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23

Materials, Purchase and Stores Management

23.1. MATERIALS MANAGEMENT

23.1.1. Introduction

- Most manufacturing concerns spend more than 60% of the money they take in, for materials, *i.e.*, materials soak up a substantial portion of the capital invested in an industrial concern.
- This emphasizes the need for adequate *materials management and control* because even a small saving in materials can reduce the production cost to a fair extent and thus add to the profits.
- *Materials Management* may be thought of as an integrated functioning of the different sections of a company dealing with the supply of materials and other related activities so as to obtain maximum co-ordination and optimum minimum expenditure on materials.
- *Materials Management* involves controlling the type, amount, location, movement, timings of purchase of various materials etc., used in an industrial concern.

23.1.2. Functions of Materials Management

(*i*) Materials planning

(*ii*) Procurement or purchasing of materials.

(*iii*) Receiving and warehousing

(*iv*) Storage and store-administration.

(*v*) Inventory control.

(*vi*) Standardization, Simplification and Value-analysis.

(*vii*) External transportation (*i.e.*, traffic, shipping, etc.) and materials handling (*i.e.*, internal transportation).

(*viii*) Disposal of scrap, surplus and obsolete materials.

23.1.3. Objectives of Materials Management

(*i*) To minimize materials cost.

(*ii*) To procure and provide materials of desired quality when required, at the lowest possible overall cost of the concern.

(*iii*) To reduce investment tied in inventories for use in other productive purposes and to develop high inventory turnover ratios.

(*iv*) To purchase, receive, transport (*i.e.*, handle) and store materials efficiently and to reduce the related costs.

(*v*) To trace new sources of supply and to develop cordial relations with them in order to ensure continuous material supply at reasonable rates.

(*vi*) To cut down costs through simplification, standardization, value analysis, import substitution, etc.

(*vii*) To report changes in market conditions and other factors affecting the concern, to the concern.

(*viii*) To modify paper work procedure in order to minimize delays in procuring materials.

(*ix*) To conduct studies in areas such as quality, consumption and cost of materials so as to minimize

cost of production.

(*x*) To train personnel in the field of materials management in order to increase operational efficiency.

23.2. PURCHASING OR PROCUREMENT

23.2.1. Introduction

- The purchasing department occupies a vital and unique position in the organisation of an industrial concern because purchasing is one of the main functions in the success of a modern manufacturing concern.
- Mass production industries, since they rely upon a continuous flow of right materials, demand for an efficient purchasing division.
- The purchasing function is a liaison agency which operates between the factory organisation and the outside vendors on all matters of procurement.
- Purchasing implies – procuring materials, supplies, machinery and services needed for production and maintenance of the concern.

23.2.2. Objectives of Purchasing Department

(*i*) To procure right material.

(*ii*) To procure material in right quantities.

(*iii*) To procure materials of right quality.

(*iv*) To procure from right and reliable source or vendor.

(*v*) To procure material economically, *i.e.*, at right or reasonable price.

(*vi*) To receive and deliver materials at

- right place, and at
- right time.

Purchasing department has to perform certain activities, duties and functions in order to achieve the above mentioned objectives.

23.2.3. Activities, Duties and Functions of Purchasing Department

(*i*) Keep records – indicating possible materials and their substitutes.

(*ii*) Maintain records of reliable sources of supply and prices of materials.

(*iii*) Review material specifications with an idea of simplifying and standardizing them.

(*iv*) Making contacts with right sources of supply.

(*v*) Procure and analyze quotations.

(*vi*) Place and follow up purchase orders.

(*vii*) Maintain records of all purchases.

(*viii*) To make sure through inspection that right kind (*i.e.*, quantity, quality, etc.) of material has been purchased.

(*ix*) To act as liaison between the vendors and different departments of the concern such as production, quality control, finance, maintenance, etc.

(*x*) To check if the material has been purchased at right time and at economical rates.

(*xi*) To keep an uninterrupted supply of materials so that production continues with least capital tied in inventories.

(*xii*) To prepare purchasing budget.

(*xiii*) To prepare and update list of materials required by different departments of the organisation

within a specified span of time.

(*xiv*) To handle subcontracts at the time of high business activity.

(*xv*) To ensure that prompt payments are made to the vendors in the interest of good public relations.

23.3. PURCHASE ORGANISATION

- Purchasing department is a staff function in the overall company structure (Refer Fig.23.1).
- The internal organisation of the purchasing department is on a *line* basis, with purchasing agent, director of purchases or purchasing manager being the incharge of purchase department. He is responsible for the overall efficient operation of the department.
- The purchasing manager is, however, assisted in purchasing by a number of assistants and a few clerical staff (refer Fig. 23.1).
- The purchasing manager has the powers to execute purchasing contracts for the concern. He divides the duties among the assistants according to the nature of purchases to be made. For example, one assistant may purchase only electrical goods, another (major) raw material, third plant equipment and so on.

This functional division of efforts makes for increased specialisation and gives a chance to the assistant to better feel and know the market, he is assigned.

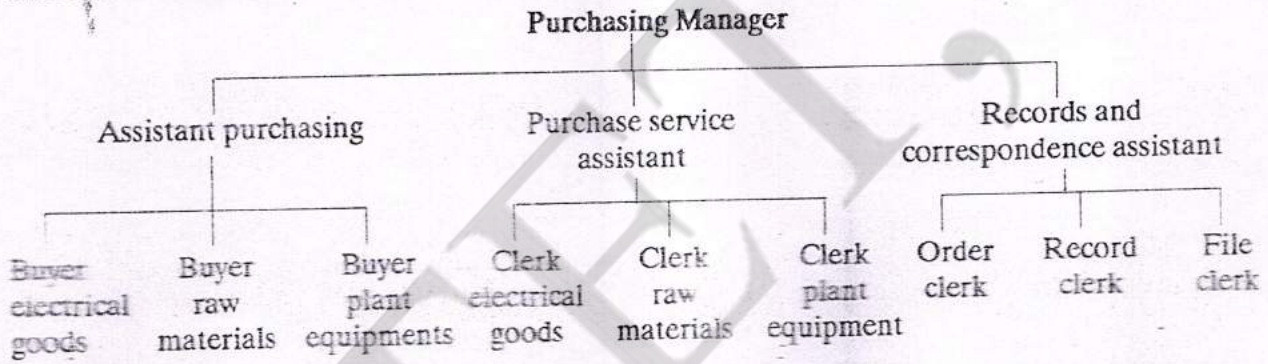


Fig. 23.1. Organisation of a Purchasing Department.

- Fig. 23.1 shows an organisation of a typical purchasing department. There are three main sections namely *purchasing, purchase service* and *records.*

1. *Purchasing section* places orders with the vendors.

2. *Purchase service section* follows the progress of the order at vendor's end, its shipment by the vendor and its final receipt in the company.

3. *Records section* maintains all records of quotations, costs, purchases, etc.

23.3.1. Centralized and Decentralized Purchase Organisations

- The problem of centralising or decentralising the purchase activities arises in large organisations—particularly in multiplant industries.

Advantages of Centralized Purchasing

- The centralization of purchasing,

(*i*) almost invariably makes for more efficient ordering of materials ;

(*ii*) forms a basis to gain bargaining advantage ;

(*iii*) eliminates duplication of efforts ;

(*iv*) helps procuring uniform and consistent materials ;

(*v*) simplifies purchasing procedure ;

(*vi*) simplifies the payment of invoices ; and

(*vii*) permits a degree of specialization among buyers.

Disadvantages of Centralized Purchasing

1. Centralized purchasing is little slower and more cumbersome than decentralized purchasing.

Applications of Centralized purchasing

1. For concerns using few materials whose quality and availability are vital to the success of the concern.

2. For purchasing small items of fairly high value such as tool bits, grinding wheels, dial gauges, etc., as well as those for which bigger quantity discounts can be obtained.

Advantages of Decentralized Purchasing

1. Improved efficiency.
2. Faster procurement of materials.
3. Control over purchases is no longer remote.
4. Decentralized operations are more flexible.

Disadvantages of Decentralized Purchasing

1. Less quantity discounts.
2. Involves duplication of efforts.

Applications of Decentralized Purchasing

1. Where different plants of a large organisation require quite different types of materials.
2. Where branch plants require heavy and bulky items such as oil products, fuels, paints, etc.
3. Where purchases are to be made within the local community to promote better public relations.

23.4. BUYING TECHNIQUES

Materials can be bought or purchased by one of the following techniques :

(*a*) **Spot Quotations.** The buyer can go to the market, collect minimum three quotations (for purchasing one material) from different suppliers, take a spot decision, pay cash and buy the commodity.

Generally the item is purchased from the vendor who furnishes a quotation of least price.

(*b*) **Floating the Limited Enquiry.** A few reliable (and otherwise registered with the company) vendors are written letters to send the price and other details for a particular commodity. A *quotation form* as shown in Fig. 23.2 is generally used for calling the quotations :

QUOTATION FORM

From .....

.....

To .....

No. M.E.D./.....

Date.....

Dear Sir,

Please submit your quotations for the materials listed below so as to reach the office of the undersigned at the latest on .....at..... Please send full details, specifications, pamphlets, and other literature if any along with the quotations. Please note the terms and conditions mentioned below:

1. Please mention on the top of envelope :

Enquiry No.....

Date on which due.....

2. Submit quotations in duplicate.
3. Preferably quote in the same order as in the enquiry letter.
4. Price each item separately and the prices quoted should be for destination.....
5. If you are unable to furnish materials as per our descriptions and wish to offer a substitute, please give details.
6. Quotations should be valid for at least one month from the date of opening.
7. Taxes should be mentioned for each case.
8. Quotations should be sent in sealed covers.
9. The right is reserved to accept or reject quotations on each item separately or as a whole.

The quotations will be opened on.....at.....in the office of the undersigned.

No.	*Description*	*Quantity*	*Unit*	*Price*	*Discount*	*Total Net Price*
1.	.....	.....	.....	.....	.....	.....
2.	.....	.....	.....	.....	.....	.....
3.	.....	.....	.....	.....	.....	.....
4.	.....	.....	.....	.....	.....	.....

Yours faithfully
Store Purchase Officer

Fig. 23.2

COMPARATIVE STATEMENT

Section.....
Enquiry letter No..... Dated.....
Last Date of Receiving Quotations.....
Date of Opening Quotations.....
Account on which the expenditure is debitable.....
Comparative statement Prepared by..... Checked by.....

Sl. No.	*Description of materials required*	*Quantity to be purchased*	*Supplier 1*	*Supplier 2*	*Supplier 3*
			RATES		
1.	.....	.....	.....	.....	.....
2.	.....	.....	.....	.....	.....
			TERMS AND CONDITION		
			1.*	1.*	1.*
			2.	2.	2.
			3.	3.	3.
			4.	4.	4.
			5.	5.	5.

1. Delivery date.
2. Place of delivery.
3. Terms of payment.
4. Taxes.
5. Packing & forwarding charges.

Fig. 23.3

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- After getting replies from vendors, the quotations are opened and a *comparative statem* one shown in Fig. 23.3 is prepared. The comparative statement helps studying and con different quotations at a glance and a quick decision can be taken as with whom to place th
- Comparative statement is analysed in the light of undermentioned points and the best qu is selected for ordering the material.
  - (*i*) Price of the (article or) material.
  - (*ii*) Material specifications and quality.
  - (*iii*) Place of delivery.
  - (*iv*) Delivery period.
  - (*v*) Taxes, etc.
  - (*vi*) Terms of payment.
  - (*vii*) Validity of tender.
  - (*viii*) Guarantee period, etc.

(C) Tenders

- A tender or a quotation is in the form of a written letter or a published document (in newsp The aim is to find the price for procuring certain materials or to get a particular work done the desired period and under specified conditions.
- *Types of* : The tenders may be of the following three types,

1. Single tender.
2. Open tender.
3. Closed tender or limited tender [Please refer to section 23.4(*b*)].

1. Single Tender. Tender is invited from one reliable supplier only. Single tender is called following conditions :

- Proprietory items.
- High quality items.
- 'C' class items such as clips, pins, pencils, etc.
- When items are required comparatively urgently.

2. Open tender. Open tender which is also called *press tender* is published in Newspaper, Journals etc., for procuring materials of desired specifications.

- It is open to everybody ; any vendor (reliable or unreliable) can furnish the quotations.
- Open tender gets very wide publicity.
- A vendor has to deposit an earnest money with the tender information. This is just to ensur the vendor does not back out from the rates etc., which he submits.
- Given below (Fig. 23.4) is a typical example of tender notice published in Newspaper :

A.P. STATE ELECTRICITY BOARD
(*PROCUREMENT CIRCLE – A*)
TENDER NOTICE

SEALED Tenders in triplicate are invited for the supply of following items. The copy of the specifica (non-transferable) can be had from the office of the undersigned by remitting rupees as indicated ag each item either by cash or by M.O. or by crossed Indian Postal Order in favour of the Accounts Of A. P. State Electricity Board, Hyderabad. The tenders will be received up to 2.30 p.m. and will be op at 3.00 p.m. on the dates as indicated hereunder.

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Sl. No.	Specification No.	Particulars	Date of opening	Earnest money	Cost of specifications (or tender)
1	AP-661	110 KVA and 25 KVA 11/.433 KV distribution transformers	5-8-75	Rs. 100	Rs. 5
2	AP-662	500 KVA and 250 KVA 11/.443 KV distribution transformers	12-8-75	Rs. 75	Rs. 5

Purchase of specifications is essential for the tenderers. The tender received without earnest money will not be considered. Earnest money shall be retained pertaining to the supplier furnishing lowest rates and it (*i.e.*, earnest money) shall automatically stand converted into Security Deposit. For other suppliers, the earnest money shall be refunded.

Chief Engineer

Fig. 23.4 Open Tender.

Earnest Money

Earnest money is demanded from the supplier who quotes the tender so that later on he does not back out from the rates he quotes for supplying the material or goods.

Security Deposit

After selecting the supplier to whom to give the tender, either on the basis of lowest rates quoted by him or otherwise, he is asked to make a security deposit so that in case the supplier fails to furnish the goods properly and in time, the security deposit can be forfeited.

23.5. QUANTITY AND QUALITY STANDARDS

23.5.1. Quantity Standards

– There are four important QUANTITY STANDARDS, namely

(*i*) Maximum inventory,

(*ii*) Minimum inventory,

(*iii*) Standard order, and

(*iv*) Reorder point.

– These quantity standards have been shown in Fig. 24.1 and explained in section 24.7.

23.5.2. Quality Standards

Quality. In the purchasing context, QUALITY refers to the suitability of a commodity for its intended use.

Therefore, in purchasing, the best is not necessarily the highest quality; the best quality can be even a lower quality.

Quality Standard. A quality standard is the description of an acceptable level of quality of a particular item.

Quality standards establish the quality objectives (of a commodity) to be measured or evaluated.

– In the past three decades, industry has seen a tremendous advance in the preciseness of its quality standards; quality has changed from a generic art to a specific science with definite quality standards and instruments to measure and compare the characteristics of a product against the quality standards set.

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– The necessary *quality standards* for a particular product are stated on the drawing in tern dimensional tolerances or written into the test *Specifications*.

The manufacturing department then makes products as per these standards and the inspec division inspects the products to the same standards.

– *Drawings* show the shape and the exact dimensions and the tolerances permitted on the pro whereas *Specifications* describe such characteristics as colour, chemical composition, mech cal properties (*i.e.*, tensile strength, hardness), kind of raw material etc.

– Specifications can be in the form of,

(*a*) *Dimensional and material specifications.* They must consist of a list of physical or chem properties desired in the product. Raw materials, oils and paints are specified this w

(*b*) *Performance specifications.* They indicate the performance or use of the purchased it for example, a component may be specified as capable of bearing a reverse bend at 10 temperature.

(*c*) *Blue prints.* Blue print is the most precise and probably the most accurate of all type descriptions and it finds applications where close tolerances or a high degree to mech cal perfection is desired.

– Both drawings and specifications describe what the product should be like after it has been m

Quality standards are dictated by the following requirements

(*i*) The efficiency with which the product can perform its function.

(*ii*) The cost and the estimated life of the product.

(*iii*) The quality of interchangeability and the ease of making assembly.

(*iv*) Appearance and FEEL of the production in use.

23.6. ORDERING OF MATERIAL OR THE PURCHASING PROCEDURE

23.6.1. Steps Involved in One Complete Purchasing Cycle

(*i*) Recognition of need, receipt and analysis of purchase requisition.

(*ii*)Selection of possible potential sources of supply.

(*iii*) Making request for quotation.

(*iv*) Receipt and analysis of quotations.

(*v*) Selection of right source of supply.

(*vi*) Issuing the purchase order.

(*vii*) Follow-up and expediting the order.

(*viii*) Analysing receiving reports and processing discrepancies and rejections.

(*ix*) Checking and approving vendor's invoices for payment.

(*x*) Closing completed orders.

(*xi*) Maintenance of records and files.

These different subdivisions of the purchasing procedure will be briefly discussed below :

1. Recognition of need, receipt and analysis of purchase requisition

– Whenever a department needs an item, it is officially brought to the notice of the purchasi department. For this purpose two procedures are followed :

(*i*) One involves the issuance of requisition by the using department or the stores departme

(*ii*) The other involves the issuance of a bill of materials.

- A purchase requisition (Fig. 23.5) forms the basis for action by the purchasing department. A purchase requisition contains the following data
  - (*i*) What material is required and of what quality ?
  - (*ii*) Quantity of material to be purchased.
  - (*iii*) Date by which the material is required.
  - (*iv*) Place at which the material should be delivered.
- Purchase requisition is prepared in duplicate and is signed by authorized individuals only.
- Purchase requisition is usually routed through the stores department in order to check whether the item is available in stores.

Requisition No.....

Date.....

Please order the under-mentioned for delivery on or before .....to.....

Quantity	*Description*	*Code No.*	*Requisition for*	*Unit price*
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

Quantity in stock.....

Maximum stock.....

Minimum stock.....

.....

Storekeeper

Order No.....

For use by Purchasing Department — Checked by.....

approved by....

Fig. 23.5. Purchase Requisition.

- A bill of material is used when standard parts and small expendable tools are to be purchased. The buyer works out total material requirements from the bill of material, goes through the list of existing inventories and finally decides the net materials to be purchased.

(*ii*) **Selection of possible potential sources of supply**

- This process consists of selecting a fair number of vendors in accordance with established guidelines, from whom quotations will be requested.
- For items which are purchased frequently, the buyer usually has a few preferred suppliers from whom he purchases regularly.
- For purchasing new items, reference may be made to one or more of the following from which information may be obtained.
  - (*a*) Catalogues,
  - (*b*) Trade journals,
  - (*c*) Advertisements,

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(*d*) Trade exhibitions and fairs, and

(*e*) Trade directories (classified).

– When considering a potential source of supply, the buyer should consider,

(1) whether to purchase from local market or farther afield ;

(2) whether to buy from a single vendor or from several vendors at a time ; and

(3) whether to purchase directly from manufacturers or through wholesalers.

(*iii*) **Making request for quotations**

– Request for quotations is made on prescribed quotation form (refer Fig.23.2) to all the selecte (possible) sources of supply.

– The request is not a purchase order, rather it is merely an enquiry to know whether the vendo can supply the desired material by the specified date and if so, then at what rate.

– Quotation form has printed on it the terms and conditions under which the buyer would like t purchase the material.

(*iv*) **Receipt and analysis of quotations**

– After receiving a number of quotations from different suppliers, they are studied and *comparative statement* (refer to Fig. 23.3) of rates and other terms and conditions mentioned i the quotations is prepared.

(*v*) **Selection of right source of supply**

– The comparative statement as prepared in step (*iv*) above serves a good guide in selecting th right source of supply.

– Other questions which might also be given a thought are,

1. Will vendor maintain quality ?
2. Will vendor supply material in time ?
3. Does the vendor have adequate facilities to handle the contract ?
4. How far the vendor's plant is situated ? etc.

(*vi*) **Issuing the purchase order**

– After selecting the right supplier, a purchase order (Fig. 23.6) is dispatched to him. The purchase order constitutes a legal document and it serves as the vendor's authority to ship the materials and bill the company.

– A purchase order once accepted by the vendor constitutes a contract for the delivery of the articles in accordance with the terms of purchase agreement.

– The purchase order is executed in six copies.

1. Two copies go to the supplier, one he preserves, other he signs and returns.
2. One copy goes to accounts section.
3. One copy goes to purchase service to follow-up the order.
4. One copy is sent to receiving department.
5. The last copy is kept in the files of the purchasing department.

(*vii*) **Follow-up and expediting the order**

– After placing the order, the purchase service section maintains contact with the vendor in order to,

1. Obtain information as to the progress of the order ;
2. ensure that delivery dates will be met ; and to
3. take corrective actions (such as transferring some of the orders to some other supplier, change the mode of shipment, *i.e.*, from rail road to air service etc.,) so that the materials can reach the plant as originally planned.

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PURCHASE ORDER
ABC HARDWARE COMPANY
6, Harrison Road
CALCUTTA

Order No.....

To
.....
.....
.....

Please enter our order for the following materials or services and note instructions given below.

Manager
Purchasing Department

Item No.	*Quantity*	*Description*	*Price*	
			Each	*Total*

1. Number of this order must appear on your invoice.
2. Please return attached acknowledgement of this order and state the delivery date.
3. Mail invoices, etc., on date of shipment.
4. Only, invoices covered by a signed purchase order will be processed.
5. Packing slip must accompany each shipment.
6. All materials shall be received subject to buyer's inspection and rejection.
7. An order may be cancelled if not fulfilled within a reasonable time.

Fig. 23.6. Purchase Order.

- Specially designed postcards containing the following information are frequently employed for routine follow-up.
  1. Purchase order Number.
  2. Pre-decided delivery date.
  3. Promising shipment date , etc.

(*viii*) **Analysing receiving reports and processing discrepancies and rejections**

- Receiving reports are the records of what has been actually received.
- Receiving reports are compared with the purchase order in order to find discrepancies, *i.e.*, variations in quantity, etc., if any.
- Discrepancies found if any during inspection as regards the quantity or quality of the received material should be promptly brought to the notice of the supplier.
- Before returning the material rejected during inspection at his end, it is necessary for the buyer to get the vendor's authorization for return and replacement.

(*ix*) **Checking and approving vendor's invoices for payment**

- Invoices should be checked to ensure that :
  1. the correct material (in quality and quantity) has been supplied ;
  2. the material has been supplied at agreed prices ; and
  3. agreed discounts have been given.

  After confirming the above, the payment is made to the vendor for the (value of) goods received

(*x*) **Closing completed orders**

- Before closing the completed orders, the file copy of the purchase order must be checked against both the receiving reports and the vendor's invoice and a notation of this fact should be made on it. It should then be removed and stored in the file of closed orders.

(*xi*) **Maintenance of records and files**

The final step in the purchasing procedure consists of filing the records of the transaction.

23.7. ACCOUNTING

- All purchase transactions initiate a chain of accounting transactions taking from charging the transaction to the proper account to the final payment of the bill.
- Basically, the checking of invoices is an accounting procedure which can be handled efficiently by the accounting department but unluckily when accounting department does so, it becomes a mere clerical routine procedure. Checking of invoices involves technical features also such as its (*i.e.*, invoice's) compliance with the description and specifications contained on the purchase order.
- For this reason and since large company funds and significant discounts are involved in accounting tasks, there should be close coordination between purchasing and accounting departments.

23.8. STORES AND MATERIAL CONTROL

23.8.1. Introduction

- Materials and supplies constitute the most important assets in the majority of business enterprises. The success of the business, besides other factors, depends to a large extent on the efficient storage and material control.
- Material pilferage, deterioration of material and careless handling of stores lead to reduced profits.
- Even losses can be incurred by concerns in which the store-room is available to all employees without check as to the quantities and purpose for which materials are to be used.

23.8.2. Requirements of a Material Control System

1. Proper coordination of departments such purchase, receiving, testing, storage, accounting, etc.
2. Making economy in purchase and use of materials.
3. Operating an internal check to verify all transactions involving materials, supplies, equipments, etc.
4. Storing materials and supplies properly in a safe place.
5. Operating a system of perpetual inventory to find at any time the amount and value of each kind of material in stock.
6. Setting of quantity standards.
7. Operating a system to see that right material is available to a department at the time of its need.
8. Keeping proper records of all material transactions.

23.8.3. Stores Management

Stores management takes care,

1. that the required material is never out of stock ;
2. that no material is available in (much) excess than required ;
3. to purchase materials on the principle of economic order quantity (refer chapter 24) so that the associated costs can be minimized ; and
4. to protect stores against damage, theft, etc.

This can be achieved through

1. A proper purchasing practice (*i.e.* when to order materials).
2. An adequate procedure of receipt and issue of materials.
3. Proper methods of storing materials.
4. An effective system of physical control of materials.
5. A proper method of keeping store records.

23.8.4. Functions of Stores Department and the Duties of the Storekeeper

1. To receive materials, goods and equipments, and to check them for identification.
2. To receive parts and components which have been processed in the factory.
3. To record the receipt of goods.
4. To correct positioning of all materials and supplies in the store.
5. To maintain stocks safely and in good and condition by taking all precautions to ensure that they do not suffer from damage, pilfering or deterioration.
6. To issue items to the users only on the receipt of authorised stores requisitions.
7. To record and update receipts and issues of materials.
8. To check the bin card balances with the physical quantities in the bins.
9. To make sure that stores are kept clean and in good order.
10. To prevent unauthorized persons from entering the stores.
11. To make sure that materials are issued promptly to the users.
12. To plan store for optimum utilisation of the cubic space (*i.e* length, breadth and height).
13. To ensure that the required materials are located easily.
14. To initiate purchasing cycle at the appropriate time so that the materials required are never out of stock.
15. To coordinate and cooperate to the full extent with the purchasing, manufacturing, inspection and production planning and control departments.

23.8.5. LOCATION AND LAYOUT OF STORES

23.8.5.1. Location

1. Location of the stores should be carefully decided and planned so as to ensure maximum efficiency.

2. The best location of stores is one that minimizes total handling costs and other costs related to stores operation and at the same time provides the needed protection for stored items and materials.

3. Store location depends upon the nature and value of the items to be stored and the frequency with which the items are received and issued.

4. In general, stores are located close to the points of use.

Raw materials are stored near the first operation, in-process materials close to the next operation, finished goods near the shipping area and tools and supplies in a location central to the personnel and equipment served.

5. All departments should have easy access to the stores and especially those which require heavy and bulky materials should have stores located nearby.

6. In big industries having many departments, stores department possibly cannot be situated where it is convenient to deliver materials to all departments and at the same time be near the receiving department ; thus it becomes often necessary to set up substores conveniently situated to serve different departments.

This leads to the concept of decentralized stores.

7. In *decentralized* stores system, each section of the industry (*e.g.*, foundry, machine shop, forging, etc.) has separate store attached with it ; whereas in centralised stores system, the main store located centrally fulfills the needs for each and every department.

– **Advantages of centralisation of stores**

(*i*) Better supervision and control.

(*ii*) It requires less personnel to manage and thus involves reduced related costs.

(*iii*) Better lay out of stores.

(*iv*) Inventory checks facilitated.

(*v*) Optimum (minimum) stores can be maintained.

(*vi*) Fewer obsolete items.

(*vii*) Better security arrangements can be made.

– **Advantages of decentralisation of stores**

(*i*) Reduced material handling and the associated cost.

(*ii*) Convenient for every department to draw materials, etc.

(*iii*) Less risk of loss by fire or theft.

(*iv*) Less chances of production stoppages owing to easy and prompt availability of material, etc.

An idea about the disadvantages of centralised and decentralised stores can be had from the advantages of decentralised and centralised stores (as explained above) respectively.

23.8.5.2. Layout

1. A good stores layout practice is one which usually brings the point or origin, store-room and point of use in adjacent and proper sequence for best flow of material.

2. Stores layout should be planned with the following objectives,

(*i*) To achieve minimum wastage of space.
(*ii*) To achieve maximum ease of operating.

3. Before planning the stores layout

(*a*) Classify all store items as follows,
(*i*) By measurement (*i.e.*, size)
(*ii*) By quantities (*i.e.* No. and weight) to be stored.
(*iii*) By frequency of handling.
(*iv*) By (material) handling arrangements.
(*v*) By possibility of perishing the items and the susceptibility to damage.

(b) List the available storage space

(*i*) Platforms
(*ii*) Floor space
(*v*) Bins
(*vi*) Trays

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(*iii*) Racks (*vii*) Drums

(*iv*) Shelves (*viii*) Barrels

(*c*) *Determine the sequence of laying out storage space for locating the materials*

(*i*) *A Unit.* It is the smallest space for storage which is given a particular identity.

(*ii*) *A Tier.* A Tier consists of a number of units placed vertically.

(*iii*) *A Row.* A row consists of a number of units joined together and spread horizontally.

(*iv*) *A section.* A section is made up of a group of rows.

(*d*) Study the size and shape of the space available for laying out the stores.

4. *The following factors should be considered while planning the stores layout* ;

(*a*) A section adjacent to the store-room should be kept reserved for the receipt of materials and for its inspection before storage.

(*b*) Store layout should be such that it provides for easy receipt, storage and disbursement of materials, preferably, nearest to the point of use.

(*c*) Store-room layout should minimise handling and transportation of materials.

(*d*) An ideal store-room layout makes optimum utilisation of the floor space and height.

(*e*) Shelves, racks, bins, etc., should be situated in clearly defined lanes, so that items are quickly stored and located for physical counting or issuing.

(*f*) Main lanes or aisles should usually be between 1.5 and 3 metres wide, depending upon the type of material and the amount of traffic involved.

Sub-aisles between racks and bins may be a minimum of 80 cm wide.

(*g*) Storage spaces should be clearly marked to ensure easy and quick identification.

(*h*) Storage space should be adequately protected against waste, damage, deterioration and pilferage.

(*i*) A place for storing a material should be decided depending upon the material characteristics, e.g. fuels and flammable gases will require separate locations, cement, welding electrodes and ferrous parts need a dry place for storing, etc.

- Portable and salable items should be stored in areas enclosed with wire-mesh partitioning so that all unauthorized persons can be kept outside that area.

(*j*) Store layout should be such that for its efficient operation it can make use of modern material handling equipments such as fork-lift coveyors, etc.

(*k*) Store layout should be such that the storekeeper is not compelled to put newly arrived material on the top of the old. As a rule, all the old stock should be consumed first before using the new one.

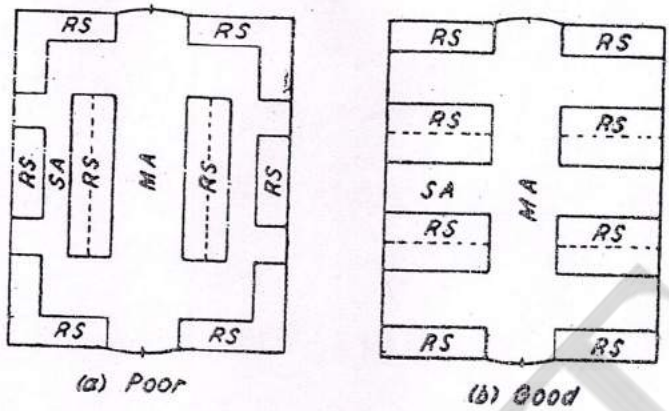
(*l*) Due space (20 to 25%) should be left in each portion of the store to allow for expansion.

(*m*) Figs 23.7 (a) and 23.7 (b) show a poor and a good layout of storage space.

23.9. RECEIPT AND ISSUE OF MATERIALS

23.9.1. Receipt of Materials

- All materials from outside sources are received by the Receiving Department.
- The receiving department unpacks the goods received and checks quantities and conditions (of the goods).
- There is a packing slip inside each package that tells what it is supposed to be and usually it gives the purchase order number.
- A copy of the purchase order (Fig. 23.6) if it exists with the receiving department, can be made use of to check the items received.



MA-Main aisle
SA-Side aisle
RS-Racks, shelves, platforms, etc.

Fig. 23.7. Storage space layout.

[N.B. For more information, refer to section 4.12]

– Otherwise, a *Materials Received Report* (Fig. 23.8) is prepared by the receiving department and is sent either to the purchase or to the accounting department to get the same checked against the purchase order.

MATERIALS RECEIVED REPORT

Received :
At.....
Delivery point
From..... .....
Vendor Address

Purchase Order No.....

Date.....

Quantity received	*Description*	*Grade*	*Condition of goods*

Counted by .....
Inspected by .....

Approved by .....
Title .....

Fig. 23.8. Materials Received Report.

– All the items after they have been received and before they are removed from the receiving department are *inspected and* sample tested to ensure that the purchase order specifications have been met.

– Results of the inspection and tests are indicated in special testing report, upon the basis of which *Clearance Report or Rejection Note* (Fig. 23.9) is prepared and sent by the inspection department to

(*a*) Purchase department.
(*b*) Production department, and
(*c*) Accounting department.

– In case of rejection, a part or whole of the consignment may be returned to the vendor, with a request either for a complete cancellation of the order or for replacement.

CLEARANCE REPORT
REJECTION NOTE

No.....
Date.....

Order No.....
Material .....
Supplier .....

THE ABOVE-MENTIONED MATERIALS
HAVE BEEN PASSED / REJECTED THROUGH INSPECTION

Details of examination :
.....
.....
.....

Reasons for rejections
.....
.....
.....

(Signed).....
Inspection Department

Goods received by
.....
(Storekeeper)

Fig. 23.9. A clearance report-cum-rejection note.

23.9.2. Issue of Materials

– Materials should be issued by the storekeeper to different departments, only upon receipt of a properly authorized withdrawal form-usually called a Material Issue Requisition form (Fig. 23.10).

MATERIAL REQUISITION

No.....

Material required for.....
(Job or Process)

Department..... Date.....

Sr. No.	*Description*	*Code No.*	*Quantity*		*Rate*	*Amount*	*Entered on store register page No.*
			Demanded	*Supplied*			

Requisitioned by ..... Approved by ..... Material Issued by ..... Received by .....

Fig. 23.10. Material Issue Requisition form.

– Material requisition is prepared in duplicate by the foreman or the manager depending upon the nature and amount of materials or goods to be withdrawn from the stores.
– Both the copies are sent to the storekeeper who issues the materials and records the quantities disbursed.

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- Both the copies are then forwarded to material accounting division for pricing and entry in the stock ledger.
- One copy of the material requisition is retained by the stock ledger clerk to be used as the basis for an entry in the Issued section of the stock ledger accounts. The balance section of the stock ledger accounts is then completed to show the new balance figures for quantity, cost, etc.
- The second copy goes to the foreman of the department who uses it as the basis for a charge to the appropriate production order for which he prepared the material requisition.

23.10. STORE RECORDS

- Two records are usually kept of materials and other goods received, issued or transferred – namely on *BIN (or STOCK) CARDS* and in the *STORE LEDGER.*
- Bin cards are written and kept in the stores, whereas store ledger is sometimes maintained by stores office or cost department.

This minimises the clerical work of the storekeeper and store ledger, *i.e.* stores accounting records are kept cleaner and accurate by an experienced personnel in the stores office or cost department.

23.10.1. Bin Cards

- In a store room, materials and other items are kept in appropriate bins, drawers or other receptacles ; some items are stacked, while others are racked.
- For each kind of material, a separate record is kept on a *BIN CARD* or *STOCK CARD* which shows details of quantities of each type of material received, issued and on hand each day. The storekeeper maintains bin cards up-to-date.
- Bin card is attached to each bin or shelf.
- A bin card is not considered as an accounting record ; it simply informs store-keeper of the quantities of each item on hand.

  Bin cards may be made in duplicate ; one card is attached to the bin (containing the material) and the second remains with the storekeeper on his table for ready reference to the quantity of any materials on hand.
- A bin card is used as a check on the stock ledger accounts in the material accounting division.
- Besides the details of the issue and receipt of materials, a bin card may contain the following information as well to increase it utility :
  - (*i*) The maximum and minimum quantity of each material to be carried out.
  - (*ii*) Normal quantity of each material to be ordered.
  - (*iii*) When certain materials or items require placing orders in advance, (*e.g.* when purchasing from some foreign country) an ordering level (between the maximum and minimum quantity) may be specified on the bin card so that the materials can be ordered and procured in time.
- Bin cards are checked periodically by the stores inspectors to see that they are accurately maintained. Discrepancies, if any, are noted.
- Fig. 23.11 shows a BIN (or STOCK) CARD.

23.10.2. Stores Ledger

- Store ledger is identical with bin card except that money values are shown.
- The ledger is usually of the loose-leaf or card type, each account representing an item of material in store.
- The store ledger accounts may be maintained by a separate material accounting department or in small concerns by the store-keeper himself.

BIN CARD

Bin No.....
Material.....
Code No.....
Stores Ledger Folio.....

Maximum Quantity.....
Ordering level.....
Minimum Quantity.....

Date	*Quantity Received*	*Quantity Issued*	*Balance*	*Remarks*

Fig. 23.11. BIN or STOCK CARD.

Fig. 23. 12 shows a *Stores Ledger Account.*

Entries in *ordered section* are made as a copy of purchase order is received from purchasing department.

STORES LEDGER ACCOUNT

Material..... Code..... Maximum Quantity.....
Bin No..... Folio..... Minimum Quantity.....

ORDERED				*RECEIVED*					*ISSUED*						*BALANCE*		
Date	*P.O. No.*	*Q*	*D.E.*	*Date*	*P.O. No.*	*Q*	*Unit cost*	*Total cost*	*Date*	*R No.*	*Deptt*	*Q*	*Unit cost*	*Total cost*	*Q*	*Unit cost*	*Total cost*

P.O. No. - Purchase order No.
Q - Quantity
D.E. - Date expected
R. No. - Requisition No.

Fig. 23.12. Stores Ledger Account.

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- After the material has been received and checked, the entries are made in the *Received section* from the invoice or the receiving department report.
- Entries are made in the Issued section from material requisitions received from store keepers for materials issued to different departments.

23.11. CODIFICATION OF MATERIALS

(Note : Refer to section 5.10.2 also)

- The use of material specification code numbers is an advantage, not only to the purchase department and drawing office, but also to the pricing clerk in the cost department, in that ambiguity is eliminated.
- Each material or item in the stores should be clearly identified so that the same can be easily located at the time of need. This is achieved by allocating CODE numbers.
- The code should be meaningful and impart a unique identity to each material.

If a material is described by its trade name, as well as by a serial number and also by its function, it is quite likely that different quantities of the same material might be located at three different places in the same store. This increases size of the inventory and creates an unnecessary confusion. Codification of materials removes this difficulty and avoids duplication of materials.

- A code consists of a combination of letters and numbers. The objective is to progress from general to particular.

Examples of material codes

(*a*) – B.S. 609 means Brass Screw 6 mm x 9 mm

– S.S. 815 means Steel Screw 8 mm x 15 mm

(*b*) Another code may be made up as follows :

Class	1* * *	– * * Primary material
Sub-class	* 1 * *	– * * Iron and carbon steel
Group	* * 6 *	– * *Bar
Series	* * * 4	– * * Mild Steel
	* * * *	– 8*8 mm diameter
	* * * *	– * B Bright (bar)

Thus 1164-8B implies a bright mild steel bar 8 mm diameter.

(*c*) ACC/TA/6–implies air-conditioner compressor, top assembly part number 6.

23.12. PHYSICAL VERIFICATION OF STORES (OR STOCK TAKING)

(A) Necessity of :

Physical verification of stores is essential in order to :

(*i*) ensure the correctness of stocks held by comparing them with the balance shown in the store ledger or bin cards ;

(*ii*) avoid shortages of materials in the stock ;

(*iii*) check losses in inventory due to

- pilferage ;
- improper storage or misplacement ;
- deterioration, etc.

(*iv*) correct and update store-records ;

(*v*) calculate the values of stock carried for the balance sheet and profit and loss account ;

(*vi*) calculate the rate of turn-over of an item ;

(*vii*) ensure maximum economy in stock carrying ;

(*viii*) effect insurance covers.

(B) Disadvantages of Physical stock taking

(*i*) Loss in production ; unless and until during period of physical stock taking, plant overhaul etc. is planned.

(*ii*) Labour and over-time expenses in carrying out stock taking (in order to complete it in a shorter duration of time).

Disadvantages of physical stock taking are minor as compared to the advantages achieved through it.

(C) Methods of physical stock taking

1. Annual Physical verification.

2. Perpetual Inventory and Continuous Stock Taking system.

1. Annual Physical Verification

(*i*) Near the year end, stores are closed for a few days ; no material, etc. is issued to any shop in the plant. In case this leads to plant shut down, activities such as repair and overhaul of equipment and machinery are resorted to.

(*ii*) A team of stores inspectors or stores verifying officers physically check and count each and every item laying in the complete store. They tally it with the quantities marked on bin cards and store ledgers.

(*iii*) Step (*ii*) above leads to the formation of a list of surplus and short items.

Damaged and obsolete items can also be traced and recorded.

(*iv*) Inspectors check a number of item everyday as per a preplanned schedule and finish the complete work within a few days.

(*v*) This method of stock taking is advantageous in the sense that all the items are checked at one time, so there is no confusion about any item being left unchecked.

Moreover, this method helps recording discrepant items at one time and at one place.

2. Perpetual Inventory and continuous Stock Taking system

(*i*) Annual Physical verification method may work well for a small plant involving a limited number of store items, because it is not economical to shut down a large plant involving huge inventory quantities for a number of days.

(*ii*) A more appropriate method for large plants is – the Perpetual Inventory and Continuous Stock Taking System which records store balances after every receipt and issue and facilitates regular checking and obviates closing down of the plant for stock taking.

(*iii*) Under this system, store items are checked continuously throughout the year ; a number of items are counted daily or at frequent intervals and checked (compared) with the bin cards and stores ledger.

(*iv*) Discrepancies found if any, owing to incorrect entries, breakage, pilferage, over-issue, placing of items in wrong bin, etc., are investigated and corrected accordingly.

(*v*) Every item of the store is checked atleast once or twice a year.

(*vi*) To reduce the work load, an item is checked generally when it reaches its minimum level.

Advantages. The perpetual inventory and continuous stock taking system claims the following advantages :

1. It is not necessary to close down the plant or stop production for stock taking.

2. Since, only a few items are to be checked every day, as compared to annual physical verification,

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this method is less costly, less tiring, less cumbersome and hence is more accurate.

3. Discrepancies and incipient defects in the stores system are readily discovered and can be rectified before much damage through loss or irregular practices has occurred.

4. Slow moving stocks can be noted and, where necessary, action may be taken to prevent their accumulation.

5. The audit extends to comparing the actual stock with the maximum and minimum level and thus ensures that stocks are kept within the limits specified.

6. Since, stock is kept within the specified limits, the capital invested in the store-items cannot exceed the amount arranged and prescribed for the same.

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24

Inventory Control and Management

24.1. INVENTORY

Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in good working order. The quantity and the value of every item is also mentioned in the list.

Inventory is actually 'money' kept in the store room in the shape of a high speed steel bit, a mild steel rod, milling cutters or welding electrodes.

24.2. INVENTORY CONTROL

- Inventory control is concerned with achieving an optimum balance between two competing objectives. The objectives are :
  - (*i*) to minimize investment in inventory,
  - (*ii*) to maximize the service levels to the firm's customers and its own operating departments.
- Inventory control may be defined as the scientific method of finding out how much stock should be maintained in order to meet the production demands and be able to provide right type of material at right time in the right quantities and at competitive prices.

24.3. INVENTORY CLASSIFICATION

Inventory may be classifed as follows :

(i) Raw inventories. They include, raw material and semifinished products supplied by another firm and which are raw items for the present industry.

(ii) In-process inventories. They are semi-finished goods at various stages of manufacturing cycle.

(iii) Finished inventories. They are the finished goods lying in stock rooms and waiting dispatch.

(iv) Indirect inventories. They include lubricants and other items (like spare parts) needed for proper operation, repair and maintenance during manufacturing cycle.

24.4. INVENTORY MANAGEMENT

- To manage these various kinds of inventories two alternative control procedures can be used

(i) Order point system

- This has been the traditional approach to inventory control. In this system, the items are restocked when the inventory levels become low.
- Lot size and reorder point calculations are the more spectacular aspect of *inventory management*. Once the calculations are complete, the routing commences for checking deliveries and physical countpf the amount on hand.

(2) Materials Requirments Planning (MRP)

- MRP is sometimes thought of as an inventory control procedure. It is really more than that.
- MRP is the technique used to plan and control manufacturing inventories.
- MRP is a computational technique that converts the master schedule for end products into a detailed schedule for the raw material and components used in the end products.

The detailed schedule identifies the quantities of each raw material and component item. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products.

It is important that the proper *control procedure* be applied to each of the four types of inventory as explained earlier.

In general, *MRP* is appropriate control procedure for inventory type (*i*) and (*ii*) (*i.e.* raw materials, purchased components and in-process inventory).

Order point systems are often considered as the appropriate procedure to control inventory types (*iii*) and (*iv*) (*i.e.* finished goods, maintenance and repair parts, cutting tools and fixtures, plumbing supplies etc.).

24.5. INVENTORY CONTROL, ITS OBJECTIVES AND HOW TO ACHIEVE THEM

Inventory control aims at keeping track of inventories. In other words, inventories of required quality and in desired quantities should be made available to different departments as and when they need. This is achieved by,

(*a*) Purchasing material at an economical price, at proper time and in sufficient quantities so as not to run short of them at any instant.

(*b*) Providing a suitable and secure storage location.

(*c*) Providing enough storage space.

(*d*) A definite inventory identification system.

(*e*) Adequate and responsible store room staff.

(*f*) Suitable requisition procedure.

(*g*) Up-to-date and accurate record keeping.

(*h*) Periodic inventory check up.

(*i*) Division of inventory under *A*, *B* and *C* items, exercising the control accordingly and removing obsolete inventroy.

A good control over the inventories offers the following Advantages

(*a*) One does not face shortage of materials.

(*b*) Materials of good quality and procured in time minimises defects in finished goods.

(*c*) Delays in production schedules are avoided.

(*d*) Production targets are achieved.

(*e*) Accurate delivery dates can be ascertained and the industry builds up reputation and better relations with customers.

24.6. FUNCTIONS OF INVENTORIES

Inventories

1. Separate different operations from one another and make them independent, so that each operation (starting from raw material to finished product) can be performed economically. For example, ordering of raw material can be carried out independently of the finished goods distribution and both of these operations can be made low cost operations say by ordering raw material and distributing finished goods in one big lot, than in small batch sizes. Besides economy, the men and machinery also can be better utilized if the operations are separated and carried out in various departments than if coupled and tied at one place.

2. Maintain smooth and efficient production flow.

3. Purchase in desired quantities and thus nullify the effects of changes in prices or supply.

4. Keep a process continually operating.

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5. Create motivational effect. A person may be tempted to purchase more if inventories are displayed in bulk.

24.7. ECONOMIC ORDER QUANTITY

Concept. A problem which always remains is that how much material may be ordered at a time. An industry making bolts will definitely like to know the length of steel bars to be purchased at any one time. This length of steel bars is called 'Economic Order Quantity" and an economic order quantity is one which permits lowest cost per unit and is most advantageous.

Before calculating economic order quantity it is necessary to become familiar with terms like maximum inventory, minimum inventory, standard order and reorder point, which are known as *Quantity Standards*. Figure 24.1 shows different quantity standards.

Starting from an instant when inventory OA is in the stores, it (inventory) consumes gradually in quantity from A along AD at a uniform rate. It is preknown that it takes L number of days between initiating order and receiving the required inventory. Therefore as the quantity reaches point B, purchase requisition is initiated which takes from B to C, that is time R. From C to D is the inventory procurement time P. At the point D when only reserve stock is left, the ordered material is supposed to reach and again the total quantity shoots to its maximum value, *i.e.* the point $A'(A=A')$.

Maximum Quantity OA is the upper or maximum limit to which the inventory can be kept in the stores at any time.

Minimum Quantity OE is the lower or minimum limit of the inventory which must be kept in the stores at any time.

The purpose should be to hold enough and not excessive stock of material. *Stock holding:*

(*a*) Avoids running out of stock.

(*b*) Helps creating a buffer stock which may be utilized if the material falls below the minimum level.

(*c*) Makes sure the predecided delivery dates.

(*d*) Provides quick availability of materials.

(*e*) Takes care of price fluctuations and shortage of inventory in the market.

(*f*) Advises regarding, obsolete and slow moving items.

(*g*) Helps in standardization and thus reducing the variety of items to be handled.

Standard Order. ($A'D$) is the difference between maximum and minimum quantity and it is known as economical purchase inventory size.

Reorder Point (B) indicates that it is high time to initiate a purchase order and if not done so the inventory may exhaust, and even reserve stock utilized before the new material arrives.

From B^1 to D^1 it is *as lead time* (L) and it may be calculated on the basis of past experience. It includes :

(*a*) time to prepare purchase requisition and placing the order ;

(*b*) time taken to deliver purchase order to the seller;

(*c*) time for seller (vendor) to get or prepare inventory; and

(*d*) time for the inventory to be dispatched from the ventor's end and to reach the customer.

Time, (*a*) above is known as requisition time (R) and (*b*) +(*c*) +(*d*) is the procurement time (P).

The economic lot size for an order or the economic order quantity depends upon two types of costs :

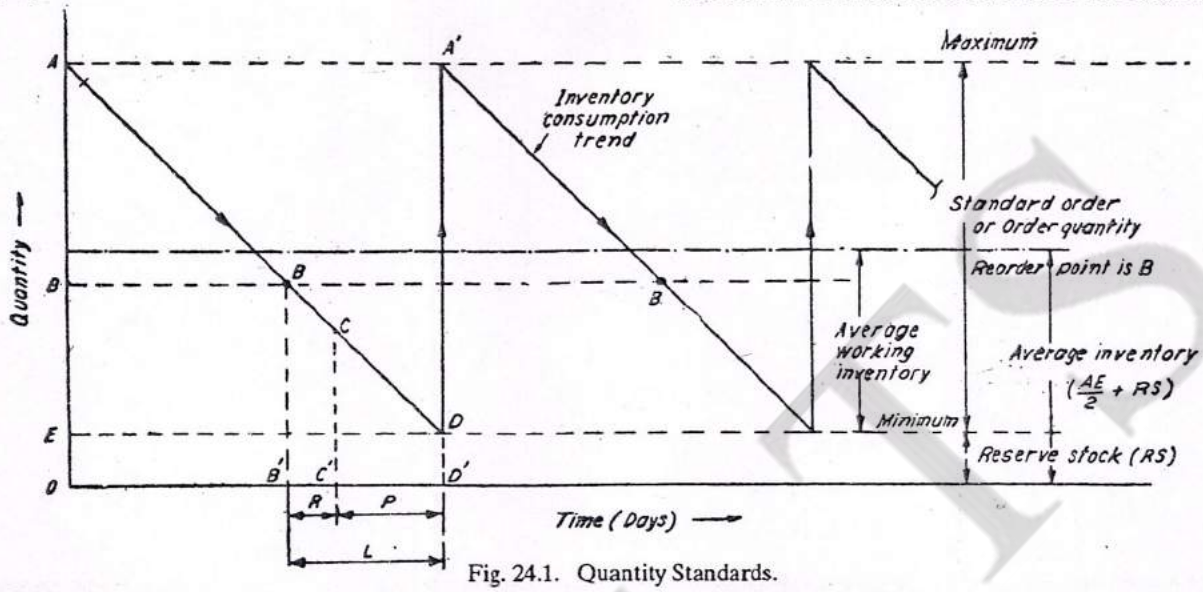


Fig. 24.1. Quantity Standards.

(*a*) *Inventory procurement costs, which consist of expenditure connected with*

1. receiving quotations;
2. processing purchase requisition;
3. following up and expediting purchase order;
4. receiving material and then inspecting it; and
5. processing seller's (vendor's) invoice.

Procurement costs decrease as the order quantity increases (see Fig. 24.2)

(*b*) Carrying costs, which vary with quantity ordered, base on average inventory and consist of :

1. interest on capital investment;
2. cost of storage facility, up-keep of material, record keeping etc ;
3. cost involving deterioration and obsolescence ; and
4. cost of insurance, property tax, etc.

Carrying costs are almost directly proportional to the order size or lot size or order quantity,

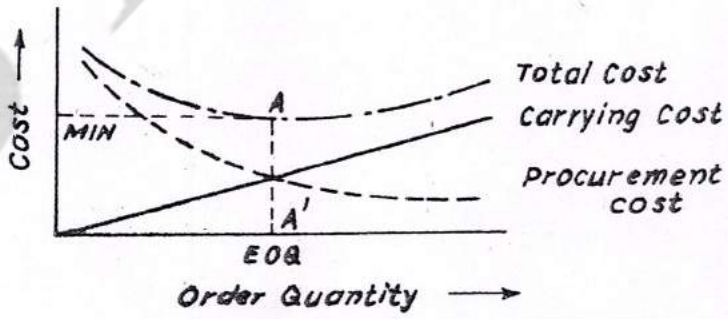


Fig. 24.2. Relationship between cost and quantity

In Fig. 24.2 the procurement costs and inventory carrying costs have been plotted with respect to quantity in lot. Total cost is calculated by adding procurement cost and carrying cost. Total cost is minimum at the point *A* and thus *A'* represents the economic order quantity or economic lot size.

Another method of finding *E.O.Q.* that is by mathematical means, is given below :

Let Q is the economic lot size or *E.O.Q.*

C is the cost for one item.

I is the cost of carrying inventory in percentage per period, including insurance, obsolescence, taxes etc.

P is the procurement cost associated with one order.

and U is total quantity used per period say annually.

Number of purchase orders to be furnished

$$= \frac{\text{Total quantity}}{E.O.Q.} = \frac{U}{Q}$$

Total procurement cost = Number of purchase orders x cost involved in one purchase or procurement

$$= \frac{U}{Q} \times P \qquad ...(a)$$

Average annual inventroy $= Q/2$

Inventory carrying cost = Average inventory × cost per item × cost of carrying inventory in percent per period.

$$= \frac{Q}{2} \times C \times I \qquad ...(b)$$

Total cost, $T = (a) + (b)$

$$T = \frac{U \times P}{Q} + \frac{Q}{2} \times C \times I$$

$$T = U.P.Q^{-1} + \frac{Q}{2} \times C \times I$$

To minimize the total cost, differentiate T, *w.r.t.*, Q and put it equal to zero

$$\frac{dT}{dQ} = \frac{d}{dQ}\left(U.P.Q^{-1} + \frac{Q}{2} \times C \times I\right)$$

$$0 = -U.P.Q^{-2} + C.I/2 \text{ or } UP/Q^2 = C.I/2$$

$$Q^2 = 2U.P./C.I.$$

$$Q = \sqrt{\frac{2\,U.P.}{C.I.}} \qquad ...(i)$$

***Example 24.1** : Given that*

(*i*) Annual usage, U=60 units

(*ii*) procurement cost, P=Rs.15 per order

(*iii*) cost per piece, C=Rs. 100

(*iv*) cost of carrying inventory I, a percentage including expenditure on obsolescence, taxes, insurance, deterioration etc. = 10%. Calculate *E.O.Q.*

Solution :

$$Q = \sqrt{\frac{2\,U.P}{C.I}}$$; substituting the values

$$Q = \sqrt{\frac{2 \times 60 \times 15}{100 \times (10/100)}} = 13.41$$

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Therefore, number of order per year $= \frac{60}{13.41} = 4.47$ say 5.

Hence Q or E.O.Q $= \frac{60}{5} = 12$ units (Ans.) (rounded)

The readers may try the following problems.

Problem : 24.1 : The rate of use of a particular raw material from stores is 20 units per year. The cost of placing and receiving an order is Rs. 40. The cost of each unit is Rs 100. The cost of carrying inventory in per cent per year is 0.16 and it depends upon the average stock. Determine the economic order quantity. If the lead time is 3 months, calculate the reorder point [Ans. 10, 5 units]

Problem : 24.2 : Find Economic Order Quantity from the following data :

Average annual demand	= 30,000 units
Inventory carrying cost	= 12% of the unit value per year
Cost of placing on order	= Rs. 70
Cost of unit	= Rs 2

[Ans. 4183,4286 (rounded figure)]

Problem : 24.3 : A factory uses two pieces per day of a rod 6 mm in diameter and 150 mm long in one of their manufacturing processes. The rod costs Rs. 3 each and the total expenses involved in purchasing and receiving them are Rs. 50 per order. The annual inventory carrying cost per item is Re. 1. The procurement period is 3 days and minimum stock kept is 8 pieces. Find out,

(*i*) Standard ordering quantity,
(*ii*) Reorder point, and
(*iii*) maximum stock,

[Ans. (*i*) 245,200 (rounded), (*ii*) 14, and (*iii*) 208]

24.8. INVENTORY MODELS

Concept

- Inventory models determine when and how much inventory to carry.
- Inventory models handle chiefly two decisions.
  (1) How much to order at one time, and
  (2) When to order this quantity to minimize total costs.
- Lowest-cost decision rules for inventory management pertain to either buying products from ouside or producing them within the company.
- *Simple inventory models* assume no delivery delay and that demand is known.
- *Probabilistic models* handle situations of risk and uncertainty.

Types of inventory models

(1) Simple EOQ model,
(2) EOQ model with stockouts allowed,
(3) Inventory models under risk.

(1) Simple EOQ model

- The simple EOQ model can be used if the demand is known with certainty
- The demand and lead time are known.
- The item will be purchased from outside (the firm) and that demand will continue well into the future.
- It is also assumed that not only the demand is known with certainty, but that is the same from day to day and that stockouts, are not allowed. Under these assumptions, Fig 24.3 depicts the inventory position through time.

– If we start to observe the inventory position immediately after receipt of an order, the quantity in stock Q decreases steadily until a lead time's supply is reached. If *lead time* (L) is 5 days and demand is 4 (pieces) per day, a lead time's supply is 20 pieces or units. Therefore when 20 units remain in the store, an order is placed. This is called the *re-order pointr.* Exactly 5 days after the order is placed, the stock is replenished and the cycle repeats itself.

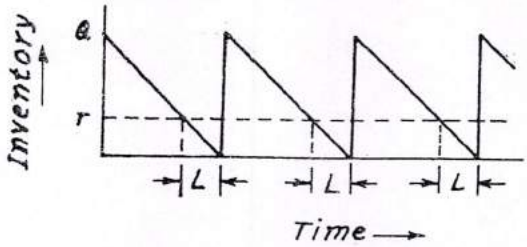


Fig. 24.3. Time pattern for inventory level for simple EOQ model.

– for further details refer article 24.7.

(2) EOQ Model with stockout allowed

– *Stockout* means runnning out of stock.

– In simple EOQ model, the stock was always available.

– The *out of stock* position will lead to a *back order.* This situation is frequently found in mailing-order houses where an item is temporarily out-of-stock and the customer is willing to wait until it is replenished.The firm does suffer some cost in this situation, since, at the very least, some expediting and extra communication (perhaps in the form of telephone calls or postcards) with the customer, must take place. In addition to the explicit costs, repeated backorders will certainly lead to an erosion of goodwill.

In some situations, backorders may be economically justified. For instance, with very high-value items such as commercial jet planes, no invetory is carried and a backorder state always exists.

– The second possible outcome of an out-of stock position is the *lost sales.* Here the cost is much more severe. In this case, the customer places an order, receives an out-of-stock response, and takes his business elsewhere. The company must take into account the likelihood that the customer will not return and that thererfore the profit on future sales might also be lost. In addition, the loss in goodwill that this will precipitate may also persuade others to purchase elsewhere.

– Since backorder and lost sales costs are hard to estimate, service levels are frequently specified. For exmaple, management may feel that stockouts should not occur more than 2% of the time.

– Fig 24.4 shows time pattern of inventory levels when stockouts are incurred.

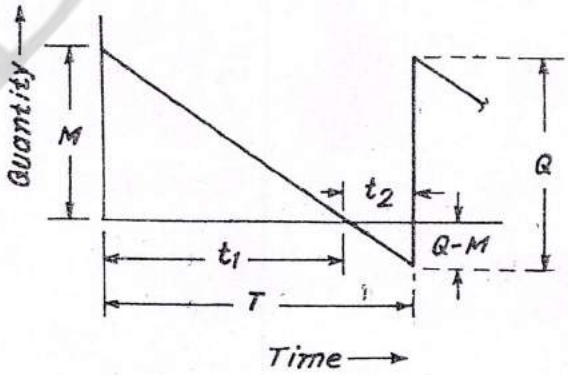


Fig. 24.4. EOQ Model with stokouts allowed.

In this case

$$Q = \sqrt{\frac{2UP}{CI}}\sqrt{\frac{CI+B}{B}} \quad \text{and } M = \frac{QB}{CI+B}$$

where Q is Economic order quantity

U is Annual use

P is Procurement cost per order

C is cost per piece

I is cost of carrying inventory, a percentage–including insurance, obsolescence, taxes etc.

B is cost incurred for every backorder

M is maximum inventory.

Example 24.2

Find Q and M from the following data :

U= 10,000 units, P= Rs. 100 per order, C = Rs. 10 per unit

B=Rs 15 per each backorder incurred, I = 20%

Solution

$$Q = \sqrt{\frac{2UP}{CI}}\sqrt{\frac{CI+B}{B}}$$

$$= \sqrt{\frac{2\times 10{,}000\times 100}{10\times\left(\frac{20}{100}\right)}}\sqrt{\frac{10\times\left(\frac{20}{100}\right)+15}{15}} = 1000\times 1.064 = 1064 \text{ (Ans)}$$

$$M = \frac{QB}{CI+B} = \frac{1064\times 15}{10\times\left(\frac{20}{100}\right)+15} = 938.82 \text{ (Ans)}$$

(3) Inventory model under risk

- In the simple EOQ model it was assumed that demand and lead time were both known with certainty. Under this condition, whenever inventory levels reached a lead time's worth of demand, an order was placed. Then as the stock was finally depleted, a replenishment order would arrive.
- We did find, however, that if backorders had a *finite* cost, a reorder level below the average lead time demand may be appropriate. This strategy would result in some desired number of backorders. We can, therefore, conclude that the purpose of reorder levels is not to prevent stockouts, but to keep them within desired limits.
- In the case of *fluctuating demand,* it may be quite logical to set reorder levels above the average lead time demand; for if we reorder when there is only enough in stock to meet the average demand during lead time, an out-of stock position will occur whenever demand exceeds this average value. To protect from undesirably large stockout situations, *safety stocks* (reserves) are maintained.

  They will provide the cushion needed whenever demand exceeds this average.
- Safety stocks (OS) can be defined as the difference between the reorder level and the average lead time demand (Fig. 24.5) Therefore as the reorder point is raised, the safety stock increases and the likelihood of a stockout during any cycle decreases.
- Fig. 24.5 shows the inventory pattern through time for a particular item which exhibits fluctuating demand.

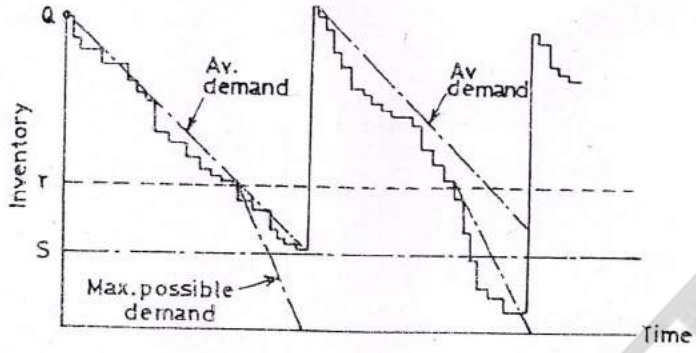


Fig 24.5. Inventory levels under conditions of fluctuating demand.

– An order is placed whenever stock levels fall to '*r*'. On the average, stock will be depleted to '*s*' when the replenishment order arrives. During the first cycle we see that demand was about average; however in the second cycle (Fig. 24.5) the demand was much greater than average. Protecting the system from a stockout during the lead time, was a safety stock maintained at *S*. If more protection was desired, the level of 'r' could have been increased. With a higer 'r', the safety stock would have been larger and the chances of a stockout occurring in any one cycle would have been lower.

Table 24.1

Lead time demand, u	*p(u)*	*Probability that demand will exceed u*
43	0.00	1.00
44	0.02	0.98
45	0.03	0.95
46	0.04	0.91
48	0.09	0.74
50	0.10	0.54
52	0.10	0.33
54	0.08	0.16
56	0.05	0.04
58	0.01	0.00

– Table 24.1, was compiled from data collected over several periods.

When $p(u) = 0.02$, it implies that for 2% of these periods demand was 44, in 3% of them, demand was 45 and so on.

The last column in Table 24.1 illustrates the probability that demand will exceed any of these levels, u. For example, the probability that demand will exceed 56 units is 0 04. The last column will be very useful for setting safety stocks when a service criterion is given.

– In many cases, it might be quite difficult to determine the actual cost of a stockout. An indirect way to assess this is to specify a service level. For example, the manager of the product line whose lead time was recorded in Table 24.1 might feel that the likelihood of a stockout should not exceed 4% during any one cycle. Therefore, the reorder point should be set at $r=56$. We would, therefore, expect an out-of-stock situation to occur in only one out of 25 ordering periods.

24.9. ABC ANALYSIS

24.9.1. Necessity

As the size of the industry increases, the number of items to be purchased and then to be taken care of also increases. Purchase and control of all items at a time and in bulk much before their use, irrespective of their usage value, price or procurement problems, blocks and involves a lot of money and man hours, and is therfore uneconomical.

ABC analysis helps segregating the items from one another and tells how much valued the item is and controlling it to what extent is in the interest of the organisation.

24.9.2. Procedural Steps

1. Identify all the items used in an industry.
2. List all the items as per their value.
3. Count the number of high valued, medium valued and low valued items.
4. Find the percentage of high, medium and low valued items. High valued items normally contribute for 70% or so of the total inventory cost and medium and low valued items, 20 and 10% respectively.
5. A graph can be plotted between percent of items (on *X*-axis) and per cent of total inventory cost (on *Y*-axis). Figure 24.6 shows such a graph.

It can be seen that 70% of the total inventory cost is against 10% of the total items (called *A*-items), 20% against 20% of the items (*B*-items) and 10% against a big bulk, *i.e.* 70% of the items (called *C*-items).

Thus *ABC* analysis furnishes the following information :

1. *A*-items are high valued but are limited or few in number. They need careful and close inventory control. Minimum and maximum limits, and reorder point is set for *A* items. Such items should be thought of in advance and purchased well in time. A detailed record of their receipt and issues should be kept, and proper handling and storage facilities should be provided for them.

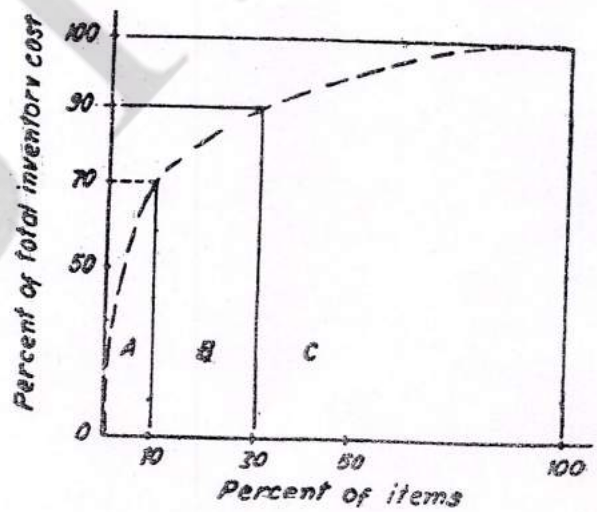


Fig. 24.6. ABC analysis.

Such items being costly are purchased in small quantities oftenly and just before their use. This of-course increases the procurement costs and involves a little risk of non-availability. However, the locked up inventory cost decreases and the problems of storage and care taking are minimized.

A-items generally account for 70-80% of the total inventory cost and they constitute about 10% of the total items.

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2. *B*-items are medium valued and their number lies in between A and C-items. Such items need moderate control. They are more important than C-items. They are purchased on the basis of past requiements, a record of receipts and issues is kept and a procurement order is placed as soon as the quantity touches reorder point. These items being comparatively less costly, a safety stock of up to 3 months may be kept, whereas it needs a stock of fortnight or so in case of *A* items. *B*-items also require careful storage and handling.

In brief, *B*-items need every care but not so intensive as is required for *A*-items.

B-items generally account for 20 to 15% of the total inventory cost and constitute about 15 to 20 % of the total items.

3. *C*-items are low valued, but maximum numbered items.

These items do not need any control, rather controlling them is uneconomical. These are the least important items like clips, all pins, washers, rubber bands, etc. They are generally procured just befor they finish. No expediting is necessary, no records are normally kept and a safety stock of 3 months or even more can be purchased at an instant. Future requirements of such items are never calculated and a two bin system is sufficient to hint procurement.

C-items generally account for 10 to 5% of the total inventory cost and they constitute about 75% of the total items.

24.10. MATERIAL REQUIREMENTS PLANNING (MRP)

Introduction

- As explained earlier, MRP is a computational technique that converts the *master schedule* for end products into a *detailed schedule* for raw material and components used in the end products. The detailed schedule identifies the quantities of each raw material and component items. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products.

  The purpose of MRP is to ensure that materials and components are available in the right quantities and at the right time so that finished products can be completed according to the master production schedule.
- MRP is often considered to be a subset of inventory control. It is an effective tool for minimizing unnecessary inventory investment.

  MRP is also useful in production scheduling and purchasing of materials.
- The concept of MRP is relatively straight forward. What complicates the application of the technique is the sheer magnitude of the data to be processed.

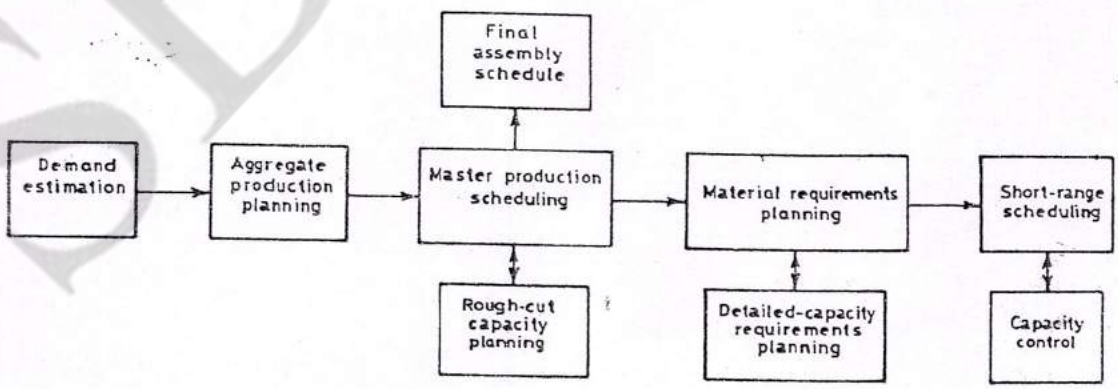


Fig 24.7. Production Planning and Scheduling Process

Functions

An MRP system has three major *Functions/uses* :

1. Control of inventory levels,
2. Assignment of priorities for components, (depending upon their delivery dates) and
3. Determination of *capacity requirements* at a detailed level.

Capacity requirements planning (CRP) is a system for determining if a planned production schedule can be accomplished with available capacity and, if not, making adjustments as necessary.

Inputs to MRP

– MRP converts the master production schedule into the detailed schedule for raw materials and components. For the MRP program to perform its function, it must operate on the data contained in the master schedule. However, this is only one of three sources of input data on which MRP relies. The three inputs to MRP are :-

1. The master production schedule and other order data.
2. The bill-of-material file, which defines the product structure.
3. The inventory record file.

Fig 24.8 shows the flow of data into the MRP processor and its conversion into useful output reports.

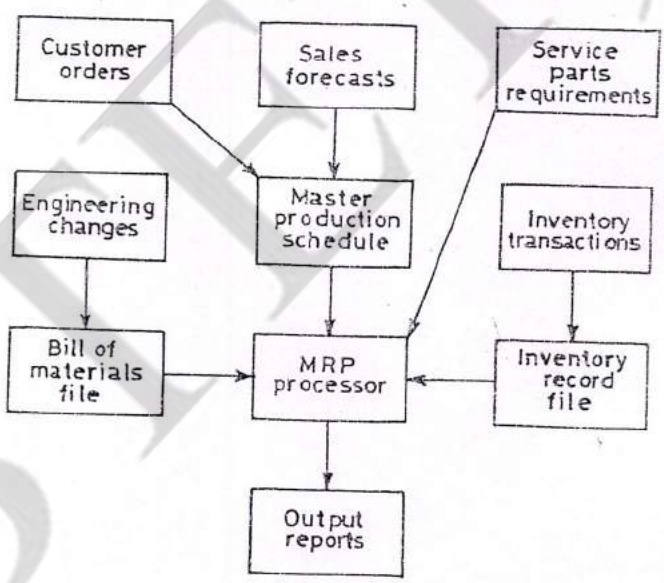


Fig. 24.8. Structure of an MRP system.

Master production schedule

– The master schedule is based on an accurate estimate of demand for the firm's product, together with a realistic assessment of its production capacity.

– The master production schedule (Fig. 24.9) is a list of what end products are to be produced, how many of each product is to be produced, and when the products are likely to be ready for shipment.

– The general format of a master production schedule is illustrated in Fig 24.9. It may show weekly or monthly delivery schedules.

Week number	6	7	8	9	10
Product P1			50		100
Product P2		70	80	25	
etc.					

Fig. 24.9. Master production schedule for products P_1 and P_2 showing week delivery quantities.

Bill-of-materials file

- In order to compute the raw material and component requirements for end products listed in the master schedule, *the product structure* must be known. This is specified by the *bill-of-materials* which is a list of component parts and sub-assemblies that make up each product. Putting all these assembly lists together, we have the bill-of-materials file (BOM).
- Fig 24.10 shows the structure of an assembled product. It shows, subassembly S_1 is the *Parent* of components C_1, C_2 and C_3. Product P_1 is the parent of sub assemblies S_1 and S_2 and so on.

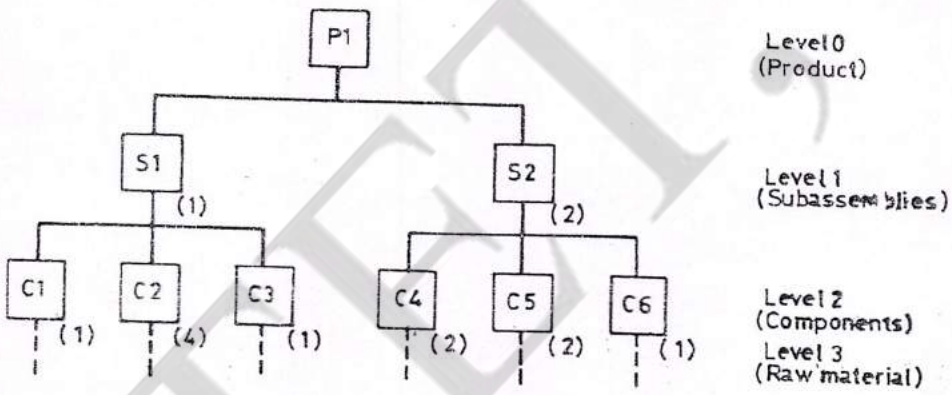


Fig 24.10. Product structure for product P_1

The product structure must also specify how many of each item are included in its parent. This is accomplished in Fig. 24.10 by the number in parentheses to the rigth and below each block. For example, subassembly S_1 contains four of components C_2 and one each of components C_1 and C_3.

Inventory record file

- It is mandatory in MRP to have accurate current data on inventory status. This is accomplished by utilising a computerized inventory system which maintains the *inventory record file* or *item master file*. (Fig. 24.11)
- A definition of the lead time for the raw material, components and assemblies must be established in the inventory record file. The ordering lead time can be determined from purchasing records. The manufacturing lead time can be determined from the process route sheets.

It is important that the inputs to the MRP processor be kept current. The bill-of-materials file must be maintained by feeding any engineering changes that affect the product structure into the BOM. Similarly, the inventory record file is maintained by inputing the inventory transactions to the file.

Working of MRP

- The MPR processor (Fig 24.8) operates on data contained in the master schedule, the bill-of-materials file and the inventory record file.

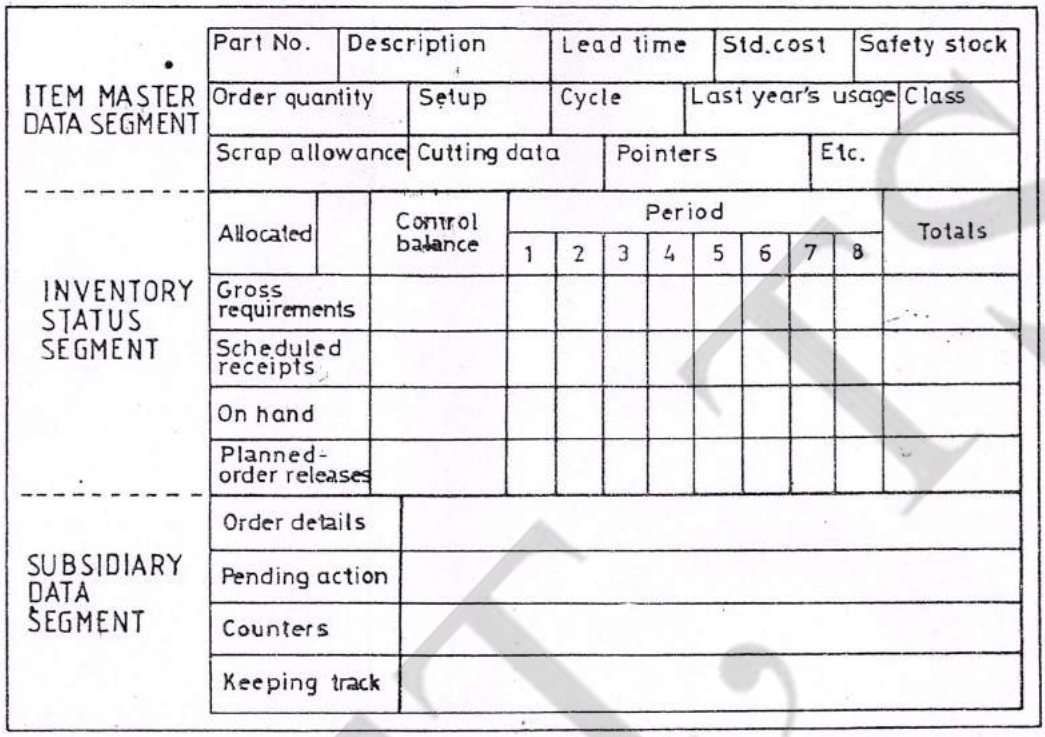


Fig. 24.11. Record of an inventory item.

– The *master schedule* specifies a period-by-period list of final products required.

The *BOM* defines what materials and components are needed for each product.

The *inventory record file* contains information on the current and future inventory status of each component.

– The MRP program computer – how many of each component and raw material are needed by *exploding* the end product requirements into successively lower levels in the product structure.

Referring to master schedule (Fig 24.9), 50 units of product P_1 explode into 50 units of subassembly S_1 and 100 units of S_2 and components : $C_1=50$, $C_2=200$, $C_3=50$, $C_4=200$, $C_5=200$ and $C_6=100$ units. The quantities of raw materials for these components would be determined in a similar manner.

– There are several *factors* that must be considered in the MRP parts and materials explosion.

(1) Components and subassemblies already existing in the stock must be considered for determining requirements for meeting the master schedule.

(2) The MRP processor must determine when to start assembling the subassemblies by offseting the due dates for these items by their respective manufacturing lead times. Similarly, the component due dates must be offset by their manufacturing lead times.

The MRP program performs these lead-time-offset calculations from data obtained in the inventory record file and from route-sheet data.

(3) Some components and many raw materials are common to several products. The MRP processor must collect these common use items during the part explosion. The total quantities for each common use item are then combined into a single net requirement for the item.

(4) Since master production schedule provides time-phased delivery requirements for the end products, this time phasing must be carried through the calculations of the individual component and raw material requirements.

MRP Output reports

– The MRP program generates a variety of outputs that can be used in the planning and management of plant operations. These outputs include :

(*a*) **Primary outputs**

(1) Order release notice, to place orders that have been planned by the MRP system.

(2) Reports showing planned orders to be released in future periods.

(3) Rescheduling notices, indicating changes in due dates for open orders.

(4) Cancellation notices, indicating cancellation of open orders because of changes in the master schedule.

(5) Reports on inventory status.

(*b*) **Secondary outputs**

(1) Performance reports of various types, indicating costs, item usage, actual versus planned lead times etc.

(2) Exception reports, showing deviations from schedule, orders that are overdue, scrap and so on.

(3) Inventory forecasts, indicating projected inventory levels in future periods.

Benefits of MRP

(1) Reduction in inventory.

(2) Improved customer service–late orders are reduced as much as 90%.

(3) Quicker response to changes in demand.

(4) Better machine utilization.

(5) Greater productivity.

24.11. MANUFACTURING RESOURCE PLANNING (MRP II)

– MRP was originally developed as a computer system for planning material orders.

Manufacturing personnel soon discovered that capacity planning and scheduling could be integrated with MRP and the closed loop MRP concept was born. More sophisticated software packages evolved into complete manufacturing control systems.

– The use of an MRP-based system to plan all the resources of a manufacturing company is called *MRP II.*

MRP II includes strategic financial planning as well as production planning through the use of simulation capabilities to answer what-if questions. What-if capabilities are routinely used to evaluate alternative plans.

– MRP II is a total company system, in which functional groups interact commonly and formally and make joint decisions. Finally, the system is *user-transparent.* Users at all levels understand and accept the logic and realism of the system and need not work outside the formal system.

– Fig 24.12 shows one such system–MRPS: *Manufacturing Resource Planning System* developed by CINCOM systems, Inc. MRPS includes the vertical dimension of production planning, master production scheduling, MRP and shop floor control. The system also expands horizontally to include inventory control, purchasing and other planning considerations.

24.12. OPERATING CYCLE

– The *operating cycle* refers to the *length of time* necessary to complete the following cycle of events :

1. Convert cash into inventory.
2. Convert inventory into receivables.
3. Convert receivable into cash.

– In phase 1, cash is used to produce inventory. For manufacturing firms, this phase would start with the purchase of raw materials and would conclude with the manufacturing process delivering goods to inventory.

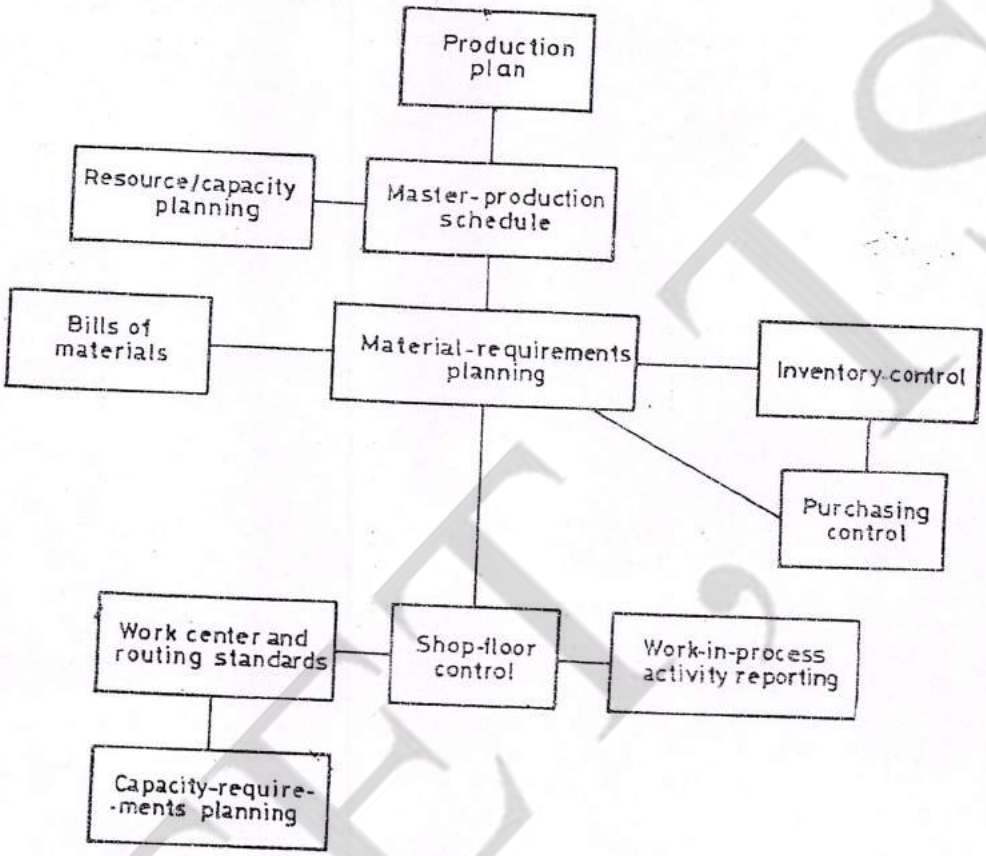


Fig. 24.12. The structure of MRPS.

– In the second phase of the cycle the inventory is converted into receivables as sales are made to customers.

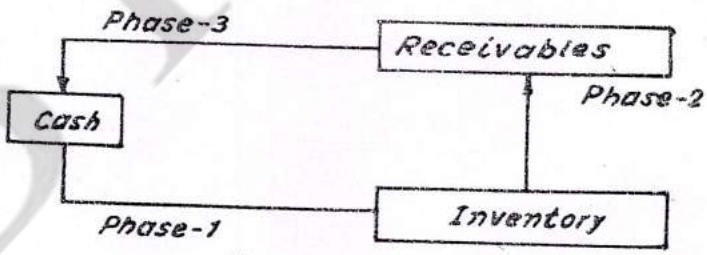


Fig. 24.13. Operating cycle.

– The last phase of the operating cycle, phase 3, sees the *receivables* being collected and the operating cycle is complete.

Firms that have no *credit terms* (cash and carry firms) would have no phase 2 since they will sell only on cash. *Receivables* are *notes* and *acceptances receivables*. These are short term promissory instruments of indebtedness that reflect obligations owed the firm.

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25

Material Handling

25.1. INTRODUCTION AND DEFINITION

Starting from the time, the raw material enters the factory gate and goes out of the factory gate in the form of finished products, it is handled at all stages in between, no matter it is in the stores or on the shop floor. It has been estimated that average material handling cost is roughly 20 to 60% of the total production cost and the ratio between the weight of handled material to produce an item and the weight of the finished item may vary between 40 to 50. A component may be handled even 50 times or more before it changes to finished product. It, thus, becomes clear that the cost of production of an item can be lowered considerably by making a saving in the material handling cost.

Material handling involves the movements of materials, manually or mechanically in batches or one item at a time within the plant. The movement may be horizontal, vertical or the combination of horizontal and vertical.

Material handling emphasizes upon the need of installing efficient and safe methods and equipments for material handling. It has been found that 35 to 40% of the plant accidents are the results of bad methods of material handling.

25.2. FUNCTIONS AND PRINCIPLES OF MATERIAL HANDLING

The two main functions of material handling section are :

1. To choose production machinery and assist in plant layout so as to eliminate as far as possible the need of material handling ; and

2. To choose most appropriate material handling equipment which is safe and can fulfil material handling requirements at the minimum possible overall cost :

In general, the functions and principles of good material handling are as follows :

(*a*) Minimize the movements involved in a production operation ,

(*b*) Using the principles of containerization, unit load or palletization, aim at moving optimum number of pieces in one unit.

(*c*) Minimize the distances moved, by adopting shortest routes.

(*d*) Employ mechanical aids in place of manual labour in order to speed up the material movements.

(*e*) Changes in sequence of production operations may be suggested in order to minimize back tracking and duplicate handling.

(*f*) Safe, standard, efficient, effective, appropriate, flexible and proper sized material handling equipment should be selected.

(*g*) Handling equipments arrangement should minimze distances moved by products and at the same time handling equipments should not interfere with the production line.

(*h*) Utilize gravity for assisting material movements wherever possible.

(*i*) Design containers, packages, drums etc., to economize handling and to reduce damage to the materials in transit.

(*j*) Material handling equipments should periodically be resorted to check ups, repairs and maintenance.

25.3. ENGINEERING AND ECONOMIC FACTORS

The two most important factors for analysing or solving a material handling problem are :

1. Engineering factors, and
2. Economic factors.

25.3.1 The Engineering Factors taken into Consideration

(*a*) The conditions of existing building and plant layout,

(*b*) Production processes and equipments.

(*c*) Nature of materials and products to be handled, and

(*d*) The existing material handling equipments.

(*a*) If a material handling system is to be formulated for an existing building and facility layout, one has to study various features of the building, like door locations and sizes, ceiling heights, roof and floor strengths, stairs, columns, and width of aisles, etc. Unfavourable features may restrict the use of fast and most suitable material handling equipments. One has to strike a balance and decide which feature of the building or existing layout is to be kept as it is and which others can be modified to advantage.

(*b*) It involves the type of production equipment, processes, method of production, quantities of materials involved in handling, sequence of operations, etc. On the basis of these factors an optimum system of material handling can be evolved or at least some factors can be modified to achieve a better material handling system.

(*c*) Much depends upon the nature of raw materials, materials in process, quantities to be handled and distances to be travelled by them. A flexible, safe, and economical material handling system is developed taking into consideration the conditions, fragility and bulk of the materials involved.

(*d*) The usefulness and effectiveness of existing material handling equipment is evaluated from its performance of handling different products. If found necessary, additional material handling equipments are purchased to reinforce the material handling operations.

25.3.2. Economic Factors. The cost of material handling equipment, operating costs, repair and maintenance costs, taxes, insurance and depreciation costs are considered for economic analysis. A material handling system with the lowest prospective cost is selected.

The operating costs are reduced by, purchasing flexible material handling systems, increasing the amount of material to be handled at one time, minimizing the idle time for the equipment, increasing speed of handling and by acquiring material handling equipments of standard design.

A material handling system is said to be economical if the cost of handling per unit weight of the material for a particular movement is minimum. Economy in material handling can be achieved by employing gravity aided movements, minimizing the distances of material travel, and by using such systems in which the product from the machine directly falls over material handling equipment (say a conveyor or chute) and is taken to its destination without any assistance from the machine operator.

Proper periodic inspection, repair and maintenance of a material handling equipment increases its life, adds to its reliability, smoothens the flow of material and economizes the production system.

25.4. RELATIONSHIP TO PLANT LAYOUT

Material handling and plant layout are closely interrelated, and a reciprocal relationship exists between the two. An effective layout involves least material handling and less costly material handling equipments. It permits, material handling without any loss of time, with minimum delays and least back tracking. The total number of movements and the distances moved in one movement are also considerably

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reduced in a properly designed plant layout. In a poorly planned layout, the aisle's/sub-aisle's widths or ceiling heights may not be sufficient to accommodate efficient material handling equipments; even if used somehow or other, the back tracking or duplication of material movements may not permit the material handling system to be economical.

On the other hand, an efficient material handling system helps building an effective plant layout around itself. Various departments are located such that the material handling is minimized . Space requirements are considerably reduced. Material movements are much faster and more economical. Bottlenecks and points of congestion are removed. Machines and workers do not remain idle due to lack of material. Production line flow becomes smooth.

25.5. SELECTION OF MATERIAL HANDLING EQUIPMENT

A wide variety of material handling equipments is in the market; some equipments are for general purpose use and others are of special purpose use. The choice of a particular equipment depends upon the specific requirements or the conditions of an industry. Naturally, the best equipment will be one which permits smooth and continuous production flow, involves less accidents, reduces production cycle time, promotes better working conditions, incurs less fatigue to the operators and brings down the total material handling costs.

The following factors may be considered while selecting a material handling equipment :

(a) Material to be moved. The size of material, its shape, weight, delicacy, nature (solid, liquid, gas) and its chances of getting damaged during handling, etc., should be considered.

(b) Plant buildings and layout. Widths of aisles, ineqality in floor levels, width of the doors, height of the ceiling, strength of floor and walls, columns and pillars etc., to a great extent influence the choice of a material handling equipment. For example, low ceiling heights may not permit stacking of palletized materials, weak roofs limit the use of overhead conveyors and steps between two floors will not allow trucks to operate.

(c) Type of production machines. Different machines have different outputs per unit time. The material handling equipment should be able to handle the maximum output.

(d) Type of material flow pattern. A vertical flow pattern will require elevators, conveyors, pipes etc., whereas horizontal flow pattern will need trucks, overhead bridge cranes, conveyors, etc.

(e) Type of production. The type of production affects to a large extent the selection of the material handling equipments. Conveyors are more suitable for mass production on fixed routes and powered trucks for batch production; because conveyors though costly, can handle more volume of production per unit time as compared to trucks, whereas a truck is a more flexible equipment.

(*f*) Cost of material handling equipment.

(*g*) Handling costs.

(*h*) Life of the equipment.

(*i*) Amount of care and maintenance required for the material handling equipment.

25.6. MAINTENANCE OF MATERIAL HANDLING EQUIPMENTS

The proper maintenance of material handling equipments is extremely essential for preventing the occurrence of bottlenecks or points of congestions. Production line flow can be maintained only if the material handling equipment is in the proper working order.

Preventive maintenance is by far one of the best maintenance techniques suggested for material handling equipments.

By preventive maintenance, the equipments can be kept running thereby minimizing costly interruptions in the production schedule. A little periodic inspection and minor adjustments may be enough to prevent equipment breakdown. Preventive maintenance consists of frequent inspections and

examination of the material handling equipments, with special attention to the components requiring it. The aim is to uncover conditions leading to breakdown or harmful depreciation. Preventive maintenance also includes lubrication, adjustment, or repair while the equipment is still in a minor stage of defect.

Three stages of preventive maintenance are :

(*a*) Inspection,

(*b*) Repair, and

(*c*) Overhaul.

The maintenance system for a few material handling equipments like cranes, hoists, and coveyors has been discussed below :

25.6.1. Hoists and Cranes

(a) Inspection. All parts, open or covered are inspected for wear and tear. Worn out or unworkable components like wire ropes, wheels, bearings, bolts, etc., are removed. Brakes are adjusted and lubrication is provided wherever necessary.

(b) Repair. The repairable parts of the system, after inspection are corrected for small repairs and minor defects are rectified. Systems like open gear transmission, couplings, riveted, and bolted joints, trolley, brakes, guards, etc., may be repaired.

(c) Overhaul. Overhauling involves dismantling the complete-mechanism and replacing all damaged components. Crane structure, buffers, rails, open gear transmission, pulley blocks, etc., may be replaced and various sub-mechanisms may be alligned and adjusted.

25.6.2. Conveyors

(a) Inspection. Belts or rollers are inspected for tensions and wear and tear. Gear box is properly lubricated, various fasteners are tightened and safety guards are checked.

(b) Repairs. Rollers and belts are checked, adjusted or repaired. Couplings, packings, safety guards, steel structures, gear transmission, bearings, fastener joints, threaded components, etc., are adjusted or repaired as per their conditions.

(c) Overhaul. The conveyor system is completely dismantled. Components, worn out and beyond repair like belts, bearings, packings, oil seals, rollers, drums, fasteners, and couplings are replaced. Structures, safety guards, etc., may be repaired as per their conditions.

25.6.3. Repair Cycle

A typical repair cycle may be as follows :

(*a*) New Equipment
(*b*) Inspection-1
(*c*) Inspection-2
(*d*) Inspection-3
(*e*) Repair-1
(*f*) Inspection-4
(*g*) Inspection-5
(*h*) Inspection-6
(*i*) Repair-2
(*j*) Inspection-7
(*k*) Inspection-8
(*l*) Inspection-9
(*m*) Repair-3
(*n*) Inspection-10
(*o*) Inspection-11
(*p*) Inspection-12
(*q*) Repair-4
(*r*) Inspection-13
(*s*) Inspection-14
(*t*) Inspection-15
(*u*) Overhaul-1

This cycle involves 15 inspections, 4 repairs and 1 overhaul. The time duration between two stages

say (*c*) or (*d*) and (*e*) may range from 1 month to 6 months or even more, depending upon the type of material handling equipment and the time for which it has been used.

25.7. TYPES OF MATERIAL HANDLING EQUIPMENTS

25.7.1 Introduction. A wide range of material transporting and handling equipments are available--suitable to most of the industrial requirements. Such equipments though need a high capital investment. prove very paying in the long run. They

(1) minimize the total handling time;

(2) promote, easier, safe and cleaner handling;

(3) eliminate idle time of workers and machines which would be there, otherwise, while waiting for the materials for necessary operations;

(4) make material movements fast;

(5) decrease fatigue incurred by the workers;

(6) add to safety;

(7) locate, and stock materials better and in less space; and

(8) lastly their operations can be automated to increase production.

25.7.2. Characteristics of Material Handling Equipments. Every material handling equipment possesses certain characteristics with respect to

- Materials
  - Bulk 1
  - Packaged 2.
- Movement
  - Vertical 3
  - Horizontal 4
  - Combination of vertical and horizontal 5.
- Supervision required
  - Close 6
  - Little 7
  - Equipment is automatic or semi-automatic 8.
- Path followed
  - Variable 9
  - Fixed 10
  - Fixed area 11.
- Speed
  - Variable 12
  - Fixed 13
  - Either fixed or variable 14.
- Power required for the operation of equipment
  - Electricity 15
  - I.C. Engine 16
  - Manual 17
  - Gravity 18.

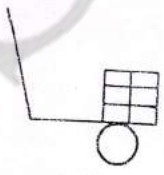


Fig. 25.1.
Two wheeled truck.

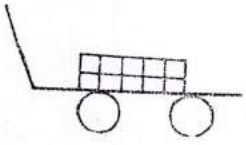


Fig. 25.2
Four wheeled truck.

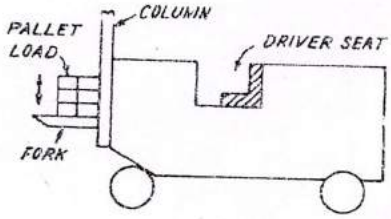


Fig. 25.3
Fork lift truck.

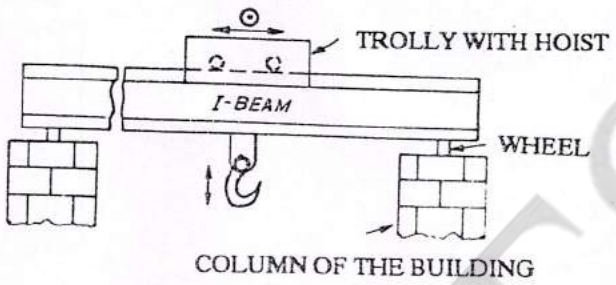


Fig. 25.4. Overhead bridge crane.

25.7.3. Classification of Material Handling Equipments

(*a*) *Industrial Trucks*
Flexible, versatile and most extensively used

- Manual
  - 2 Wheeled (Fig. 25.1)
  - 3 Wheeled
  - 4 Wheeled (Fig. 25.2)

  Characteristics
  CH : 1, 2, 4, 6, 9, 12, 17

  Excellent for intermittent small distance movements.
- Powered
  - Driver walk (Driver remains on ground)
    - Platform type — CH : 2, 4, 6, 9, 12, 15, 16
    - Pallet lift
    - High lift fork — 1, 2, 4, 5, 6, 9, 12, 15, 16
  - Driver ride (Driver on the truck)
    - Platform
      - Low lift — CH : 1, 2, 4, 6, 9, 12, 15, 16
      - High lift — CH : 1, 2, 4, 5, 6, 9, 12, 15, 16
    - Pallet lift — CH : 2, 4, 6, 9, 12, 15, 16
    - Telescopic fork lift (fork-lifts by the principle of telescopic tubes) — CH : 1, 2, 4, 5, 6, 9, 12, 15, 16

In FORK LIFT TRUCK (see Fig. 25.3) the forks are attached to a column on the truck. Forks can be lifted to the desired height along with the material (boxes, etc.) on them and the material can be stacked at the proper place, even very close to the roof. Fork lift trucks are used for short distances (40 to 70 metres) travel and find indoor applications normally

(*b*) *Cranes*
- Overhead bridge crane (Fig. 25.4) — CH : 1, 2, 5, 6, 11, 15
- Jib crane (Fig. 25.5) — CH : same as for overhead crane.
- Gantry crane (Fig. 25.6) — CH : 2, 5, 6, 11, 14, 15

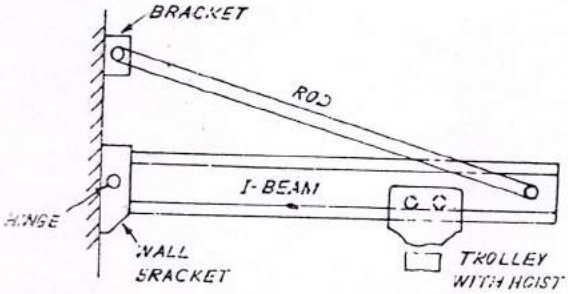


Fig. 25.5. Jib crane.

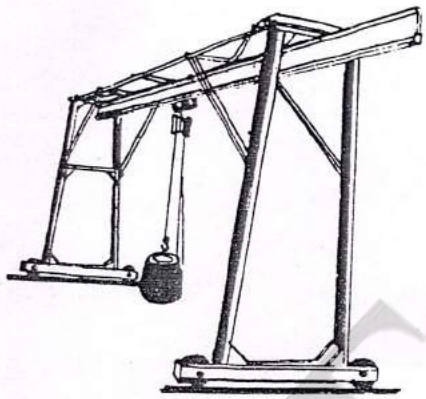


Fig. 25.6. Gantry crane.

CRANES are employed for lifting and lowering bulky items and packages or cases. They find applications in heavy engineering and generally in intermittent type of production. They provide overhead movements. The crane hook can move in a rectangular area (overhead bridge crane) or a circular area (jib crane). An overhead bridge crane finds applications in most of the industries, making engines, compressors, pressure vessels, foundries, steel mills, etc. A jib crane is preferred where lifting of the jobs is required in a few locations only or where bridge crane cannot be erected; for example, outside near the wall of the building. In a jib crane the hoist unit may be mounted on an I-section jib which is in turn supported on a column. A gantry crane acts as an auxiliary to bridge crane. It is on wheels and can be moved at the place of use.

- (c) *Hoists*
  - Chain type (manual)
    CH : 1, 2, 3, 6, 11, 12, 17
  - Pneumatic
  - Electrical
    - CH : 1, 2, 3, 6, 11, 12, 15

HOIST may be mounted on a single rail. It finds applications in wire drawing and many other factories employing chemical cleaning of material, etc.

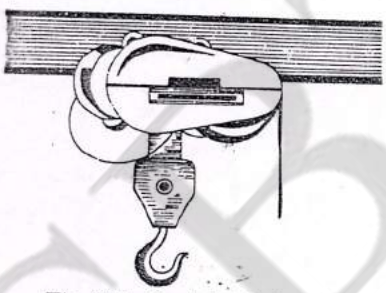


Fig. 25.7. Electrical hoist.

- (d) *Monorail*
  - Trolley
    CH : 2, 4, 5, 7, 10, 15
  - Carrier
    CH : 1, 2, 4 , 5, 7, 10, 15

MONORAIL is an I-section beam attached to the ceiling and having either a trolley or carrier moving along it. The material can be transferred from one place to another along the beam. It is employed for intermittent type material handling in machine shop and other shops.

CONVEYORS are employed to transport materials, over a fixed path which may be horizontal or inclined (up or down), to different locations in a factory. They prove economical if the flow of material is continuous.

In a *belt conveyor,* the belt may be flat or of trough shape to hold (granular) materials which may tend to fall from the flat belt. The belt material may be rubber covered canvas, steel, plain fabric or woven wire (high temperature use). A fixed conveyor is used on the mass production shop floor whereas portable conveyors are preferred for intermittent jobs like unloading of a freight car, etc.

(e) *Conveyors*

- Belt conveyor (See Fig. 25.8)
  - Flat CH : 1, 2, 3, 4, 5, 8, 10, 14, 15, 16
  - Troughed CH : 1, 3, 4, 5, 8, 10, 15, 16
  - Fixed/Portable CH : 1, 2, 3, 4, 5, 8, 10, 14, 15, 16.
- Roller gravity
  - Spiral CH : 2, 3, 4, 5, 8, 10, 12, 18
  - Fixed CH : 2, 4, 5, 8, 10, 12, 18
  - Portable CH : 2, 4, 5, 8, 10, 12, 18
- Roller line (See Fig. 25.9)
  - Chain drive CH : 2, 4, 5, 8, 10, 14, 15
  - Belt drive CH : 2, 4, 5, 8, 10, 14, 15
- Drag
  - Screw CH : 1, 3, 4, 5, 8, 10, 13, 15
  - Pusher bar CH : 2, 3, 4, 5, 8, 10, 13, 15
  - Overhead chain CH : 1, 2, 4, 5, 7, 10, 13, 15
- Bucket CH : 1, 3, 5, 8, 10, 13, 15, 18
- Chain or cable CH : 1, 2, 4, 5, 8, 10, 13, 14, 15 (Fig. 25.10)
- Pipe line (pneumatic).

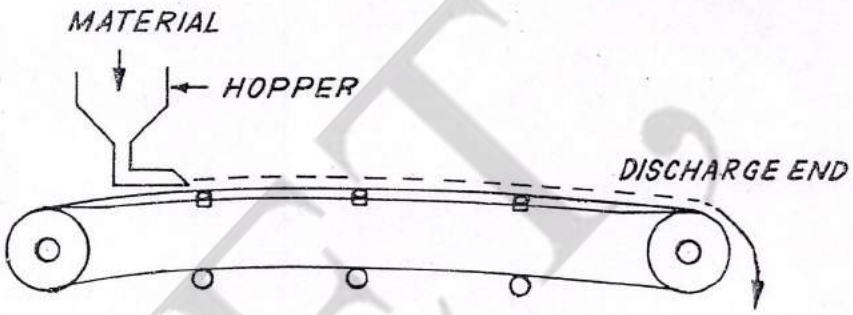


Fig. 25.8. Belt conveyor.

Roller conveyors may be gravity aided or powered and are employed for transporting products having flat bottoms. Bigger jobs can be handled as they are, whereas small items are put in boxes, tins or pallets before being transferred. Roller conveyors can move the material along straight or curved paths. Gravity type conveyors should be preferred as compared to line conveyors wherever practical. Gravity conveyor is easy to set up as it does not involve any power drive. Packages of hosiery goods, steel sheets, etc., can be transferred using gravity conveyors.

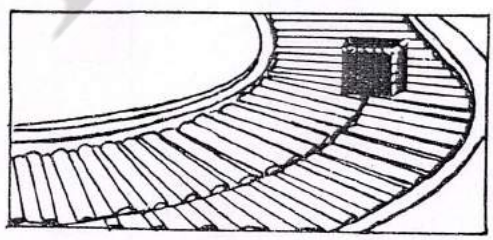


Fig. 25.9. Roller conveyor.

Belt conveyors are substituted for roller conveyors when the parts are small and are required to be transferred separately, from one station to another.

The mechanism of transporting the materials in a drag conveyor can be a screw (as in automatic feed in poultry farms), a pusher bar, a scraper (for moving granular or powder materials) or an overhead endless chain along a fixed path. The chain has chain links which push the material forward.

A ***bucket conveyor*** moves the granular materials or powder or liquid. The buckets may be mounted on a chain or belt.

A ***chain conveyor*** (Fig. 25.10) consists of overhead mounted endless chain. It is supported from the ceiling and has a fixed path to travel. It saves valuable floor space. The arrangement is such that the lifting

mechanism (may be an electromagnet or a hook) lowers down for loading and unloading of the products. Chain conveyors are used in refrigeration industries for painting and plating of the refrigerator shells. In another application a telescopic mast (pole) may join its upper end with the overhead chain conveyor and the lower end with a trolley; so that as the endless chain moves, the trolley (with the material in it) also moves in the direction in which chain travels.

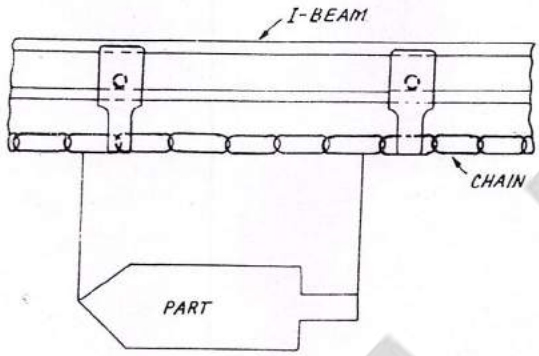


Fig. 25.10. Chain conveyor.

Pipe line conveyors are used for transporting granular (wheat) or pulverized materials (salt) through the pipes. Gravity or air flow moves the material ahead.

(f) Slides and chutes
- Straight
- Spiral — CH : 1, 2 3, 5, 7, 10, 13, 18
- Wood/steel
- Vibrating — CH : 1, 3, 5, 7, 8, 10, 13, 15

They transfer small jobs which can slide down under gravity. Vibrating slides transport materials up an incline also (cigarette factories). Chutes have sheet metal or roller base for transferring components down the incline. Chutes generally feed parts (which they receive from, say sheet metal presses) to the conveyor which takes the parts to their destination.

(g) *Lifts :* In multistorey plants, material is lifted up and transported by lifts. It is a fast and flexible equipment for floor to floor travel. Buckets or trays can be mounted on the endless chain running from the ground floor to the top floor. The material can be loaded in the trays automatically.

(h) Tractors and Trailers : Tractors, three wheeled or four wheeled (CH: 1,2,4,6,9,12,15,16) employ I.C. Engine drive and are generally used for outdoor applications. Material is loaded in the trailers (CH: 1,2,4,6,9,14) which are attached to the towing tractor. Trailers can either be uncoupled from the tractor train, or the material loaded in them can be dumped out, at respective stations. Tractor train is very helpful in big industries.

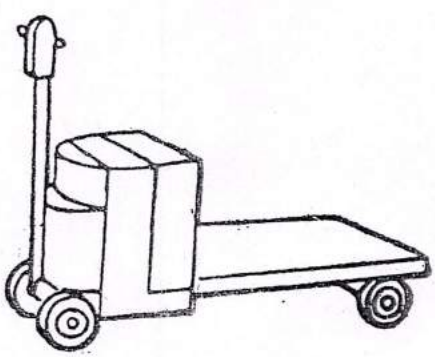


Fig. 25.11. Platform truck (low-lift type).

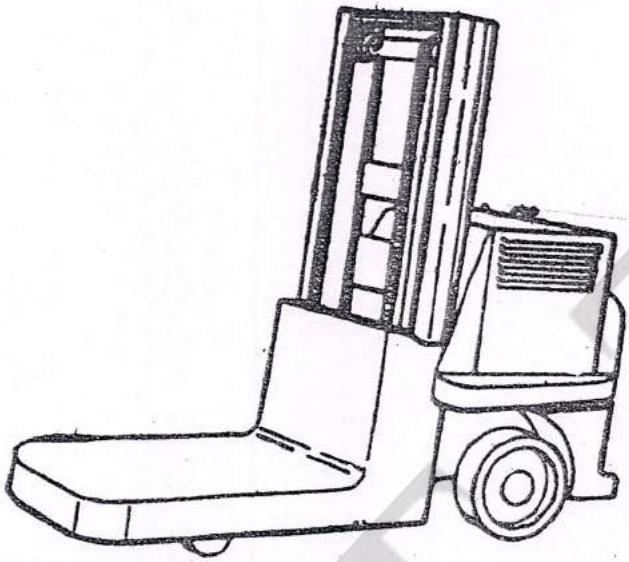


Fig. 25.12. Platform truck (high-lift type).

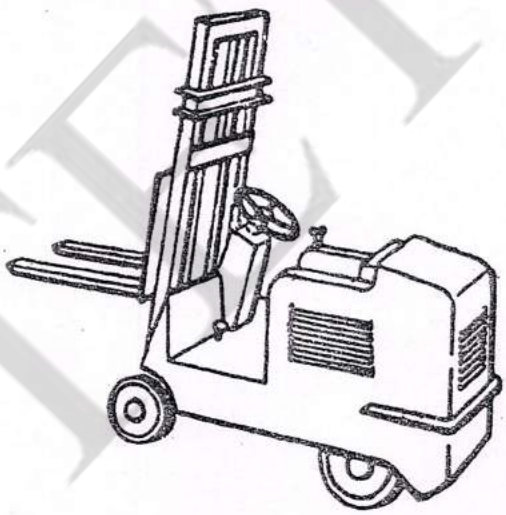


Fig. 25.13. Fork truck (counterbalance type).



Fig. 25.14. Chain hoist.

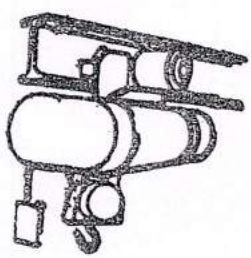


Fig. 25.15. Electric hoist.

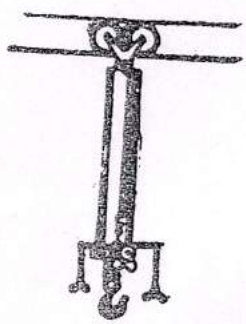


Fig. 25.16. Air hoist.

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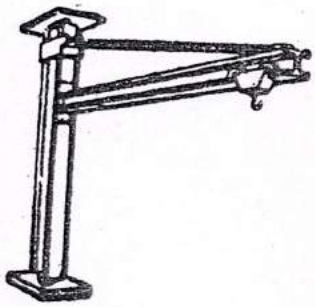


Fig. 25.17. Jib crane.

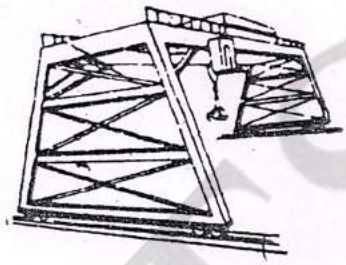


Fig. 25. 18. Gantry crane.

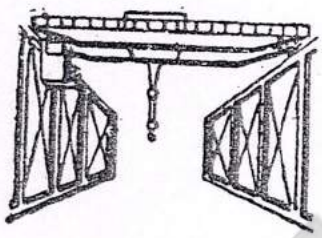


Fig. 25.19. Bridge crane.

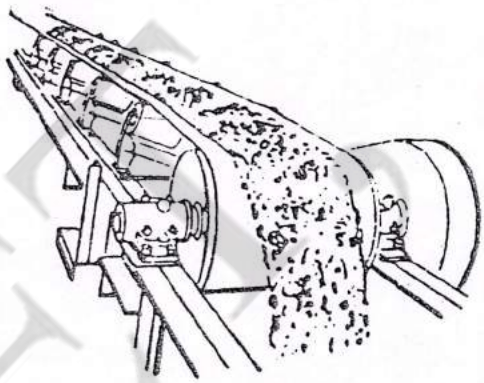


Fig. 25.20. Belt conveyor.

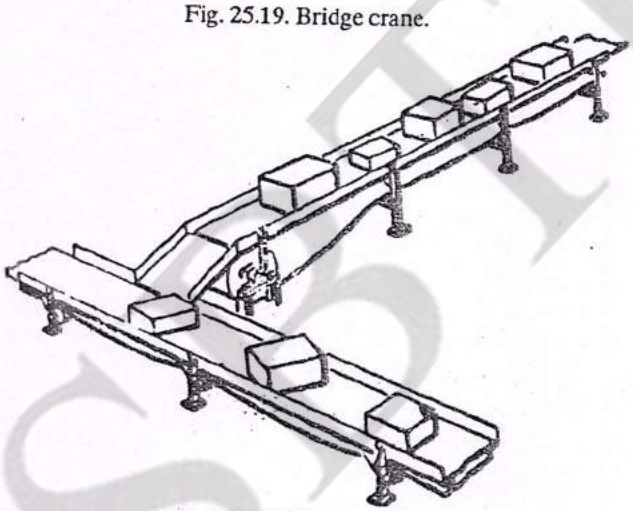


Fig. 25.21. Belt conveyor.

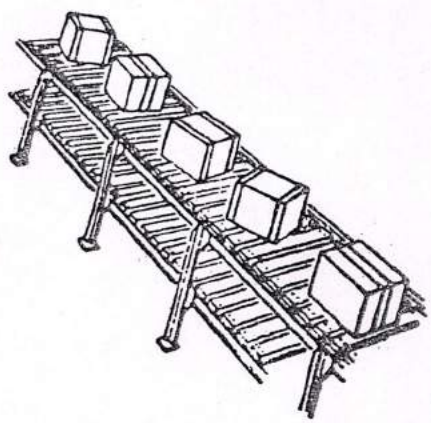


Fig. 25.22. Slat conveyor.

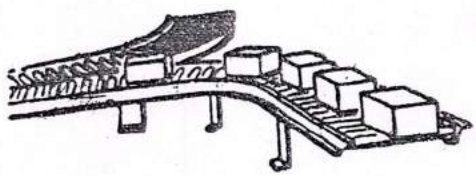


Fig. 25.23. Roller conveyor.

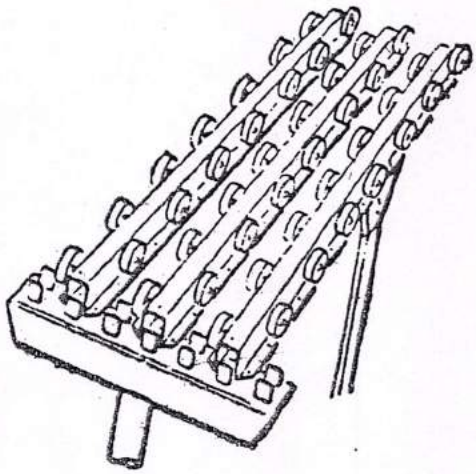


Fig. 25.24. Wheel conveyor.

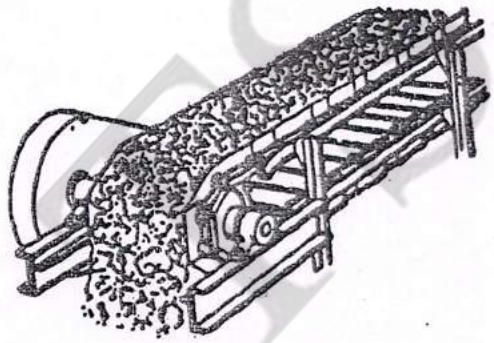


Fig. 25.25. Apron conveyor.

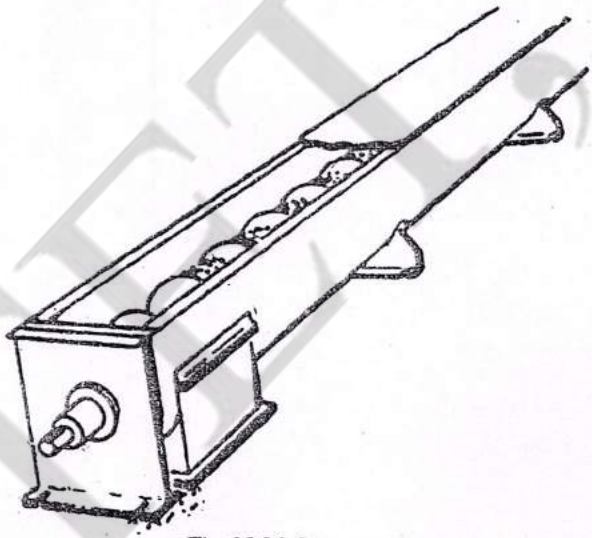


Fig. 25.26. Screw conveyor.

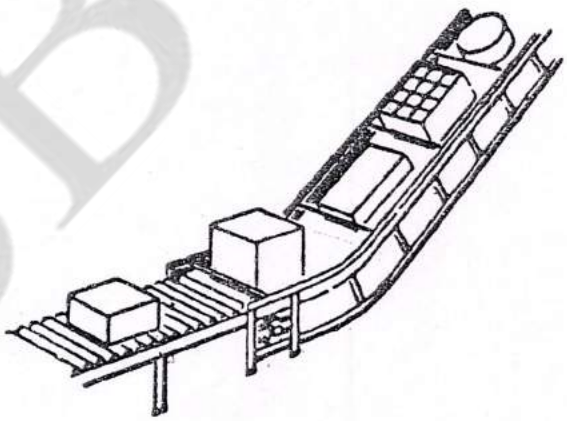


Fig. 25.27. Pusher bar conveyor.

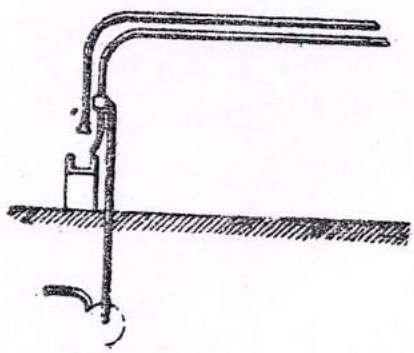


Fig. 25.28. Pneumatic conveyor.

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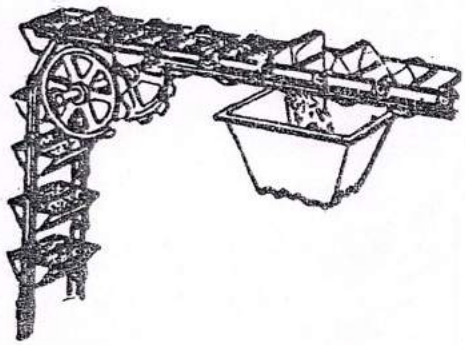


Fig. 25.29. Pivoted bucket conveyor.

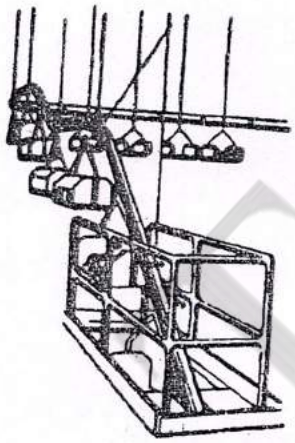


Fig. 25.30. Trolley conveyor.

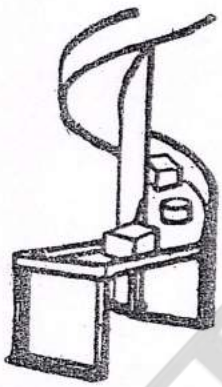


Fig. 25.31. Spiral chute.

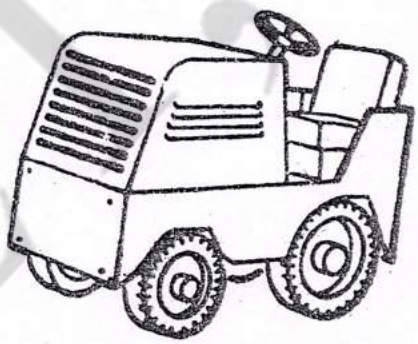


Fig. 25.32. Industrial tractor.

25.8. PRINCIPLE OF UNIT LOAD AND CONCEPT OF CONTAINERIZATION AND PALLETIZATION

It is easier and faster to move hundred small parts say castings or cardboard sheets by grouping them in one unit than moving them individually one by one. This principle of unit load can also be explained like this. If the bearer of a hotel removes cups, plates and other crockery from a table by placing them in a tray, it is called material handling by unit loads. Definitely, he would have spent much more time and efforts in removing all the crockery by one cup or one plate at a time.

By using available machines (like one for strapping steel strips around cotton bales), fork lift trucks, skids and pallets (see Fig. 25.33), it is easy to handle materials in unit loads and stack them neatly and properly (even as high as the ceiling) thereby reducing the storage space requirements.

Depending upon the types of items to be transferred, a suitable pallet can be designed. For example, items irregular in shape and liable to be damaged by crushing utilize a post pallet (See Fig. 25.34) whereas small jobs can be placed in wire mesh box (See Fig. 25.35).

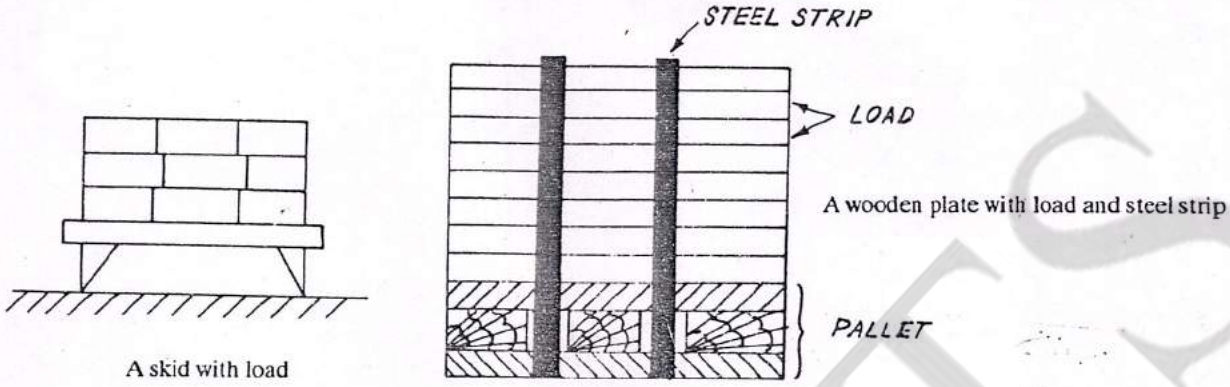


Fig. 25.33. Skid and pallet.

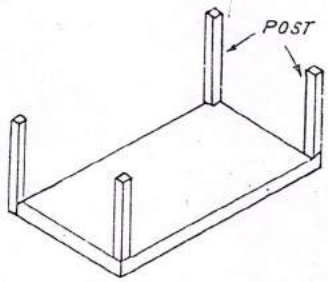


Fig. 25.34. Pallet with 4 posts.

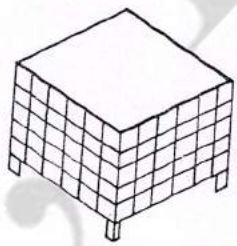


Fig. 25.35. Wire mesh box.

Containerization uses principle of unit load. In this system, big metal containers have number of small products filled in them. These containers are placed on the truck or in the trailers which are pulled by tractors or trucks. Afterwards, the containers can be loaded on railway trailers and can be taken to places from where, with the help of cranes, they can be shipped. Items like refrigerators, air-conditioners or televisions can be sent to distant places using the principle of containerization. The system is much safer and involves a lot of saving.

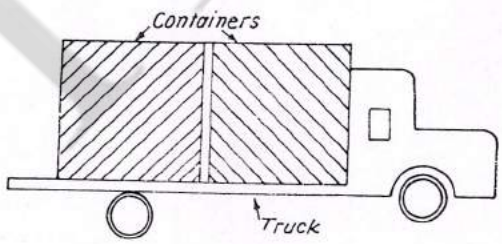


Fig. 25.36. Truck with containers.

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