 3 months)

$$\text{No. of orders per year} = \frac{12}{3} = 4$$

$$\text{Order Qty. per order} = \frac{80{,}000}{4} = 20{,}000 \text{ units}$$

$$\text{Ordering cost per year} = 4 \times 80 = \text{Rs. } 320$$

$$\text{Inventory carrying cost per year} = \frac{20{,}000}{2} \times 0.16 = \text{Rs. } 1600$$

$$\text{Total variable cost per year} = 320 + 1{,}600 = \text{Rs. } 1920$$

$$\left.\begin{matrix}\text{Increase in the variable cost as}\\ \text{compared with that of EOQ ordering}\end{matrix}\right\} = 1{,}920 - 1{,}440 = \text{Rs. } 480$$

4. *Determine safety stock, reserve stock and buffer stock for the data given below :*

Normal usage = 100 per week

Lead time = 4 to 6 weeks

Minimum usage = 50 per week

Maximum usage = 150 per week

Re-order quantity = 600 nos

Also calculate the Re-order level, minimum and maximum levels of inventory and also average inventory level.

Solution :

$$\text{Buffer stock (BS)} = \left(\begin{matrix}\text{Average}\\ \text{lead time}\end{matrix}\right) \times \left(\begin{matrix}\text{Average}\\ \text{usage rate}\end{matrix}\right)$$

$$= 5 \times 100 = 500 \text{ nos.}$$

Safety stock is for usage at normal rate during the extension of lead time.

Max extension of lead time = 6 – 5 = 1 week

Normal usage rate = 100 per week

Safety stock (SS) = (6 – 5) × 100 = 100 nos

Reserve stock is to meet the excess usage requirement during normal lead time.

Excess usage requirement = 150 – 100 = 50 per week

Reserve stock (RS) = 5 × 50 = 250 nos

Re-order level = S.S.+ R.S. + B.S

= 100 + 250 + 500 = 850 nos.

Minimum inventory level = S.S.+ R.S. = 100 + 250 = 350 nos.

$$\text{Max inventory level} = \left(\begin{matrix}\text{Minimum}\\ \text{level}\end{matrix}\right) \times \left(\begin{matrix}\text{Order}\\ \text{quantity}\end{matrix}\right)$$

$$= 350 + 600 = 950 \text{ nos.}$$

$$\text{Average inventory level} = \frac{\text{Min. level} + \text{Max. level}}{2}$$

$$= \frac{350 + 950}{2} = 650 \text{ nos.}$$

5. *A company uses 1,200 units per month of an electronic component each costing Rs. 2. Placing each order costs Rs. 50 and the carrying cost is 6% per year of the average inventory.*

(i) Find EOQ.

(ii) If the company gets 5% discount if it places single order, should they accept the discount offer?

(iii) Find break even discount percentage which matches EOQ ordering.

Solution :

Annual demand for the component (D) = 1200 × 12 = 14,400 nos.

Unit price of the component (C) = Rs. 2

Ordering cost per order (S) = Rs. 50

Inventory carrying charges per year (i) = 6%

(i) Determination of EOQ :

$$EOQ = \sqrt{\frac{2 \times 14{,}400 \times 50}{2 \times 0.06}} = 3{,}464 \text{ units}$$

$$\text{No. of orders per year} = \frac{14{,}400}{3{,}464} = 4.15 = 4$$

$$\text{Modified EOQ} = \frac{14{,}400}{4} = 3{,}600$$

$$\text{Total cost for EOQ ordering} = \begin{pmatrix}\text{Cost of}\\ \text{materials / year}\end{pmatrix} + \begin{pmatrix}\text{Ordering}\\ \text{cost}\\ \text{per year}\end{pmatrix} + \begin{pmatrix}\text{Inventory}\\ \text{carrying}\\ \text{cost per year}\end{pmatrix}$$

$$TC_{(EOQ)} = DP + \frac{D}{Q} S + \frac{Q}{2} C \cdot i$$

$$= 14{,}400 \times 2 + \frac{14{,}400}{3{,}600} \times 50 + \frac{3{,}600}{2} \times 2 \times 0.06$$

$$= 28{,}800 + 200 + 216 = \text{Rs. } 29{,}216$$

(ii) Decision regarding discount offer of 5%

$$\text{Discounted unit price (C)} = 2 \times 0.95 = \text{Rs. } 1.90$$

$$\left.\begin{matrix}\text{Order qty. to avail}\\ \text{discount } (Q_1)\end{matrix}\right\} = 14{,}400 \text{ nos. } (i.e., \text{ single order per year})$$

$$\left.\begin{matrix}\text{Total cost under}\\ \text{discount offer}\end{matrix}\right\} = T.C._{(Disc)}$$

$$T.C._{(Disc)} = DC_1 + \frac{D}{Q_1} S + \frac{Q_1}{2} C_1 \cdot i$$

$$= 14{,}400 \times 1.90 + \frac{14{,}400}{14{,}400} \times 50$$

$$+ \frac{14{,}400}{2} \times 1.90 \times 0.06$$

$$= 27{,}360 + 50 + 820.80 = \text{Rs. } 28{,}230.80$$

Since, $TC_{(Disc)} < TC_{(EOQ)}$, the decision is to accept the discount offer of 5% on unit price.

(iii) Determination of break even discount percentage which matches EOQ ordering.

Let x be the new discounted price to match EOQ ordering.

$$\text{Then, total cost } T.C._{(BE/Disc)} = D(x) + \frac{D}{Q_1} S + \frac{Q_1}{2} (x)\, i$$

$$T.C._{(BE/Disc)} = 14{,}400\,(x) + \frac{14{,}400}{14{,}400} \times 50 + \frac{14{,}400}{2} \times (x) \times 0.06$$

$$= 14{,}400x + 50 + 432x = 14{,}832x + 50$$

$$T.C._{(BE/Disc)} = T.C._{(EOQ)}$$

$$i.e., \quad 14832x + 50 = 29{,}216$$

$$14832x = 29,216 - 50 = 29,166$$

$$\therefore \quad x = \frac{29,166}{14,832} = 1.966$$

$$\text{Break even \% discount} = \left(\frac{C - x}{C}\right) \times 100 = \left(\frac{2 - 1966}{2}\right) \times 100 = 1.7\%$$

6. *A factory uses annually 24,000 units of a raw material which costs Rs. 1.25 per unit. Placing each order costs Rs. 25 and carrying cost is 6% per year of the average inventory.*

(a) Find the economic order quantity and the total inventory cost including the cost of material.

(b) The factory works for 320 days a year. If the procurement time is 10 days and safety stock is 450 units, find the re-order point, the minimum, maximum and average inventories.

Solution :

Annual demand (D) = 24,000 nos.

Unit price (C) = Rs. 1.25

Ordering cost per order (i) = Rs. 25

Inventory carrying charges per year (C_i) = 6%

(a) $$EOQ = \sqrt{\frac{2 \times 24,000 \times 25}{1.25 \times 0.06}}$$

EOQ = 4,000 units

Total cost = Cost of materials + Cost on materials

$$= \left(\begin{matrix}\text{Cost of materials} \\ \text{per year}\end{matrix}\right) + \left(\begin{matrix}\text{Ordering cost} \\ \text{per year}\end{matrix}\right) + \left(\begin{matrix}\text{Inventory carrying} \\ \text{cost per year}\end{matrix}\right)$$

$$= DP + \frac{D}{Q} S + \frac{Q}{2} C \cdot i$$

$$= 24,000 \times 1.25 + \frac{24,000}{4,000} \times 25 + \frac{4,000}{2} \times 1.25 \times 0.06$$

$$= 30,000 + 150 + 150$$

Total cost = Rs. 30,300

(b) If the factory works for 320 days a year,

$$\text{Consumption rate per day} = \frac{\text{Annual demand}}{\text{No. of working days per year}}$$

$$= \frac{24,000}{320} = 75 \text{ units}$$

Safety stock = 450 units

Procurement lead time = 10 days

Buffer stock i.e., lead time consumption = Lead time × Consumption rate

Re-order point (or re-order level) = Safety stock + Buffer stock

= 450 + 750 = 1,200 units

$$\text{Minimum inventory level} = \text{Safety stock} = 450 \text{ units}$$

$$\text{Maximum inventory level} = \left(\begin{matrix}\text{Minimum inventory}\\ \text{level}\end{matrix}\right) + \left(\begin{matrix}\text{Order qty.}\\ \text{(i.e., EOQ)}\end{matrix}\right)$$

$$= 450 + 4{,}000 = 4{,}450 \text{ units}$$

$$\text{Average inventory level} = \frac{\text{Min. inventory level} + \text{Max. inventory level}}{2}$$

$$= \frac{450 + 4{,}450}{2} = \frac{4{,}900}{2} = 2{,}450 \text{ units}$$

7. *XYZ Company uses fixed period replenishment system for planning its inventory of consumable material for one such item, the average consumable material. For one such item the average consumption is 120 units/month, lead time for procurement is 6 months and review period is 3 months.*

Work out the replenishment level and order quantity at the time of first review, if the stock on hand is 520 units and that on order is 150 units.

Solution :

$$\text{Buffer stock} = \left(\begin{matrix}\text{Normal}\\ \text{consumption rate}\end{matrix}\right) \times \left(\begin{matrix}\text{Normal}\\ \text{lead time}\end{matrix} + \begin{matrix}\text{Review}\\ \text{period}\end{matrix}\right)$$

$$= 120 \times (6 + 3) = 120 \times 9 = 1{,}080 \text{ nos.}$$

There is no need of safety stock and reserve stock as there is no data in the problem regarding extension of lead time and variation in consumption rate.

$$\left.\begin{matrix}\text{Hence, Desired inventory level (DIL)}\\ \text{or Target inventory level (TIL)}\end{matrix}\right\} = \left(\begin{matrix}\text{Buffer stock}\\ \text{+ Research stock}\\ \text{+ Safety stock}\end{matrix}\right)$$

$$= 1{,}080 + \text{Nil} + \text{Nil} = 1{,}080 \text{ units}$$

$$\left.\begin{matrix}\text{In fixed order period system, the}\\ \text{order quantity at a review period}\end{matrix}\right\} = \text{DIL} - \text{Virtual stock}$$

$$\text{Virtual stock} = \left(\begin{matrix}\text{Stock on hand}\\ \text{+ Stock on order}\end{matrix}\right)$$

$$\left.\begin{matrix}\text{At first review}\\ \text{virtual stock}\end{matrix}\right\} = 520 + 150 = 670 \text{ units}$$

$$\text{Hence order quantity} = 1{,}080 - 670 = 410 \text{ nos.}$$

$$\left.\begin{matrix}\text{Replenishment or Desired}\\ \text{inventory level}\end{matrix}\right\} = 1{,}080 \text{ units.}$$

8. Compute the EOQ given the following information.

No. of units bought at a time	Price per unit (Rs.)
Less than 1000	10.00
1000 to 2999	9.85
3000 and above	9.70

The order cost is Rs. 60 per order and carrying cost is 20% of the price.

The annual estimated demand for the item is 6,000 units.

Solution :

For unit price of Rs. 10/- we compute the economic order quantity (EOQ) as shown below:

$$EOQ = \sqrt{\frac{2 \times 6000 \times 60}{10 \times 0.2}} = \sqrt{36 \times 10^4} = 100 \times \sqrt{36} = \textbf{600 units}$$

$$\text{Number of orders per year} = \frac{6000}{600} = 10 \text{ orders}$$

$$\text{Ordering cost per year} = 60 \times 10 = \text{Rs. } 600/-$$

$$\text{Average inventory} = \frac{600}{2} = 300 \text{ units}$$

$$\text{Inventory carrying cost per year} = 300 \times 10 \times 0.2 = \text{Rs. } 600/-$$

$$\text{Total inventory cost} = \text{Rs. } 600 + \text{Rs. } 600 = \text{Rs. } 1200$$

$$\text{Discount per year} = \text{Nil}$$

$$\text{Purchase cost of materials per year} = 6000 \times 10 = \text{Rs. } 60{,}000/-$$

$$\left.\begin{matrix}\text{Total cost per year including cost} \\ \text{of materials and cost on materials}\end{matrix}\right\} = 60{,}000 + 1200 = \text{Rs. } 61{,}200/-$$

Next we consider various options of ordering e.g., number of orders ranging from one to nine per year and compute the total cost per year including the cost of materials and choose the option (i.e., number of orders) for which the total annual cost is the minimum. These calculations are tabulated below:

No. of Orders	1	2	3	4	5	6	7	8	9	10
Order Size	6000	3000	2000	1500	1200	1000	857	750	667	600
Unit Price (Rs.)	9.70	9.70	9.85	9.85	9.85	9.85	10	10	10	10
Average Inventory	3000	1500	1000	750	600	500	429	375	334	300
Annual Ordering Cost (Rs.)	60	120	180	240	300	360	420	480	540	600
Annual Inventory Carrying Cost (Rs.)	5,820	2,910	1,970	1,478	1,182	985	858	750	668	600
Cost of Materials per year	58,200	58,200	59,100	59,100	59,100	59,100	60,000	60,000	60,000	60,000
Total Annual Cost	64,080	61,230	61,250	60,818	60,582	60,445 min.	61,278	61,230	61,208	61,200

It is observed from the above table that EOQ = 1000 results in lowest total annual cost of Rs. 60,445 and the decision is to order a lot size of 1000 units per order.

9. *From the following data draw an ABC analysis graph after classifying A, B & C class items.*

Item	Unit Price	Annual Consumption (units)
1	200.0	3,000
2	2.0	60,000
3	5000.0	20
4	12.5	200
5	9.0	350
6	25.0	6,000
7	1000.0	40
8	70.0	300

Solution :

Step No. 1 : Determination of annual consumption value:

Item	[Annual Consumption (units) × Unit price (Rs.)]	Annual Consumption value (Rs.) (ACV)
1	3000 × 200	6,00,000
2	60,000 × 2	1,20,000
3	20 × 5000	1,00,000
4	12.5 × 200	2,500
5	9 × 350	3,150
6	25 × 6000	1,50,000
7	1000 × 40	40,000
8	70 × 300	21,000

Step No. 2 : Re-arrange the item in the descending order of annual consumption value and calculate cumulative ACV.

Item	Annual Consumption Value (ACV) in descending order	Cumulative ACV	
1	6,00,000	6,00,000	A
6	1,50,000	7,50,000	
2	1,20,000	8,70,000	B
3	1,00,000	9,70,000	
7	40,000	10,10,000	C
8	21,000	10,31,000	
5	3150	10,34,150	
4	2500	10,36,650	
	10,36,650		

Step No. 3 : Since the basis for ABC classification is not given in the problem, assume the following basis.

Category	Percentage of total ACV
A	70
B	20
C	10

70% of Total ACV = 0.70 × 10,36,650 = 7,25,655

Since this value is near to cumulative ACV of Rs. 7,50,000, categorize items 1 and 6 under 'A' category.

(A + B) together account for 90% of ACV.

90% ACV = 0.9 × 10,36,650 = Rs. 9,32,985

Since this value is nearer to cumulative ACV of Rs 9,70,000 categorize items 2 and 3 under 'B' category. The remaining items, 7, 8, 5 and 4 are categorized under 'C' category.

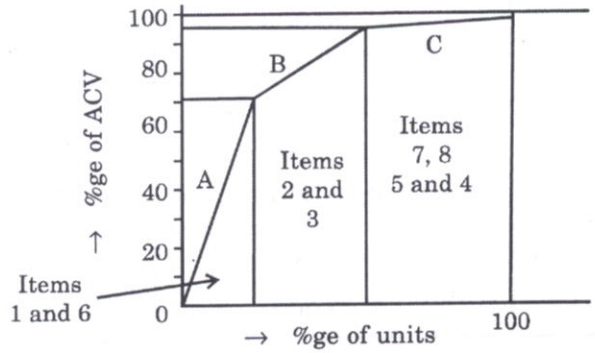
Step No. 4 : Construction of ABC analysis graph

$$\text{Exact \%age of ACV of 'A' category items} = \frac{7,50,000}{10,36,650} \times 100 = 72.34\%$$

Exact %age of (A + B) items $= \frac{9,70,000}{10,36,650} \times 100 = 93.57\%$

%age of ACV of 'B' item = 93.57 – 72.34 = 21.23%

%age of ACV of 'C' item = 100 – 93.57 = 6.43%



10. *The following data is available on consumption pattern of certain materials in an organisation.*

Group	No. of Items	Monthly Consumption (units)	Price Item (Rs.)
I	40	3000	9
II	20	270	100
III	100	1700	5
IV	200	1500	4
V	60	340	50
VI	300	2500	1
VII	250	2000	2
VIII	30	170	500

Find out A, B, C items when

'A' item account for 85% of consumption value.

'B' item account for 10% of consumption value.

'C' item account for 5% of consumption value.

Solution :

Step No. 1 : Calculation of Monthly Consumption Value (MCV)

Group	No. of Items per group	Monthly Consumption (units)	Unit Price (Rs.)	Monthly Consumption Value (MCV)
I	40	300	90	10,80,000
II	20	270	100	5,40,000
III	100	1700	5	8,50,000
IV	200	1500	4	12,00,000
V	60	340	50	10,20,000
VI	300	2500	1	7,50,000
VII	250	2000	2	10,00,000
VIII	30	170	500	25,50,000
			Total	89,90,000

Step No. 2 : Rearrange the groups in the decreasing order of MCV and calculate cumulative MCV for each group.

Group	MCV in descending order (Rs.)	Cumulative MCV (Rs.)	
VIII	25,50,000	25,50,000	
IV	12,00,000	37,50,000	
I	10,80,000	48,30,000	A
V	10,20,000	58,50,000	
VII	10,00,000	68,50,000	
III	8,50,000	77,00,000	
VI	7,50,000	84,50,000	B
II	5,40,000	89,90,000	C

Step No. 3 : Classifying the group as A, B & C based on MCV

85% of total MCV = 0.85 × 89,90,000 = 76,41,500

Since this value is nearer to cumulative MCV of 77,00,000 the groups VIII, IV, I, V, VII and III are categorized under group 'A'

(A + B) Comprise 95% of MCV

95% of MCV = 0.95 × 89,90,000 = Rs. 85,40,500

Since this value is nearer to 84,50,000, groups VI is under category 'B' and group II is under category 'C'.

QUESTIONS

1. Define the terms 'inventory' and 'inventory management'. Why are inventories held in businesses?
2. Explain the various techniques of inventory control.
3. Bring out the organisational arrangement for invetory control.
4. What do you understand by inventory control? Mention its main objectives.
5. Explain ABC technique of inventory control.
6. State the reasons for carrying the raw materials, work-in-progress and finished goods inventories.
7. Define the following terms :

   (a) Acquisition cost ; (b) Carrying cost ; (c) Stock-out cost ; (d) Over-stocking cost
8. Distinguish between cost of materials and cost on materials?
9. Compare and contrast fixed order quantity inventory system with fixed order period inventory system.
10. What are the effects of low stock holding and high stock holding?
11. Define the terms safety stock, reserve stock, and buffer stock with the help of a diagram and explain the terms minimum stock level, maximum stock level, re-order level, and lead time.
12. Derive Eoq formula for instantaneous supply model. State the assumption on which it is based? What are its limitations?
13. Distinguish between :

   (a) 'Fixed quantity' system and `Fixed period' system of inventory control

(b) 'Fluctuation inventory' and 'Average inventory'
(c) Maximum inventory level and Re-order level.

14. Write short notes on :
(a) Safety stock ; (b) FSN analysis ; (c) Two-bin system ; (d) Inventory turnover ratio

15. "Two basic questions for which answers are sought in an inventory problem are :
(i) When to replenish the inventory and
(ii) How much to order for replenishment". EXplain.

I PROBLEMS

1. For a given item, there is constant demand rate. Annual demand is 60,000 nos. The price per item is Rs. 30. The ordering cost is estimated as Rs. 300 per order and inventory carrying cost is 30% per annum. What should be the optimal ordering quantity? If 2000 units purchased at time, a discount of 5% on unit price, is offered by the supplier. Do you accept this offer?

2. A company uses every month 1500 units of a component costing Rs. 1.20 each. Each purchase order costs Rs. 50 and the inventory carrying cost is 6% per year of the average inventory. Find (a) EOQ (b) If 5% discount is given for a single order placement, is it worth?

3. A company uses monthly 2,500 units of a component costing Rs. 1.5 each Ordering cost is Rs. 50 and the carrying cost is 5% per year of the average inventory.
(i) Calculate EOQ (ii) Should the company accept the offer made by the supplier, a 5% discount on the cost price if the order is placed for the annual demand (iii) At what percentage of discount it breaks even?

4. ABC company manufacturing consumer durables requires 20,000 units of a raw material per annum. The ordering cost is Rs. 300 per order and inventory carrying cost is 30% per annum on average inventory. The purchase price quoted is Rs. 10 per unit if the quantity purchased is less than 5000 units. A quantity discount of 5% on unit price is allowed if 10,000 units are purchased. Do you accept the discount offered by the supplier?

5. For a given item of constant demand rate, the yearly demand is 6025 units. The price of the item per units is Rs. 60. The ordering cost is Rs. 225 per order and the inventory carrying cost is 30% p.a. What is the optimal ordering policy? The vendor offers 1% discount if 1500 units are purchased at a time. Do you accept the discount offer?

6. ABC company proposes to buy an item for which the annual demand is 2,000 units. The ordering cost is estimated at Rs. 25 per order and the inventory carrying costs are charged at 30% p.a. The price schedule quoted by the supplier is as below:

Order Quantity	Price per Unit (Rs.)
1 to 99	50
100 to 499	45
500 & above	40

What is the optimal order quantity?

7. TFG company uses 25,000 nos. of a component per year. It costs Rs. 100 to place and receive an order and carrying cost is 30% of unit price. The supplier quotes the following prices for the component.

Quantity	Unit Price
0 – 499	Rs. 21.60
500 – 999	Rs. 20.95
1000 +	Rs. 20.90

(a) What is the EOQ? (b) What is the minimum total cost? (c) How much time will elaps between orders?

8. A firm has several items of inventory. The average number of each of these items as well a their unit costs are listed below:

Item No.	Average Inventory Units	Average Cost per Unit (Rs)
1	5000	1.50
2	250	10.00
3	450	2.40
4	2000	17.50
5	25	200.00
6	20	160.00
7	300	6.00
8	200	70.00
9	3000	3.00
10	1500	2.50
11	5000	10.00
12	1800	2.00
13	3000	2.20
14	4500	4.00
15	800	1.20

Classify these items as XYZ on the basis that,

X items account for 80% of total inventory value

Y items account for 15% of total inventory value

Z items account for 5% of total inventory value

9. From the following data, classify A, B, & C class items:

Items No.	Unit Price (Rs.)	Annual Consumption (units)
1	200	3,000
2	2	60,000
3	5000	20
4	12.5	200
5	9	35
6	25	6,000
7	1000	400
8	70	300
9	10	1,000
10	5	9,000
11	30	101
12	1000	1

10. Classify the following items into A, B & C category

Sl.	Items	Annual Usage (in kgs)	Price per kg (Rs.)
1	Graphite	4000	10
2	Toluene	800	5
3	Wax	600	10
4	Cap	2000	6
5	Drums	1000 nos.	18 each
6	Oil	150	9
7	Carton	3000 nos.	0.2 each
8	Powder	200	0.5
9	Spirit	400	1
10	Hydrochloric Acid	2500	6
11	Carbon	700	15
12	Nail	5000 Nos.	0.10 each

11. Following details are known for a group of items.

Group No.	No. of Items Group	Average Weekly Consumption/item	Price per Item (Rs.)
I	310	16	4
II	50	5	10
III	50	390	15
IV	240	6	2
V	50	10	8
VI	50	200	10
VII	125	55	5
VIII	125	25	14

Find out A, B,& C items on the assumption that

'A' items account for 80% of the total consumption value

'B' items account for 15% of the total consumption value

'C' items account for 5% of the total consumption value

Calculate the actual percentage of A, B & C items to the total consumption value.

12. Calculate maximum, minimum and re-order stock level from the following information.

Maximum consumption = 2,000 units/week;

Minimum consumption = 1,500 units/week

Maximum lead time = 5 weeks

Minimum lead time = 3 weeks

Re-order quantity = 1,000 units

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