CHAPTER 26

Inventory Management

We introduce this chapter with a couplet from an unknown author.

Stock, stock, beautiful stock
Piles on the fixtures and more in the dock
Some of it ancient and some of it new
Alas, and tomorrow another lot's due.

The couplet beautifully sums up the predicament of all those who are connected with the stock (inventory). What is this inventory? What are its functions? What can be done to minimise this inventory? These and other relevant issues have been discussed in this chapter.

Historical Perspective

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.[1]

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 the 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* 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*'.[2]

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'.[3]

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

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.[5]

As of today, inventories include, among others, raw materials, part-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 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.

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.[6]

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 in tote 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.[7]

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.

Inventory 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:*

(a) Preparing a purchase order.

(b) Processing payments.

(c) Receiving and inspecting the material.

B. *Ordering from the plant:*

(a) Machine set-up.

(b) Start-up scrap generated from getting a production run started.

2. Carrying Costs

A. *Costs connected directly with materials:*
   (a) Obsolescence.
   (b) Deterioration.
   (c) Pilferage.

B. *Financial Costs*
   (a) Taxes.
   (b) Insurance.
   (c) Storage.
   (d) Interest (as the cost of capital borrowed to acquire and maintain the inventories).

G. *Aljian elaborates the carrying costs in greater details as follows:*[8]

Capital Costs

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.

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.*[9]

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 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.[10]

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	2974.61
Closing inventory	3004.30
Average inventory	2989.47
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	$\frac{97.16 \times 100}{2989.47}$
	= 3.25%
+ Interest charges	= 18.00%
Total inventory carrying cost	21.25%

Calculation of ordering cost

	(Rs. In 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
Total items contained in the order	10,800
Therefore cost per item	$\frac{29,16,000}{10,800}$ = Rs.270

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.[11] Because of these numerous interrelationships, inventory management stresses the need for integrated information flow and decision making, as it relates to inventory policies and overall systems.

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*.[12] 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.[13]

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 and consumption pattern keep changing.[22]

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.

Materials requirement planning (MRP).

Just-in-time (JIT).

Inventory Catalogue

Also called inventory directory, inventory catalogue is a pre-requirement for the successful operation of inventory control techniques. The inventory of typical production firm comprises 10,000 to 50,000 different items. A knowledge of each item and the finished product of which each is a part is essential for employing any technique of inventory control.

Inventory catalogue is prepared after all inventory items have been described, classified and coded. Properly maintained inventory directory pays two important dividends.

An inventory catalogue serves, first as a medium of communication. It enables personnel located in many different departments to perform their jobs more effectively. A design engineer, for example, may have a choice between using either of two standard parts in an experimental design; the inventory catalogue quickly tells whether either part is carried in the inventory and may immediately be available for use in experimental work.[23]

A second benefit produced by an inventory catalogue accrues to the inventory control operation staff. This benefit takes the form of more complete and correct records through the reduction of duplicate records for identical parts. A purchasing department often buys the same part from several different suppliers, under various manufacturers and part numbers. Unless control requirements dictate otherwise, identical parts from all suppliers should be consolidated on one inventory record. A simple situation? Perhaps, but one is amazed to find in highly reputable companies, many similar cases in which, two or more inventory records bear different numbers for the same part.[24]

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 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 and expediting, 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.[25] It is for this selective approach, that ABC analysis is often called the Selective Inventory Control Method (SIM).

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 the 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.[26]

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.[27]

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.[28]

Table 26.1 is a typical illustration of the above procedure.

Table 26.1 : Example of ABC Inventory Analysis

Inventory item	*Annual use in Rs.*	*% of total inventory usage in Rs.*
101	3000	0.3%
B 102	40000	4.0% B
103	2000	0.2%
104	10000	1.0%
105	5000	0.5%
A 106	400000	40.0% A
107	7000	0.7%
108	9000	0.9%
109	8000	0.8%
A 110	300000	30.0% A
111	1000	0.1%
B 112	50000	5.0% B
113	15000	1.5%
B 114	20000	2.0% B
B 115	90000	9.0% B
116	8000	0.8%
117	7000	0.7%
118	11000	1.1%
119	9000	0.9%
120	5000	0.5%
Total 20 items	Rs. 10,00,000	100.0%

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

The same information is shown graphically in Fig. 26.3

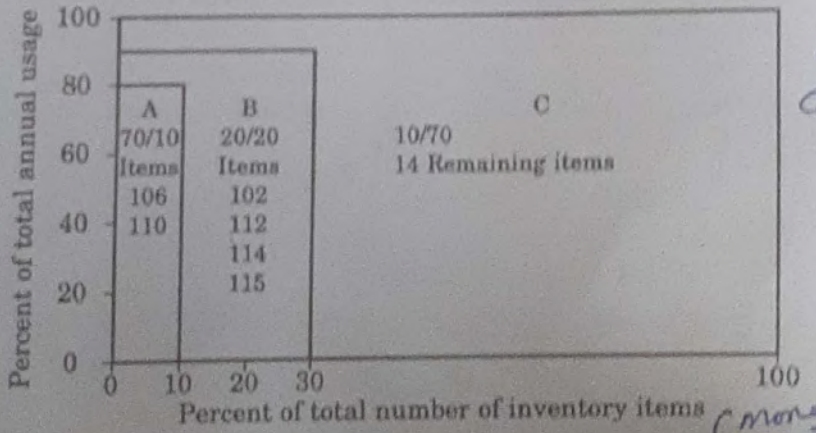


Fig. 26.3 ABC Analysis

Once ABC analysis has been done, the following broad policy guidelines can be established in respect of each category:[29]

Items A	Items B	Items C
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. Ordering 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 many sources as possible for each item	7. Two or more reliable sources	7. Two sources for each 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 efforts	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 (HML) classification follows the same procedure as is adopted in ABC classification. Only difference is that in HML, the classification unit value is the criterion and not the annual consumption value. The items of inventory should be listed in the 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. 2000 and above will be H items, Rs. 1000 to 2000 M items and less than Rs. 1000, L items.

The HML analysis is useful for keeping control over consumption at departmental levels, for deciding the 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, the 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 is 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 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 the lead time analysis and in deciding on purchasing strategies.

FSN Analysis

FSN stands 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 an 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.

Economic Order Quantity

As was explained earlier, under the fixed order quantity system of inventory management, an order for supplies is placed when the existing stock reaches re-order 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 Opt Q (Optimum Quantity) is the order size at which the total cost, comprising ordering cost plus carrying cost, is the least. Fig. 26.4 illustrates the EOQ graphically.

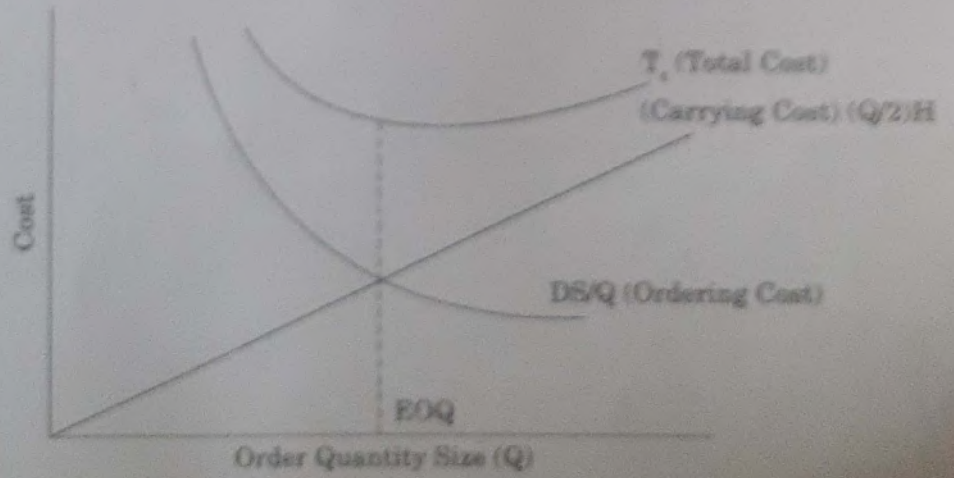


Fig. 26.4 Graphic presentation of EOQ

- Critical supply items (those having most effect on customer's service), will be ordered in greater than normal quantities. The time of supply of quantities selected will over-ride EOQ.[36]

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 higher 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-maximum are based on an objective rational basis, the system can be very effective.[37]

Two-Bin Technique

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 the rate of consumption is fairly constant and for items, the 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 the lower level staff and there is need to take physical count of inventory also.[38]

A possible disadvantage of the system is the requirement of additional storage facilities and perhaps some practical difficulty in keeping the two stocks properly separated.[39]

Materials Requirement Planning (MRP)

The discussion in inventory we had till now, may be called a classical approach to inventory management and control. A somewhat more elaborate and improved approach, called Materials Requirement Planning (MRP), has been developed in recent years and is gaining popularity in industry.

MRP is a new solution to an old problem: having stock of materials always on hand when needed without carrying excess inventory. Highly dependent upon computer technology, MRP is most helpful to firms with finished goods or end products which are made from a number of components and which are also subject to uneven or lumpy demand. The tech separates the various components and co-ordinates purchasing and delivery with prod

This results in materials arriving exactly when needed for production and, at the same time, reduces the length of time when materials are held in stock. MRP plans and controls goods on order and generates data for determining when and what specific materials will be needed to meet the previously planned production schedule.

In its bare essence, MRP operates on the lines as shown in Fig. 26.5. Inputs from management and sales would be customer orders and orders to produce within the company for stock. Basic inventory information would be provided by regular inventory records.

MRP would then co-ordinate the above information with a *bill of material*, usually prepared by production engineers. The bill of materials is not simply a list of parts, but, is 'structured', meaning that, it indicates the manner in which a product is put together from parts into sub-assemblies and then into final assemblies. The items listed can then be time phased and made into a master schedule, which becomes a prime tool of MRP. The *master schedule* can be thought of as a 'production forecast', which in turn can generate material and capacity records over a period of time, taking into account, the inter-dependency of these requirements. As shown in fig. 26.5, MRP, then issues orders for materials either through purchasing or through the internal manufacturing facility.[40]

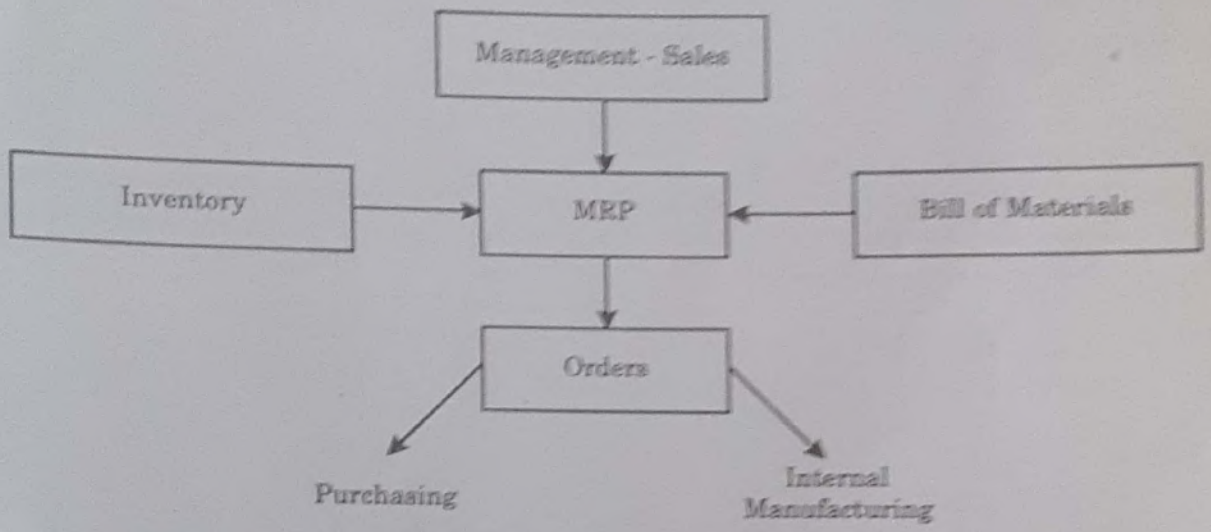


Fig. 26.5 Co-ordinating role of MRP

Just in Time

Popularly known in its acronym JIT, just in time is highly discussed in materials management circles these days. The concept is alternatively known as ZIPS (zero inventory production system), MAN (materials as needed), NOT (nick of time), or ZIN (zero inventories).

As a concept, JIT means that virtually no inventories are held at any stage of production and that the exact number of units is brought to each successive stages of production at the right time.

The JIT concept originated from the Motomachi plant of Toyota in Japan, where the system has been perfected and results achieved. The plant has a long line of trutks waiting outside with full loads of automotive parts and components for the assembly line. As soon as one truck comes out at one end of the plant, another gets inside. There is no warehouse for the parts. Upholstered seats, for example, are fed to the production line directly from the back of the truck.[41]

Xerox, in its bid to catch up with the Japanese standards of efficiency, has implemented the JIT concept. The Rank Xerox plant was purchasing for its use nearly $ 400 million worth materials from 5,000 suppliers. They reduced the number of suppliers to 300 and developed long term relationships with them.

Nearer at home, we have the Maruti Udyog Ltd., where inventories vary from two hours stocks for items like car seats, bumpers and steering systems to a two-month level for nuts and bolts.[42] Then there is the FSL (Food Specialities Ltd.,) which has inventory of finished products of five to six weeks of production.[43]

Though we have instances of companies which have attempted to minimise inventories, they are far and few in between.

The JIT concept assumes certain conditions which are found wanting in our industries. What is required, for example, for its successful implementation is a complete restructuring of the industry, so that all ancillary industries and suppliers of inventory operate in the vicinity of the main industry to avoid problems of transportation. If the suppliers are located at considerable distances and there is more than one supplier, problems in delivery are bound to arise. There should be one supplier and the products supplied must be of the best quality to prevent rejections and consequent delays.[44]

Another pre-requisite for the successful implementation of the ZIN concept is the introduction of redesigned cooling and auxiliaries to achieve rapid change over set-ups in order to reduce the batch sizes.[45]

It will take a long time before companies in our country introduce the ZIN concept. Right now, they do hold inventories (sometimes lasting one year's consumption) and determining optimum inventories is relevant for them.

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, overall signals for bankers or the top management, but are not adequate for functional managers, who are most concerned with sorting out day-to-day problems of co-ordination in respect 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 :[46]

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 = $\frac{\text{Cost of goods sold}}{\text{Average finished goods inventory at cost}}$

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

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

Obsolescence and pilferage = Rs.20,000

Cost of in-wards inspection = Rs.48,000

The company has an average inventory of Rs.60 lakh and has placed 3400 orders in the year of review. Calculate the cost per order and inventory carrying 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.

(P.G.D.M.M./G.D.M.M. Examination, June, 1997).

3. For a given item of constant demand rate of 60,000 units per annum, the unit price is Rs.60/-, the ordering cost per order is Rs.600/- and the carrying cost is 30 percent per annum on average inventory value. What would be the total cost at optimal order quantity? The vendor is offering a quantity discount of 5 percent if 20.000 units are purchased at a time. The shelf life of the item is three months. Do you accept the discount offer? Give reasons for your decision. (PGDMM/PDMM - Exam. Dec, 96)

Solution

(a) Calculation of economic order quantity (EOQ) :

$$EOQ = \sqrt{\frac{2 \times \text{Annual Demand} \times \text{Cost per order}}{\text{Price per unit} \times \text{Cost of carrying inventory as percentage}}} = \sqrt{\frac{2D\,C_o}{P\,C_i}}$$

$D = 60{,}000$ units $C_o = $ Rs.600/- $P = $ Rs.60/- $C_i = 30\%$

$$EOQ(Q) = \sqrt{\frac{2 \times 60{,}000 \times 600}{60 \times 0.30}} = 2000 \text{ units}$$

(b) Total cost at optimal order quantity (i.e., EOQ) :

$$\text{Total cost } TC_{(EOQ)} = \frac{D}{Q} C_o + \frac{Q}{2} P C_i$$

$$= \frac{60{,}000}{200} \times 600 + \frac{2000}{2} \times 60 \times 0.30$$

$$= 18{,}000 + 18{,}000 = \text{Rs.}36{,}000$$

(c) Decision regarding discount offer :

Quantity to be ordered to avail discount of 5% on unit price $Q_1 = 20{,}000$ units

Discounted unit price $= (1 - 0.05) \times 60$

$= 0.95 \times 60 = $ Rs.57

Result of discount

(i) Savings in cost of material.

(ii) Savings in ordering cost per year due to reduction in number of orders per year.

(iii) Loss due to increased ordering cost per year, due to higher average inventory.

(iv) Loss due to obsolescence if the order qty. exceeds the total consumption during the shelf life of the item.

(i) Calculation of savings in cost of material :

$$\text{Savings in cost of materials per annum} = \frac{5}{100} \times 60 \times 60{,}000 = \text{Rs.}1{,}80{,}000$$

(ii) $$\text{Savings on account of reduced number of orders} = \left[\frac{60{,}000}{200} - \frac{60{,}000}{20{,}000}\right] \times 600$$

$$= (30 - 3) \times 600$$

$$= 27 \times 600 = \text{Rs.}16{,}200$$

(iii) Loss on account of higher average inventory $= \frac{Q_1}{2} \times P_1C_i - \frac{Q}{2} PC_i$

$$= \left(\frac{20,000 \times 57}{2} - \frac{2000 \times 60}{2}\right) \times \frac{30}{100}$$

$$= 10,000 \times 57 \times 0.3 - 1000 \times 60 \times 0.3$$

$$= 1,71,000 - 18,000 = \text{Rs.}1,53,000$$

(iv) Calculation of loss if ordered quantity exceeds the total consumption during shelf life :

Annual demand = 60,000 units

Monthly demand = 5000 units

Shelf life = 3 months

Consumption during shelf life = 5000 x 3 = 15,000 units

Order quantity per order = 20,000 units

Qty. that becomes obsolete = 20,000 – 15,000 = 5,000 units

Loss due to obsolescence = 5000 x unit price

= 5000 x 57 = 2,85,000/-

Total savings if discount offer is accepted = (Savings in cost of materials) + (Savings on account of reduced no. of orders)

= 1,80,000 + 16,200

= 1,96,200

Total loss if discount offer is accepted = (Loss due to higher average inventory carrying cost) + (Loss due to obsolescence if any)

= 1,53,000 + 2,85,000

= 4,38,000/-

Since total loss is greater than the total savings, there will be a net loss of (4,38,000 – 1,96,200) i.e., 2,41,800. Hence the discount offer is not acceptable.

4. The ABC Fun novelty company buys 80,000 shipping containers per year. Price of each container is Rs.0.40. Cost of purchase is Rs.80 per order, cost of holding one container per year = Re.0.10. Bank rate of interest is 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? (ICWA Final – June, 1995)

Solution

Annual demand (D) = 80,000 units

Unit price (P) = Re.0.40

Ordering cost per order (C_o) = Rs.80/-

Holding cost per item per year = Re.0.10/-

Safety stock = 450 units

Procurement lead time = 10 days

Buffer stock (i.e., lead time consumption) = Lead time x Consumption rate

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

= 450 + 750 = 1200 units

Minimum inventory level = Safety stock = 450 units

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

= 450 + 4000 = 4450 units

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

$$= \frac{450+4450}{2} = \frac{4900}{2} = 2450 \text{ units.}$$

8. The demand for a certain item is random. It has been estimated that the monthly demand of the item has a normal distribution with a mean of 680 and a standard deviation of 130 units. The unit price of the item is Rs.10/-. The ordering cost is Rs.20/-, the inventory carrying cost is estimated to be 25 percent per year respectively. The procurement lead time is constant and is one week. Find the most economic ordering policy and the expected cost of controlling inventory, given that the service level is 97.5%.

(ICWA Final - Stage 3 – June, 1997)

Solution

Average or mean monthly demand = 680 nos.

Annual demand (D) = 680 x 12 = 8160 units

Unit price (P) = Rs.10/-

Ordering cost per order (C_o) = Rs.20/-

Inventory carrying charges/year (C_i) = 25%

(i) Economic ordering quantity (EOQ) $= \sqrt{\frac{2D\,C_o}{P\,C_i}}$

$$EOQ = \sqrt{\frac{2\times 8160\times 20}{10\times 0.25}}$$

$$= \sqrt{1,30,560} = 361.33$$

$$\text{No. of orders per year} = \frac{8160}{361.33} = 22.58 \approx 23$$

Modified EOQ (at 23 orders per year) = 355 nos.

(ii) Calculation of reserve stock to cater for variation in consumption pattern, i.e., normal distribution pattern of variation with a mean of 680 and a standard deviation of 130 units.

Reserve stock at 97.5% service level = $K\sigma_L$

Where K is service level constant @97.5% service level

The value of K = 1.96 from table given at Annexure-C

(area under standard normal probability distribution)

σ_L = Standard deviation for lead time (L)

$= \sigma \times \sqrt{L}$

$= 130 \times \sqrt{1} = 130$ units

$\therefore$ Reserve stock $= 1.96 \times 130 = 255$

Minimum inventory level = 255 nos.

Maximum inventory level = Minimum inventory level + EOQ

$= 255 + 355 = 610$ nos.

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

$$= \frac{255 + 610}{2} = \frac{865}{2} = 433$$

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

$$= 23 \times 20 + \left(\frac{355}{2} \times 10 \times 0.25\right)$$

$= 460 + 433 \times 10 \times 0.25$

$= 460 + 1082.50$

$=$ Rs.1542.50

9. Veena industries, manufacturers of computer peripherals, require certain items costing Rs. 3.75 each. The annual demand is 24,000 nos. Average lead time is 6 weeks and the demand per week is 460 with a standard deviation of 50 nos per week. The company stipulates the policy of maintaining a service level of 95% (K = 1.64). Though normal lead time is 6 weeks, it is fluctuating and maximum lead time that occurred is 10 weeks. The cumulative probability of its occurrence, i.e., 7,8,9,10 weeks is 0.25. The ordering cost is Rs. 180 per order and the inventory carrying cost is 30% p.a. Based on the above information, design fixed order quantity inventory system and explain how it operates. (G.D.M.M. Exam – June 1996)

Solution

Annual demand (D) = 24,000 units

Ordering cost per order (C_o) = Rs.180/-

Inventory carrying charges/year (C_i) = 30%

Unit Price of the item (P) = Rs 3.75

CHAPTER 23

Purchasing

As of today, there are four different groups of buyers, viz., (a) consumers, (b) middlemen, (c) government agencies and (d) manufacturers. Consumers buy various items for their own consumption and they constitute the single largest group of buyers. In fact, the whole economy is dependent on this group for survival. The second group comprises such a motley collection of traders as wholesalers, retailers, and distributors who buy not for their own consumption, but to sell to others. They act as the link between the primary producers and the ultimate consumers. Government agencies consisting the third category of purchasers, buy "tin pins to giant aeroplanes" for use in government departments. The fourth category of purchases include manufacturers who convert raw materials and other inputs into saleable products. They buy raw materials, components, consumables and packing materials for use in industrial establishments where, saleable products are produced. The subject of purchasing is discussed here as it applies to the buying, made by manufacturers.

Definition

In its narrow sense, the term 'purchasing' refers merely to the act of buying an item at a price. This very narrow conception of purchasing has been gradually widened during the last 70 years.

A broader meaning of purchasing makes it a managerial, activity which goes beyond the simple act of buying and includes the planning and policy activities covering a wide range of related and complementary activities. Included in such activities are the research and development strategies required for the proper selection of materials and sources from which those materials may be bought, the follow-up to insure proper delivery, the development of proper procedures, methods and forms to enable the purchasing department to carry out the established policies; the co-ordination of the activities of the purchasing department with such other internal divisions of the concern as traffic, receiving, store-keeping, and accounting, so as to facilitate smooth operations and the development of a technique of effective communication with the top management of the company so that, a true picture of the performance of the purchasing function is presented.[1]

Some writers use the term 'procurement' instead of purchasing. The term procurement is broad in its meaning and covers the duties performed by the purchasing department as well as such additional functions of materials supervision and management as inventory control, receiving, incoming inspection and salvage operations.[2]

The term procurement is too broad and hence is not used by many writers on the subject and by people who practice the profession. The term *purchasing* is most appropriate and hence is in popular usage.

The buyers or purchasing officers are the people responsible for discharging purchasing functions. They are the full time staff of the company. The head of the section or the department is the purchasing agent, also variously known as the purchasing officer, purchasing *manager* or *simply buyer*. The department where all the purchases operate is called the *purchasing department*.

The purchasing department is often called the supply department when the former is also responsible for storing things bought and stock control of what is stored.[3]

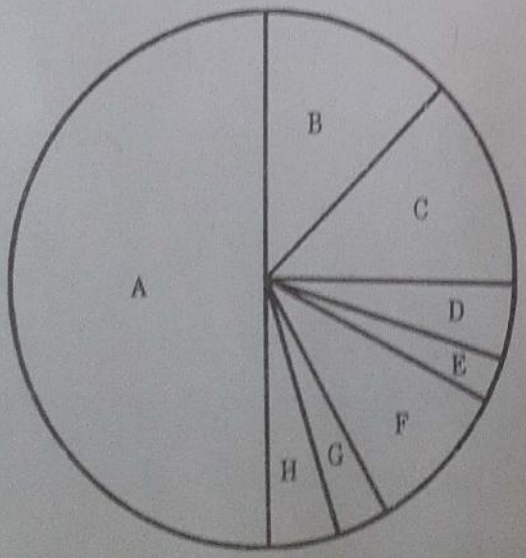
We prefer to use the term purchasing department to supply department. For us storing and stock or inventory control are independent functions to be handled by separate staff. They cannot, therefore, be attached to purchasing department.

Importance of Purchasing

1. Purchasing is a fundamental function in an industrial establishment. An industrial enterprise is primarily meant for converting raw materials into finished products. The wheels of industry will not move unless materials of the right type are bought in right quantities and made available at right time. Needless it is to say that is buying function which is responsible for supply of materials to the factory.

2. As is well known, more than 50 percent of the total cost is contributed by a single element called *materials*. It is proved that a one percent saving in materials cost is equivalent to nearly 10 percent increase in turnover. Saving in the cost of materials is achieved mainly through efficient buying.

3. An average manufacturer spends major portion of his earnings on purchases and has the largest portion of working capital tied up in inventories. The annual reports of companies prominently illustrate the way their earnings are distributed (See Fig. 23.1). High financial stakes are involved in buying and the purchasing manager is the custodian of his firm's purse; his first and foremost obligation is integrity in spending its funds.[4]



A – Materials (50.66%)
B – Wages and Salaries (12.64%)
C – Expenses (14.21%)
D – Interest (5.66%)
E – Depreciation (2.38%)
F – Corporate tax and Excise duty (10.76%)
G – Dividend (1.25%)
H – Retained earnings (2.35%)

Fig. 23.1 Distribution of income

Functions of Purchasing Department

The definition given for purchasing at the beginning of this chapter should give us an idea of about the functions of the purchasing department. For greater clarity we list the functions below. It may be emphasised that some of the functions are the sole responsibility of the purchasing department, some are shared with other departments and the remaining are the responsibilities in which the purchasing department has considerable interest.

1. Responsibilities often fully delegated to the purchasing function:
   (a) Obtaining prices.
   (b) Selecting vendors.
   (c) Awarding purchase orders.
   (d) Following up on delivery promises.
   (e) Adjusting and settling complaints.
   (f) Selecting and training of purchasing personnel.
   (g) Vendor relations.
2. Responsibilities often shared with functions other than purchasing function:
   (a) Obtaining technical information and advice.
   (b) Receiving sales presentations and arranging for sales opportunities with interested personnel.
   (c) Establishing specifications.
   (d) Scheduling orders and deliveries.
   (e) Inspecting.
   (f) Specifying delivery method and routing.
   (g) Expediting.
   (h) Accounting.
   (i) Purchasing and market research.
   (j) Inventory and warehousing policy and/or control.
   (k) Forward buying and hedging policies and procedures.
   (l) Construction contracting.
   (m) Service contracts and agreements.
   (n) Sale of scrap, salvage and surplus.
   (o) Purchasing for employees.
   (p) Contracting for machines and equipment.
   (q) Development of specifications.
   (r) General considerations of quantities or timing on planning deliveries.
   (s) Transportation and traffic.
   (t) Determination of whether to make or buy.
   (u) Customs.
   (v) Other functions.
3. Responsibilities often divorced from purchasing but of particular interest to purchasing:
   (a) Receiving and warehousing.
   (b) Payment of invoices.
   (c) Other functions.[12]

The above listing is exemplary, but not exhaustive. Company policy varies in the division of these responsibilities. Purchasing responsibilities in any company should be well defined to encourage effectiveness in operations.

Purchasing Cycle

The purchasing functions listed above will be performed in tandem to complete a transaction from its completion. Certain steps can be noticed in the process of initiating and completing the transaction. The steps are:

1. Recognition of need.
2. Description of need.
3. A suitable source is selected for the supply. Often a source has to be developed.
4. Price and availability are determined.
5. Purchase order is prepared and sent out to the supplier.
6. Acceptance of the purchase order is obtained from the supplier.
7. Follow up is done by the purchasing department to ensure timely delivery of the material.
8. Checking the invoice and approving it for making payment to the supplier.

Recognition of need

The recognition of need refers to the means by which a needed item is officially brought to the attention of the purchasing department. Two procedures are followed. One involves the issuance of requisitions or demand notes by the user department or the stores department and the other involves the issuance of a bill of materials.

A *purchase requisition* describes the needed item and becomes the basis for action by the purchasing department. Requisitions are signed by authorised individuals to avoid irresponsible purchase requests.

Requisitions are prepared by the stores department in which case they are called *routine* requisitions. Requisitions from the using departments are generally routed through the stores department and if the item is in stock, it is supplied from there, instead of being purchased. Requisitions for items not in stock are sent on to the purchasing department for action.

A *bill of materials* is a list of all items to be incorporated into a finished product that the company produces. Such bills are generally prepared at the time when engineering blueprints for the items are made. Under this method of establishing needs, the purchasing department is notified of the manufacturing scheduled by the Production Planning and Control (PPC) department. The buyer, then multiplies the items listed in the bill of materials by the total units planned for production to determine the total requirement. After the total needs have been adjusted to make use of existing inventories, the quantity to be purchased is known. The bills of materials procedure is primarily applicable to the purchase of standard parts and small expendable tools. Supplies and similar needs are usually handled by the requisition procedure.

Description of requirement

The purchase requisition describes the required item. In order to assure complete and accurate information for ordering, the requisition must include all necessary information in a form that can be readily checked and verified.

The buyer must check a requisition on the basis of his own knowledge of the item, records of past purchases and vendor catalogues. He should not change an inadequate requisition, interpret sketchy descriptions, or in anyway make judgements about a questionable requisition.

CHAPTER 11

Materials Handling

Many types of materials, viz., raw materials, purchased components, materials-in-process (i.e, semi-finished goods), finished goods, packaging materials, maintenance and repair supplies, scrap and waste and rejects or rework are used and handled in manufacturing organizations. These materials are of various size, shape and specific features. The characteristics of the materials to be used in production are determined by *product design decisions*. The layout of facilities is directly affected by the nature of these materials. For example, large and bulky materials, heavy materials, fluids, solids, flexible and inflexible materials and materials requiring special handling to protect them from conditions such as heat, cold, humidity, light, dust, flame and vibration affect the layout of facilities for handling, storing and processing these materials.[1]

Definition of Materials Handling

Materials handling is defined as the art and science of moving, packaging and storing of substances in any form. Other definitions include:

(a) Creation of time and place utility
(b) Movement and storage of material at the lowest possible cost through the use of proper methods and equipments.
(c) Lifting, shifting and placing of material which effect a saving in money, time and place
(d) Art and science of conveying, elevating, positioning, transporting, packaging and storing of materials.[2]

Scope of Materials Handling

The scope of materials handling activity within an organization depends on the type of the product manufactured, the size of the organization, the value of the product and the value of the activity being performed and the relative importance of materials handling to the enterprise.

There are three perspectives about materials handling, viz.:

(a) The traditional point of view.
(b) Plant-wide concern for overall flow of materials.
(c) The systems point of view.

In the *traditional point of view* of materials handling, the emphasis is on the movement of materials from one location to another within the confines of the individual plant. The

concern is to find the best way to move the materials from one place to another within the plant.

Plant wide concern focuses the attention on the overall flow of material in the plant. The main concern is the inter-relationships between all handling problems and the possibility of establishing an overall materials handling plan.

The systems point of view of material handling requires visualization of materials handling problems, the physical distribution activities and all closely related functions as one, an all - encompassing system. This point of view involves a much broader consideration of all materials handling activities involving the movement of materials from all sources of supply (vendors), all handling activities within and around the plant and the handling activities involved in the distribution of finished goods to all customers of the firm.

The subject of materials handling as discussed in this chapter is concerned only with handling of materials within the plant.

Importance of Materials Handling

1. Efficient materials handling is important to manufacturing operations. Materials sent by vendors must be unloaded, moved through inspections and production operations to stores and finally to the shipping department. These movements do not add value to the product but they do add to the cost.
2. Materials handling analysis is a subset of plant layout. Method study, plant layout and materials handling are all part of the design of a production facility and can hardly be treated as separate. Materials handling system and plant layout enhance effectiveness of each other. A good plant layout enables an operation to use the most efficient handling method. Efficient operation of appropriate materials handling methods reduces costs and enables maximum capabilities to be derived from a given production facility.

Objectives of Materials Handling

Even though the best solution to the materials handling problem, is *no handling*, it is hardly practicable in a manufacturing process. Hence, the *main objective* of materials handling is to reduce the number of handlings as well as the overall cost of material handling equipments and reducing the distances through which the materials are handled.

The following may be considered as other objectives of materials handling:

1. Lower unit materials handling costs.
2. Reduction in manufacturing cycle time through faster movement of materials and by reducing the distance through which the materials are moved. Reduction in manufacturing cycle time results in reduced work-in-progress inventory costs.
3. Contribution towards a better control of the flow of materials through the manufacturing facility.
4. Improved working conditions and greater safety in the movement of materials.
5. Contribute to better quality by avoiding damage to products by inefficient handling.
6. Increased storage capacity through better utilization of storage areas.
7. Higher productivity at lower manufacturing cost.

Materials Handling Principles

Certain principles have evolved to guide facility layout to ensure efficient handling of materials. Although there are no hard and fast rules, they do provide effective guidelines for the efficient movement of materials in most facility layouts.

Table 11.1 lists the materials handling principles which provide a frame-work for selecting specific materials handling devices/equipments, which are the core of the materials handling system.

Table 11.1 : Materials Handling Principles

Sl. No.	Principles
1.	Materials should move through the facility in direct flow patterns, minimizing zig-zagging or backtracking.
2.	Related production processes should be arranged to provide for direct material flows.
3.	Mechanized materials handling devices should be designed and located so that human effort is minimized.
4.	Heavy and bulk materials should be moved the shortest distance during processing.
5.	The number of times each material is handled should be minimised.
6.	Systems flexibility should allow for unexpected breakdowns of materials handling equipments, changes in production system technology, etc.
7.	Mobile equipments should carry full loads all the times.

(Source : Northern Gaither. *Production and Operations Management*. 4th Edn., P. 228)

The seven principles can be summarized in the form of the following guidelines :

1. ***Eliminate handling*** : If not, make the handling distance as short as possible.
2. ***Keep moving*** : If not, reduce the time spent at the terminal points of a route as short as possible.
3. ***Use simple patterns of material flow*** (the simplest path is a straight line path of flow which minimizes the handling distance between two points). If not, reduce backtracking, cross-overs and other congestion producing patterns as much as possible.
4. ***Carry pay loads both ways*** : If not, minimize the time spent in 'transport empty' by speed changes and route relocations.
5. ***Carry full loads*** : If not, consider increasing the size of unit loads, decreasing carrying capacity, lowering speed, or acquiring more versatile equipment.
6. ***Use gravity*** : If not, try to find another source of power that is reliable and inexpensive.

In addition to the above guidelines, there are certain other very important aspects of materials handling, such as the following :

(a) Materials handling consideration should include the movement of men, machine, tools and information.

(b) The flow system must support the objectives of receiving, sorting, inspecting, inventorying, accounting, packaging and assembling.

Since the considerations and objectives do conflict, it is essential to take a system decision followed by delicate diplomacy to establish a material movement plan that meets service requirement without sub-ordinating safety and economy.

Materials Handling Costs

The costs of materials handling arise from two sources: the cost of owning and maintaining equipment and the cost of operating the system. While the costs of owning the equipment are generally known since entries are available in the books of accounts, the costs of operating the handling system are elusive as records are not generally maintained.

4. Identification of activity relationships between departments.
5. Determination of space requirement and establishment of material flow pattern.
6. Analysis of material and building characteristics.
7. Preliminary selection of basic handling system and generation of alternative systems considering feasibility of mechanisation and equipment capabilities.
8. Evaluation of alternatives with respect to optimal material flow, utilising gravity, minimum cost, flexibility, ease of maintenance and capacity utilization.
9. Selection of the best suitable alternative system and checking it for compatibility with the layout.
10. Specification of the system.
11. Procurement of the equipment and installation of the system.

Types of Materials Handling Equipment

The materials handling equipments are classified into four basic types, viz., conveyors, cranes and hoists, trucks and auxiliary equipment.

Conveyers

These are gravity or powered devices, commonly used for moving loads from point to point over fixed paths. The various types of conveyors are:

(a) *Belt conveyor* – Motor driven belt, usually made of rubberised fabric or metal fabric on a rigid frame.

(b) *Chain conveyor* – Motor driven chain that drags materials along a metal slide base.

(c) *Roller conveyor* – Boxes, large parts or unit loads roll on top of a series of rollers mounted on a rigid frame. The rollers may be powered or unpowered.

(d) *Pneumatic conveyor* – High volume of air flows through a tube, carrying materials along with the air flow. The other types of conveyors are bucket conveyor, screw conveyor, pipeline conveyor, vibratory conveyor, tube conveyor, trolley conveyor and chute or gravity conveyors. Advantages of conveyors are that they do not require operators, will move a large volume of products and are inexpensive to operate.

[Refer to Fig.11.5]

Cranes, Elevators and Hoists

These are overhead devices used for moving varying loads intermittently between points within an area, fixed by supporting and binding rails:

(a) *Cranes* are devices mounted on overhead rails or ground level wheels or rails. They lift, swing and transport large and heavy materials. Examples are Gantry Crane, Jib Crane and Electrically Operated Overhead Crane (EOTC).

(b) *Elevators* are a type of cranes that lift materials - usually between floors of buildings.

(c) *Hoists* are devices which move materials vertically and horizontally in a limited area. They are used primarily, when materials must be lifted prior to being moved from one point to another. Example of hoists are air hoist, electric hoist and chain hoists.

Other devices under these categories are winches, monorail and the like. [Refer to Fig.11.3 (a) and (b) in page no. 176]

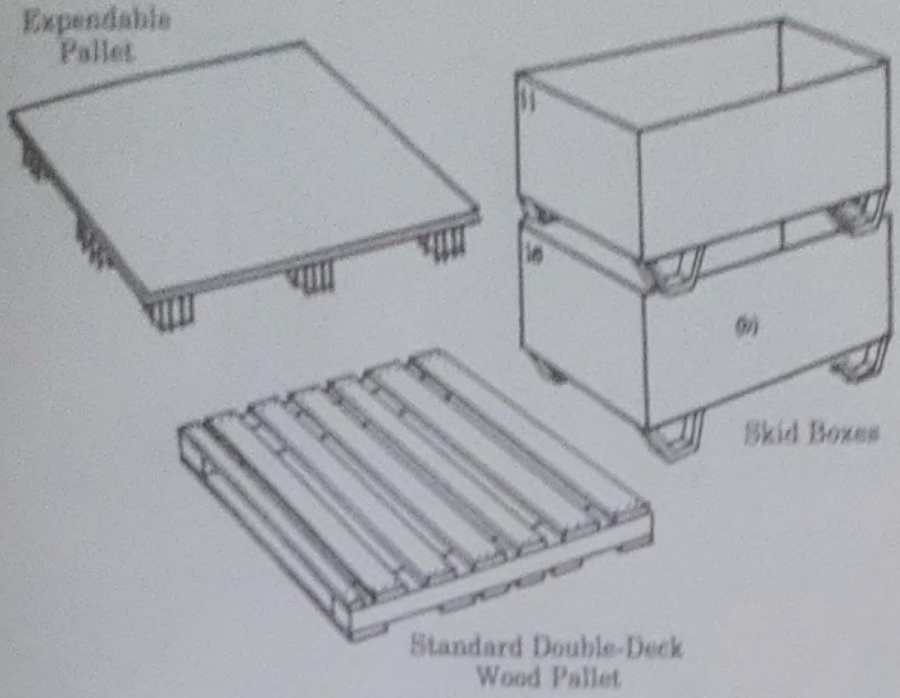


Fig. 11.2 Auxiliary equipments

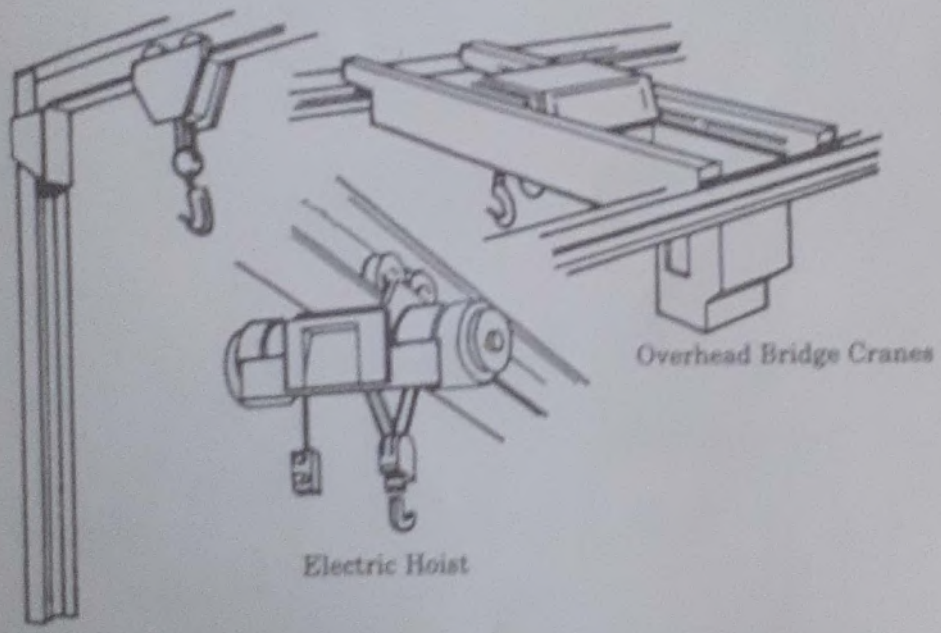


Fig. 11.3 (a) and (b) shows some types of cranes and hoists

Industrial Trucks

These devices are used for moving mixed or uniform loads intermittently over variable paths. They are electric, diesel, gasoline or liquified petroleum, gas powered vehicles equipped with beds, forks, arms or other holding devices. Examples are fork-lift trucks, pallet trucks, tractor with trailors, hand trucks and power trolleys. [Refer to Fig. 11.4]

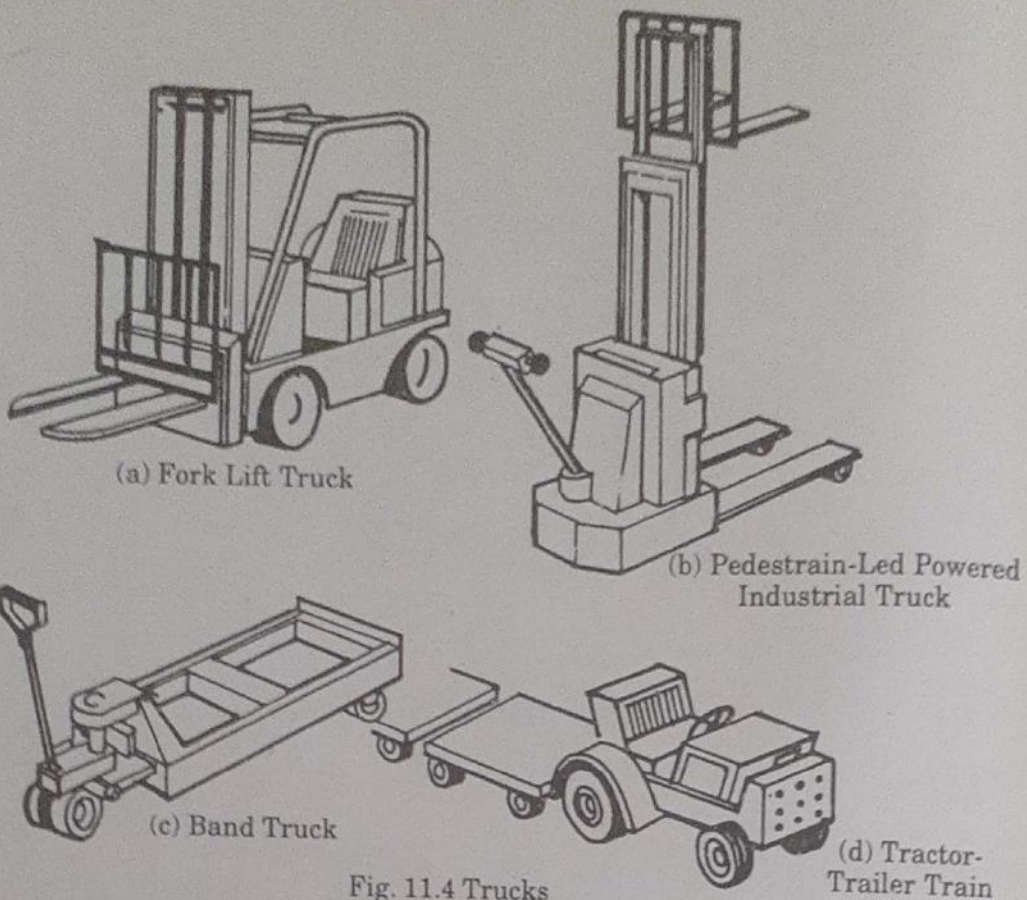


Fig. 11.4 Trucks

Auxiliary Equipments

These are devices or attachments used with handling equipment to make their use more effective and versatile. Examples are ramps, positioners, pallets, containers and turn tables. (Refer to Fig. 11.2)

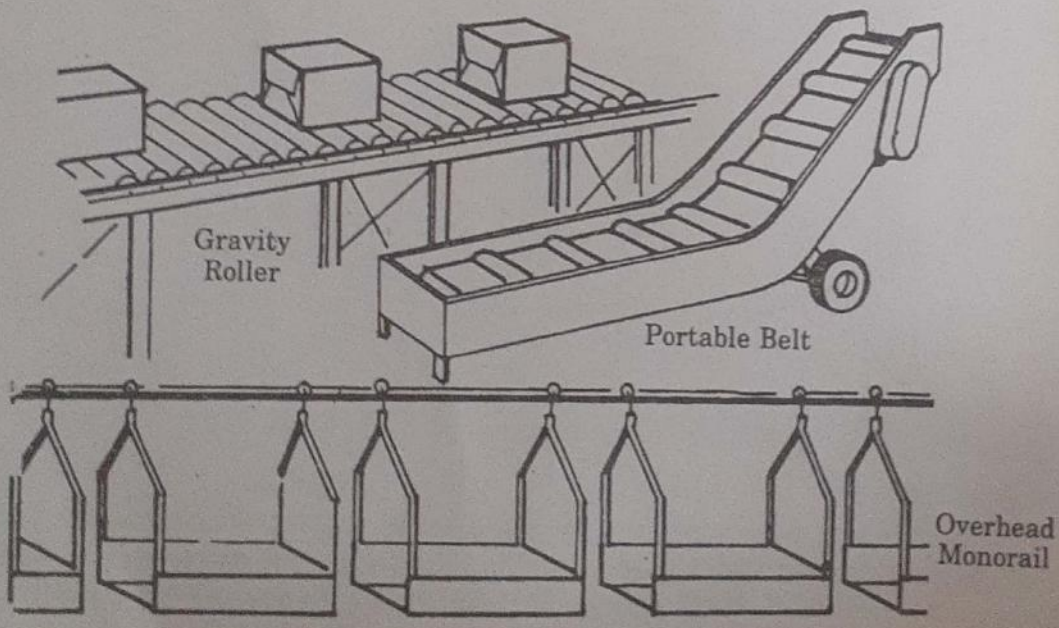


Fig. 11.5 Some conveyors in use for materials handling

Miscellaneous Handling Equipments

(i) *Pipe lines*, which are closed tubes that transport liquids by means of pumps or gravity.

(ii) *Automatic transfer devices* which automatically grasp materials, hold them firmly while operations are being performed and move them to other locations.

(iii) *Automated guided vehicle (AGV) systems* - These devices do not require operators and provide a great deal of flexibility in the paths they travel and the functions they perform. The AGVs are controlled by signals sent through wires embedded in the floor or inductive tape on the floor surface. A remote control computer is needed to control the movement of AGVs.

(iv) *Industrial robots* - A robot is a mechanism which has a movable armlike projection with a gripper on the end that can perform a variety of repetitive tasks. Robots usually have a built-in control that can be reprogrammed and hence they are very versatile.

The process design and the principles of efficient materials handling provide the framework for selecting specific materials handling devices and the core of the materials handling system. Each of the handling devices discussed above has its own unique characteristics and advantages and disadvantages.

Evaluation of Materials Handling Performance

Like any other materials activity, materials handling function should also be evaluated to judge its effectiveness. The performance of materials handling function can be evaluated with the help of several ratios such as the following:

1. Materials handling labour ratio.
2. Direct labour handling ratio.
3. Management/Operation ratio.
4. Manufacturing cycle efficiency ratio.
5. Space utilisation efficiency ratio.
6. Equipment utilisation ratio.
7. Aisle space potential ratio.
8. Materials handling personnel per 1000 factory employees.
9. Percentage of time lost by direct labour in materials.
10. Ratio of total number of moves to the total number of operations.
11. Percentage of usable cubic footage usually occupied.
12. Materials handling costs as percentage of manufacturing expenses.

QUESTIONS

1. Define the term 'materials handling' and state its objectives.
2. State the principles of materials handling.
3. What is meant by systems point of view of materials handling?
4. Bring out the importance of materials handling.
5. Briefly explain the various factors that affect the selection of materials handling equipment.
6. What are the different classifications of materials handling systems. State their applications.
7. Briefly describe the various types of materials handling systems stating their applications.