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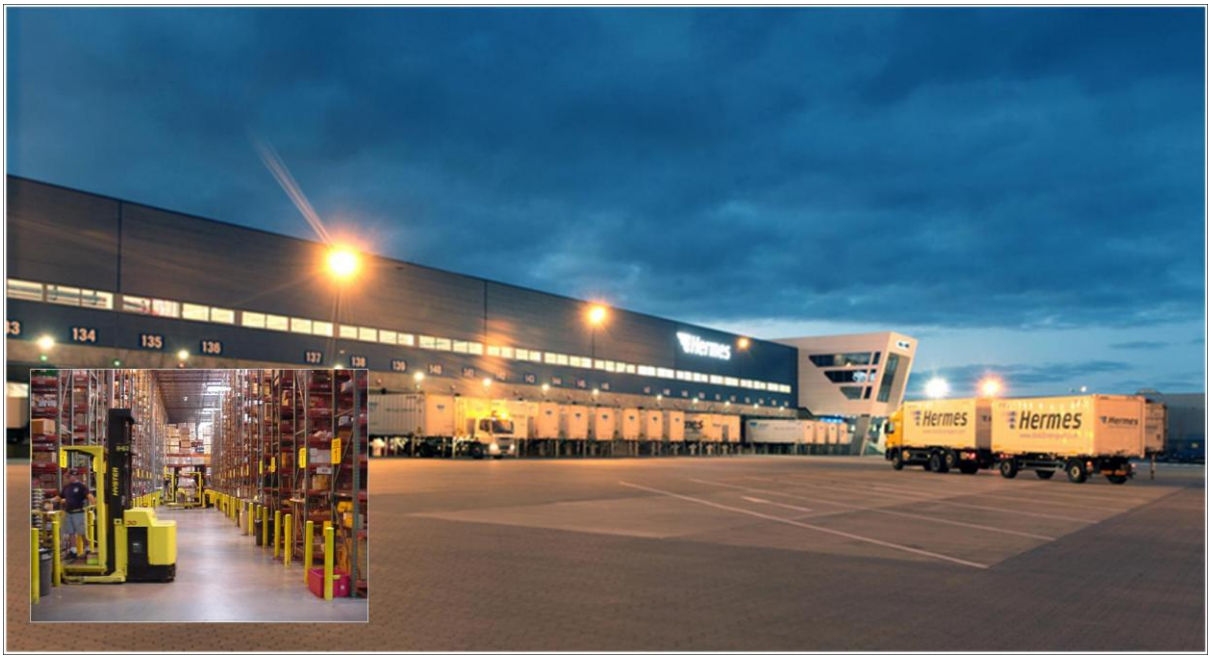
SHIPPING college

Warehousing and Inventory Management

Course Manual



Warehousing and Inventory Management Certificate

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Summary overview

What is Warehousing?

Warehousing can be defined as that part of a firm's logistics system that stores products (raw materials, parts, goods-in-process, finished goods) at and between point of origin and point of consumption, and provides information to management on the status, condition, and disposition of items being stored.

What is Inventory Management?

Inventory management is a science primarily about specifying the shape and percentage of stocked goods.

Effective inventory management is all about knowing what is on hand, where it is in use, and how much finished product results. Inventory management, or inventory control, is an attempt to balance inventory needs and requirements with the need to minimise costs resulting from obtaining and holding inventory.

Part One

1. Warehousing

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a. Introduction

We need different types of goods in our day-to-day life. We may buy some of these items in bulk and store them in our house. Similarly, businessmen also need a variety of goods for their use. Some of them may not be available all the time. But, they need those items throughout the year without any break. Take the example of a sugar factory. It needs sugarcane as raw material for production of sugar. We know that sugarcane is produced during a particular period of the year. Since sugar production takes place throughout the year, there is a need to supply sugarcane continuously. But how is it possible? Here storage of sugarcane in sufficient quantity is required. Again, after production of sugar it requires some time for sale or distribution. Therefore, the need for storage arises both for raw material as well as finished products. Storage involves proper arrangement for preserving goods from the time of their production or purchase until the actual use. When this storage is done on a large scale and in a specified manner it is called ‘warehousing’. The place where goods are kept is called a ‘warehouse’. The person in-charge of the warehouse is called ‘warehouse-keeper’.

Warehousing refers to the activities involving **storage of goods on a large-scale** in a **systematic and orderly manner** and making them **available conveniently when needed**.

In other words, **warehousing means holding or preserving goods in huge quantities from the time of their purchase or production until their actual use or sale**.

Warehousing is one of the important auxiliaries to trade. It creates **time utility** by bridging the time gap between **production and consumption of goods**.

The **effective and efficient management** of any organisation requires that all its constituent elements operate effectively and efficiently as individual small business units / facilities and together as an integrated whole corporate.

Across the supply chains, **warehousing** is an important element of activity in the distribution of goods, from raw materials and work in progress through to finished products. It is integral part to the **supply chain network** within which it operates and as such its roles and objectives should synchronise with the objectives of the supply chain. It is not a 'stand-alone' element of activity and it must not be a weak link in the whole supply chain network.

Warehousing is costly in terms of **human resources and of the facilities and equipment required,** its performance will affect directly on the overall supply chain performance. Inadequate design or managing of the warehouse systems will jeopardise the achievement of required customer service levels and the maintenance of stock integrity, and result in unnecessarily high costs.

Warehouses are built in all shapes and sizes, from facilities of a few thousand square metres handling modest throughputs, to large capital intensive installations with storage capacities in the 1,00,000 pallet-plus range, with a very high throughputs.

Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc.

Above: view inside a warehouse and a loading dock

Warehousing is nothing more than the **management of space and time**.

The **space management** portion, storage, has a cost per month, because there is a monthly cost for warehouse space.

The **time management** component includes labour involved in handling materials as they move in and out of the warehouse.

All companies with warehouses incur the same elements of cost, but they compile them differently. Some warehousing costs tend to be ignored or misallocated, because the analyst

does not recognise where they belong. In any **costing system**, allocation of overhead costs is a matter of judgment, and no specific formula will be correct for every user.

Four categories of warehouse costs

1. Handling. All expenses associated with moving product in or out of the warehouse should be included in the handling cost centre. The largest component is the labour used to handle the product that moves through the distribution centre. It includes receiving, put-away, order selection, and loading. It also may include labour to re-warehouse, repackage, or refurbish damaged product.

Handling also includes all costs associated with the equipment used to handle product in the warehouse, such as the depreciation of equipment cost, and the cost of fuel, or electricity to power the equipment.

Other handling expenses are the detention of truck or rail cars, operating supplies, and trash disposal. In effect, handling includes all those costs that are associated with "goods in motion."

2. Storage. Storage expenses are costs associated with "goods at rest." These costs would be incurred whether or not any product ever moved. Because storage expenses are related to the cost of occupying a facility, and these costs are normally accumulated each month, storage is expressed as a monthly cost. If an entire building is dedicated to an operation, storage expenses are the total occupancy cost for that facility.

3. Operations administration. These expenses are incurred to support the operation of the distribution centre. Closing the facility would eliminate these costs. Included are costs for line supervision, clerical effort, information technology, supplies, insurance, and taxes.

4. General administrative expenses. Expenses not incurred for a specific distribution centre are included in this category. General management, non operating staff, and general office expenses are examples. Allocation of such expenses to each warehouse is a judgment call.

Need for Warehousing

Warehousing is necessary for the following reasons:

1. Seasonal Production - Agricultural commodities are harvested during certain seasons, but their consumption or use takes place throughout the year. Therefore, there is a need for proper storage or warehousing for these commodities, from where they can be supplied as and when required.

2. Seasonal Demand - There are certain goods, which are demanded seasonally, like woollen garments in winter or umbrellas in the rainy season. The production of these goods takes place throughout the year to meet the seasonal demand. So there is a need to store these goods in a warehouse to make them available at the time of need.

3. Large-scale Production - In case of manufactured goods, now-a-days production takes place to meet the existing as well as future demand of the products. Manufacturers also produce goods in huge quantity to enjoy the benefits of large-scale production, which is more economical. So the finished products, which are produced on a large scale, need to be stored properly until they are cleared by sales.

4. Quick Supply - Both industrial as well as agricultural goods are produced at some specific places but consumed throughout the country. Therefore, it is essential to stock these goods near the place of consumption, so that without making any delay these goods are made available to the consumers at the time of their need.

5. Continuous Production - Continuous production of goods in factories requires adequate supply of raw materials. So there is a need to keep sufficient quantity of stock of raw material in the warehouse to ensure continuous production.

6. Price Stabilisation - To maintain a reasonable level of the price of the goods in the market there is a need to keep sufficient stock in the warehouses. Scarcity in supply of goods may increase their price in the market. Again, excess production and supply may also lead to fall in prices of the product by maintaining a balance of supply of goods, warehousing leads to price stabilisation.

Issues affecting Warehousing

Since **warehouses, stores and distribution centres** have to operate as essential component elements within supply chain networks, **key decisions when setting up** such facilities must be determined by the overall supply chain strategies for service and cost. The **factors that should be considered** include the following:

Market and product base stability: Long term market potential for growth and for how the product range may expand will influence decisions on the size and location of a warehouse facility, including space for prospective expansion. These considerations will also impact on the perceived need for potential flexibility, which in turn can influence decisions on the type of warehouse and the level of technology to be used.

Type of materials to be handled: Materials handled can include raw materials, work-in-progress (WIP), auto spare parts, packaging materials and finished goods in a span of material types, sizes, weights, products lives and other characteristics. The units to be handled can range from individual small items through carton boxes, special storage containers for liquids, drums, sacks, and palletised loads. Special requirements for temperature and humidity may also have to be met in the case of perishables and all of these will impact on the type of warehouses and technology level.

Warehouse Facility: type, size and location: The type of operation, the design capacity and size of a warehouse and its location will all be influenced if not directly determined by its exact role and position in the supply chain network, and the role, capacity and location of any other facilities in the supply chain. The customer base, level of inventory, the need for optimisation of inventory, time compression in the supply chain and the overall customer service levels should also be considered when deciding on type, size and location. A further

consideration here is whether the warehouse facility should be an own-account operation run by the company or outsourced and run by a 3PL (third party logistics provider).

Inventory and Inventory Location: Within a supply chain network there is an issue not only of what materials to stock and in what quantities, but also in what locations. Options can include distribution centres devoted to specific markets or parts of the product range distribution. The option depends on factors such as customer base, product range and service levels required.

Level of technology: can range from very basic installations with high manual input and least mechanisation to fully automated and robotic installations. The decision can be influenced by:

- Company-wide strategic marketing or employment policies,
- Financial considerations,
- Ability to achieve specified degree of throughput, and
- Required customer service level.

Other factors can include the **need for flexible operation** to meet **important demand fluctuations** such as **seasonal variations**, and the perceived future stability and growth of the market and product range. The **level of technology adopted** in any particular application should be chosen because it almost nearly matches the given requirements and objectives. It is **not true** that automation or similar technologies are **accurate in every case.** It is true that good, probably computer based communication and information systems are vital in every application, irrespective of the technology level.

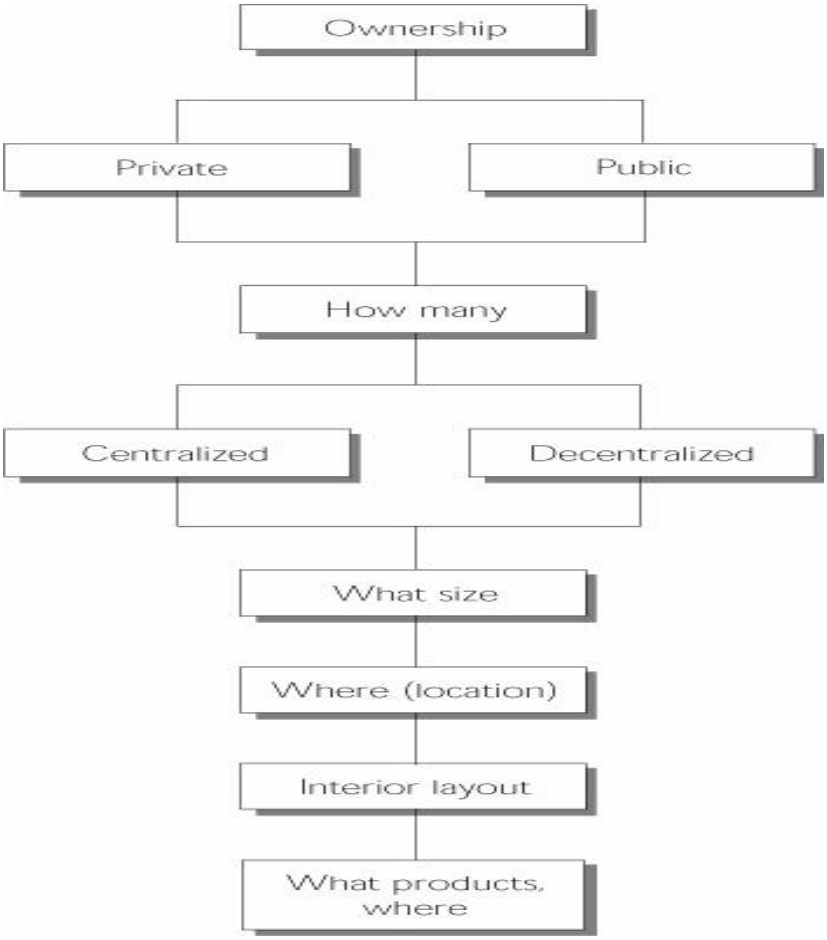
Choice of Unit load: The option of unit load or loads i.e. pallets, roll or cage pallets, tote bins, will be determined by the nature and characteristics of the materials passing through the supply chain, and this clearly encompasses an enormously wide range of goods, unit quantities, and pack types and sizes This may appear as a very important factor more subject to basic operation than to strategic influences. However, within the warehouse it can influence the option of handling equipment and the types of storage systems. In the wider context it will affect transport operations in terms of vehicle loading and unloading and vehicle utilisation.

Selection of warehouse

Warehouse Management and **Physical Distribution** are important **flow control activities in the supply chain network.** Regardless of the efficiency with which all preceding activities have been conducted, these activities have major influence in determining the **degree to which total customer service level is achieved**.

In present global business environment, the **quality of warehousing and distribution management** can have major impact on corporate performance and profitability.

The following flow chart clearly shows **hierarchy of decisions** to be made about the **selection of warehouses** in the strategic marketing policies with an objective of achieving max customer service level.



Sequence of Warehousing Decisions

The following points to be ascertained during the progression of **making warehousing decisions** are:

- Should warehousing be used?
- What forms of warehousing should be used (public or private)?
- What should be the size and number of warehouses utilised?
- Where should warehouses be located?
- What warehouse layout and design approach should be followed?

b. Types of Warehouses

The **different types of warehouses** may be classified as follows:

1. Private Warehouses
2. Public Warehouses
3. Government Warehouses
4. Bonded Warehouses
5. Co-operative Warehouses

1. Private Warehouses - The warehouses which are owned and managed by the manufacturers or traders to store, exclusively, their own stock of goods are known as private warehouses. Generally these warehouses are constructed by the farmers near their fields, by wholesalers and retailers near their business centres and by manufacturers near their factories. The design and the facilities provided therein are according to the nature of products to be stored.

2. Public Warehouses - The warehouses which are run to store goods of the general public are known as public warehouses. Anyone can store his goods in these warehouses on payment of rent. An individual, a partnership firm or a company may own these warehouses. To start such warehouses a license from the government is required. The government also regulates the functions and operations of these warehouses. Mostly these warehouses are used by manufacturers, wholesalers, exporters, importers, government agencies, etc.

3. Government Warehouses -These warehouses are owned, managed and controlled by central or state governments or public corporations or local authorities. Both government and private enterprises may use these warehouses to store their goods. Central Warehousing Corporation of India, State Warehousing Corporation and Food Corporation of India are examples of agencies maintaining government warehouses.

4. Bonded Warehouses - These warehouses are owned, managed and controlled by government as well as private agencies. Private bonded warehouses have to obtain a license from the government. Bonded warehouses are used to store imported goods for

which import duty is yet to be paid. In case of imported goods the importers are not allowed to take away the goods from the ports until such duty is paid. These warehouses are generally owned by dock authorities and found near the ports.

5. Co-operative Warehouses - These warehouses are owned, managed and controlled by co-operative societies. They provide warehousing facilities at the most economical rates to the members of their society.

Private and public warehousing

A **warehouse** may be **privately owned** and **operated by a company making its own merchandise**. This is called a private warehouse. A warehouse may be owned and operated by another organisation, including a government agency, and only used by a company on certain terms and conditions. This is called a **public warehouse**. A public warehouse may be owned by a company in the private sector but used by the general public. Irrespective of whether a warehouse is a private or a public warehouse, the following factors have to be taken into account to work out the cost of storage.

1. Interest on the capital used for buying the site.

2. Interest on the funds used to buy the furniture

3. Cost of repairs and maintenance

4. Depreciation on building and equipment

5. Insurance

6. If productivity (or efficient use) of the warehouse can be increased by 25 percent, there is an equivalent reduction in costs per unit handled and processed.

7. There are fixed costs in the shape of the cost of space per square metre or per cubic metre, etc,

8. There are variable costs in the shape of cost per unit handled or processed, which must be added to the fixed costs.

Maximum efficiency is achieved by **processing a larger number of units through the warehouse space**. The larger the number of processed units the lesser the cost per unit. There are a few considerations which must be taken into account in the use of public and or private warehousing facilities. There are advantages and disadvantages for both, and the decision on establishing a private warehouse must only be made after a careful assessment of overall benefits.

Private warehousing

The construction and maintenance of **private warehousing facilities** can be extremely costly. All the expenses have to be carefully analysed and evaluated.

These are:

1. Fixed expenses incurred on the **acquisition of land and building**, normally which are very high

2. Expenses, incurred on ensuring that warehouses are **properly equipped** with Motorised Handling Equipment (MHEs) like forklifts, conveyors, semi-automatic trucks, storage racks and bins, and mezzanine floors, etc.,

3. The cost of **wages for staff** required for peak activity periods like over time, which can be very high since retrenchment during slack periods may not be possible.

4. Extra payment like **over time wage** to be made for work on Saturdays, Sundays, and holidays.

5. Other service charges which are required in the **maintenance of warehouse operations** have to be taken into account.

6. Budgets have to be allocated for **office and record keeping equipment** for successful warehouse operations.

7. The cost of **regular maintenance and repairs** and the cost of such items as fire **extinguishers, fuel, air-conditioning, power and light** have to be taken into account.

8. The cost of **maintaining insurance records** of premiums paid for fire, theft, and also for workmen's compensation.

Public warehousing

All the forgoing cost factors operate in public warehousing as well. But, in public warehousing, the **expenses are distributed over several consignments of their clients**. In most cases, therefore, the net result is a lower cost for each consignment. Warehousing has become an extremely specialised service and a public warehousemen can provide improved service with greater flexibility for the end user. A company running a private warehouse will have to evaluate the costs incurred with the total figure for the complete service through public warehousing.

Advantages of public warehousing

Some of the advantages of public warehousing are:

1. It is in **general less expensive and more efficient and effective** to achieve more customer service level.

2. Public warehouses are usually **strategically positioned and easily available**.

3. Public warehousing is **adequately flexible to meet most space requirements**, for several plans are available to suit the requirements of different users.

4. **Fixed costs** of a warehouse are **distributed among many users**. Therefore, the overall cost of warehousing per unit works out to a lower figure.

5. Public warehousing facilities **can be given up as soon as necessary** without any additional liability on the part of the user.

6. The costs of public warehousing can be **easily and exactly ascertained**, and the user pays only for the space and services he uses.

7. **Conservation of capital** is more in public warehousing

8. It has got **enough space to handle peak requirements.**

9. Public warehousing has **reduced risk in their operations**.

10. Public warehousing has got **good economies of scale**

11. It would give **Tax advantages** for end users.

12. Knowledge of **exact storage and handling costs** are available to end users.

13. It is **insulated from labour disputes**.

Disadvantages of public warehousing

1. Problems in **communication due to system incompatibility.**

2. **Specialised services may not always be available** whenever it is needed.

3. **Adequate space may not always be available** for end users.

Advantages of private warehousing

The advantages of private warehousing are:

1. Private warehousing offers **better monitoring systems over the handling and storage of products** as required by the management from time to time which would enhance the performance of the warehouse.

2. There is **less likelihood of error** in the case of private warehousing since the company's products are handled by its own employees who are able to identify the products of their own company.

3. Private warehousing is the best choice for some of the locations and the products handled because of the **non-availability of the public warehousing**.

4. Private warehousing has **the opportunity to specially design its facilities for automatic material handling equipment** whereas public warehousing may have to design for general usage.

5. Enabling the end user to increase their efficiency by means of **better design and structured lay-out.**

6. **Efficient use of human resources in warehouse operation** improves end users' overall performance

7. **Intangible benefits** in the form of **cost reduction** in all the warehouse operations.

8. **Tax benefits** when it owns its warehouse through depreciation allowances in buildings and equipment.

Disadvantages of private warehousing

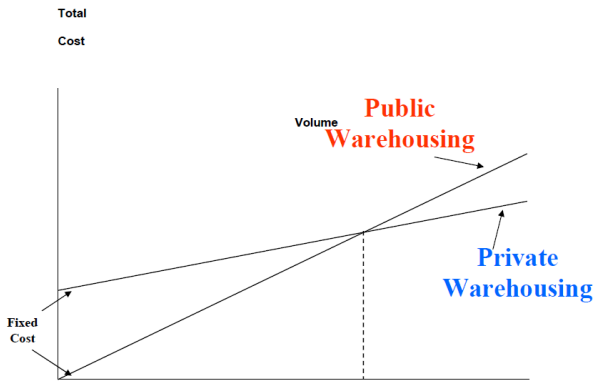
1. **Lack of flexibility** which increases the complexity in the operation.

2. **Financial issues.**

3. **Low rate of return.**

4. **Tax issues** are complicated.

The graph below clearly shows the impact of fixed costs with reference to volume of goods handled in **public warehouse as well as in private warehouse**. The organisation has to take a strategic decision in the selection of the type of warehouse which would suit its corporate goal. The organisation has to ascertain the volume of goods to be handled in their business plan in order to decide on the type of warehouse.



In practice, it is desirable to **use both private and public warehousing according to the products and customer base**. Also, private warehouses need not be owned. They may be rented or leased with or without material handling and other office equipment.

In a **public warehouse**, the warehouseman's integrity is the only security for the owner of the goods. A public warehouseman is responsible for the **protection of the quality and quantity of the goods entrusted to him**. He is not interested in the ownership or the use of goods, and is responsible for the goods only as a bailee. He is expected to take care of the

goods as a man of normal prudence. He is an ideal third party between the buyer and the seller, between the borrower and the lender. A **warehouse receipt for goods** is accepted for sale or for borrowing. Therefore, the warehouse renders physical support to trading.

c. Location of warehouses

It is apparent that **no seller can be equally near all customers or prospective customers**. The space and time also imposes significant limitation on the movement of goods from seller to buyer. In consequence, the location of the seller's production and distribution facilities in relation to those of customers is an important decision making process.

Some challengers around locations for warehouses are:

1. **Locating a warehousing system** at the production facility itself;
2. Locating a **single central distribution warehousing system** away from the production plant
3. Locating a warehousing system at **more than one place**.

But for any type of problem, the optimal location is the one that is most likely to achieve the **maximum rate of return on investment over the long run**.

Depending on the nature of the production process, the types of materials required, the characteristics of the end product and the tendency of buying companies to cluster in a given area, **proximity to raw materials** may be an overriding consideration.

For other manufacturers, **proximity to an adequate supply of labour or to customers** may be the main determinant of plants' locations.

Even though the above considerations of **raw material, labour, labour market or power** have a primary influence on site selection, often more than one location would satisfy the primary need. This permits selection among the alternatives, the one that represents the most advantageous utilisation of costs involved for providing the warehousing system while maintaining the desired quality of customer service.

The **total costs involved** are made up of:

- the cost of **transporting all inputs** required from their respective sources,
- the cost of **transporting outputs** to the markets at the various locations and
- The cost of **providing the warehousing facilities** that has been or is to be acquired.

The behaviour of these considerations may be different and opposite with respect to location. Finding the **least cost combination** will require the trading off of one category of cost from another. That is, a higher transportation cost will have to be accepted to realise a proportionately greater reduction in storage systems.

Choosing the most economical location and sizes for distribution warehouses is not a simple task. It may require the use of a **linear programming transportation technique**, often supplemented with **computer results.**

In cases of warehouses stocking finished goods, factors such as proximity of ports, railway lines, quality of roads, availability of power etc., become important considerations. Added to all the above factors the warehouses should be constructed with sufficient flexibility for expansion needs.

The following considerations **determine the location of a warehouse**:

1. **Market service area** and **cost of distribution** from the warehouse to the market service area.

2. Satisfaction of **transport requirements** and facilities available in the form of rail, link roads and road vehicles.

3. **Transportation rates** prevailing in the area and distribution costs per unit.

4. **Competition by rival companies** and whether they have a warehouse in the same area.

5. Availability of **power, water, gas sewage disposal** and their cost.

6. **Labour supply and labour costs** in the area.

7. **Industrial relations** climate and **labour productivity**.

8. **Pricing arrangements** and the level of service desired to be rendered in terms of availability of the product to the customer.

9. Individual company requirements and constraints.

10. **Real estate, excise and government taxes** assessed in the area.

11. **Attitudes of local residents and government** towards establishment of the warehouse.

12. **Restrictions** associated with warehouses.

13. Potential for **later expansion**.

14. **Cost of land** for the warehouse and other costs.

15. **Possibility of change** in the use of the facility at a later date if the company so desires, and lease or sale of the land and buildings.

Characteristics of **Ideal Warehouses**:

1. Warehouse should be **located at a convenient place** near highways, railway stations, airports and seaports where goods can be loaded and unloaded easily.

2. **Mechanical appliances** should be available for loading and unloading the goods. This reduces the wastages in handling and also minimises handling costs.

3. **Adequate space** should be available inside the building to keep the goods in proper order.

4. Warehouses meant for preservation of perishable items like fruits, vegetables, eggs and butter etc. should have **cold storage facilities**.

5. Warehouses must be designed to **protect the goods** from sunlight, rain, wind, dust, moisture and pests.

6. **Sufficient parking spaces** should be available inside the premises to facilitate easy and quick loading and unloading of goods.

7. **Round the clock security arrangement** implemented to avoid theft of goods.

8. The building should be fitted with the **latest fire-fighting equipment** to avoid loss of goods due to fire.

Qualitative factor rating method of comparison

Factor rating is a means of **assigning quantitative values** to all the factors related to each decision alternative and driving a composite score that can be **used for comparison**. It allows the decision maker to inject his own preferences into a location decision and it can accommodate both quantitative and qualitative factors.

Procedure for **qualitative factor rating:**

1. Develop a list of relevant factors.

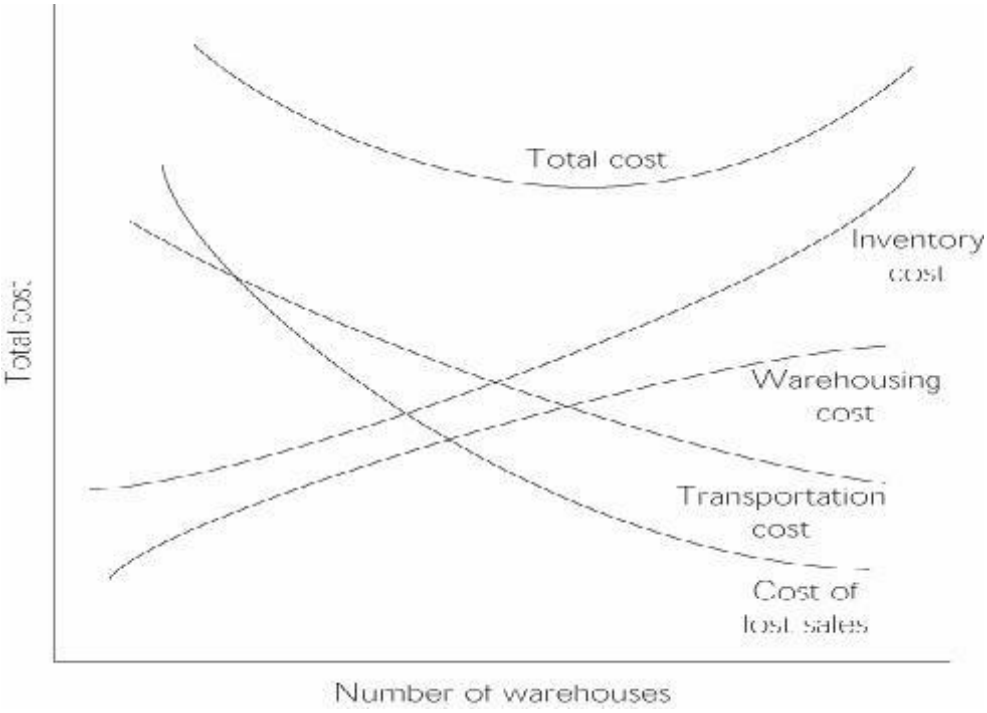
2. Assign a weight to each factor to indicate its relative importance (weights may total 10)

3. Assign a common scale to each factor (ex 0-100 points) and designate any minimum.

4. Score each potential location according to the designated scale, and multiply the scores by the weights.

5. Total the points for each location, and choose the location with the maximum points.

Weighted scores are computed by multiplying the score times with the assigned weight and summing those products. Based on this data, a location among many would get selected as the preferred location for the new warehouse.



Factors affecting the number of warehouses:

– Inventory costs

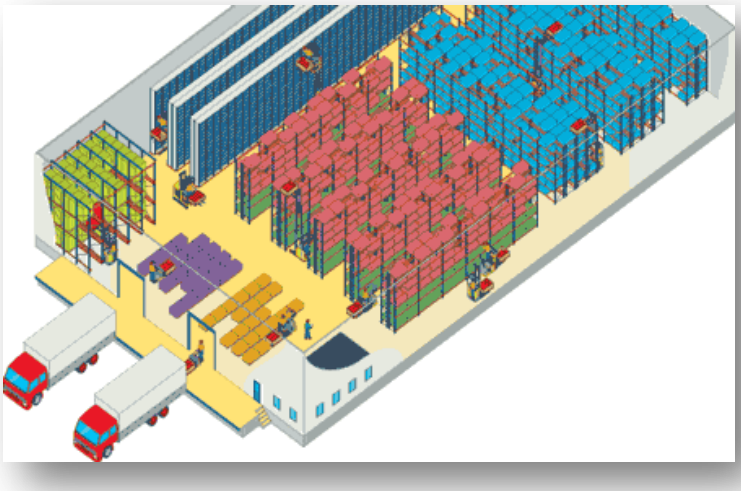
– Warehousing costs

– Transportation costs

– Cost of lost sales

– Maintenance of customer service levels

– Service small quantity buyers



d. Functions of the Warehouse

Warehousing has three basic functions:

- **movement,**
- **storage and**
- **Information transfer**.

The **movement function of a warehouse**:

1. Receiving -This includes the physical unloading of incoming transport, checking, recording of receipts, and deciding where the received goods are to be put away in the warehouse. It can also include such activities as unpacking and repackaging, quality control checks for damages and temporary quarantine storage for goods awaiting clearance by quality control.

2. Transfer or Putaway – Binning and storing the goods in their respective locations, including the temporary locations, from the receiving docking area.

3. Order picking / selection – Goods are selected from order picking stock in the required quantities and at the required time to meet customer orders. Picking often involves break bulk operations, when goods are received from suppliers in, say, whole pallet quantities, but ordered by customers in less than pallet quantity. Order picking is important for achieving high levels of customer service; it traditionally also takes a high proportion of the total warehouse staff complement and is expensive. The good design and management of picking systems and operations are consequently vital to effective warehouse performance. Packing slips are made up at this point.

4. Cross-docking - Move products directly from receiving (incoming truck to the shipping dock, outgoing truck) – these products are not stored in the warehouse. Cross-docking is commonplace in warehousing because of its impact on costs and customer service. For example, approximately 75% of food distribution involves the cross-docking of products to retail food stores. Eliminating the transfer or putaway of products reduces costs and the time goods remain at the warehouse, therefore improving customer service levels.

5. Shipping – Picked goods as per the customer order are consolidated and packed according to customer order requirements. It is shipped according to customer orders and respective destinations.

The **storage functions of a warehouse**:

1. Temporary storage –emphasises the movement function of the warehouse and includes only the storage of product necessary for basic inventory replenishment. Temporary storage is required regardless of the actual inventory turnover. The extent of temporary storage depends on the design of the logistics system and the variability experienced in lead time and demand. A goal of cross-docking is to utilise only the temporary storage function of the warehouse.

2. Semipermanent storage – is the storage of inventory in excess of that required for normal replenishment. This inventory is referred to as buffer or safety stock. The most common conditions leading to semipermanent storage are:

- Seasonal demand,
- Erratic demand,
- Conditioning of products such as fruits and meats,
- Speculation or forward buying, and
- Special deals such as quantity discounts.

The **information transfer functions of a warehouse**:

They occur **simultaneously with the movement and storage functions**. Management always need timely and accurate information as it attempts to administer the warehousing activity. Information on inventory levels, throughput levels (amount of product moving through the warehouse), stock keeping locations, inbound and outbound shipments, customer data, facility space utilisation and personnel is vital to the successful operation of a warehouse. Organisations are relying increasingly on computerised information transfer utilising electronic data interchange (EDI) and bar coding to improve both the speed and accuracy of information transfer.

Warehouse Activity Profiling

By **profiling a warehouses activities** it can be a great help in understanding its operations. A comprehensive profile based on **historical and current data** reveals characteristics that allow you to make decisions on storage and handling alternatives, slotting options, pick line requirements, system requirements, pick methods, and order releasing strategies.

With more detailed analysis you can even predict how your warehouse will operate, providing you the invaluable opportunity of being able to prepare for the future.

Two main categories of profiles make up a basic **warehouse profiling set**:

1**. Customer order** profiles - Customer order profiles represent the outbound activity, i.e., how the customers are ordering the products.

2. **Item activity** profiles - Item activity profiles provide insight into viable storing and slotting options for each item within the warehouse.

1. Customer Order Profiles - The three most basic customer order profiles are defined below.

a. Order Mix Distribution
b. Order Increment Distribution
c. Order Lines Distribution.

a. Order Mix Distribution: These distributions answer warehouse zoning questions such as “Should my fast, medium, and slow movers be zoned separately in the warehouse?” To answer this question, a distribution of the orders for fast, medium, or slow movers is compared with any combination of the three. If the warehouse data indicates that most orders call for a mix of fast and slow movers, zoning the items by velocity will have order consolidation impacts that need to be considered. Order mix profiles are also used to analyse the percentage of order lines for full cartons, broken cartons, or a combination of the two. Analysis of this information provides options on storing full and broken cartons together. The goal is to determine what percentage of your customers is ordering full and broken carton quantities of the same item, before investing time and money in changing the current storage strategy.

b. Order Increment Distribution: The order line distribution of the percentage of a full carton ordered is beneficial when evaluating if the current packaging is in logical increments for the customer. For example, if results indicate that 90% of the customers are ordering carton quantities, the warehouse can consider effective alternatives. Options could involve first the supplier by changing the carton size, second the warehouse operations by breaking down cartons at receiving in order to save time during picking, and third, the marketing department by encouraging customers to order in full carton quantities.

c. Order Lines Distribution: The distribution of the number of lines contained on each order is important when evaluating operating strategies. A warehouse with mainly one and two line orders would most likely have a very different picking strategy than a warehouse with many large multi-line orders. If your graph looks like figure 1 and you have a significant number of single-line piece-pick orders you may want to consider batch label picking these orders.

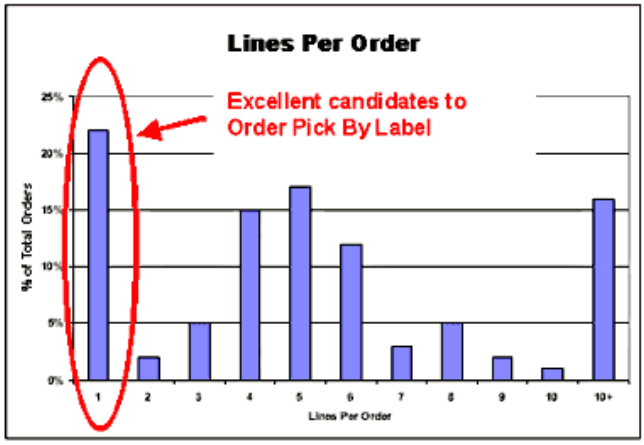


Figure 1 – Graphing Lines Per Order Can Identify Where To Pick-by-Label

2. Item Activity Profile: Primarily item activity profile is used to allocate each item in the warehouse.

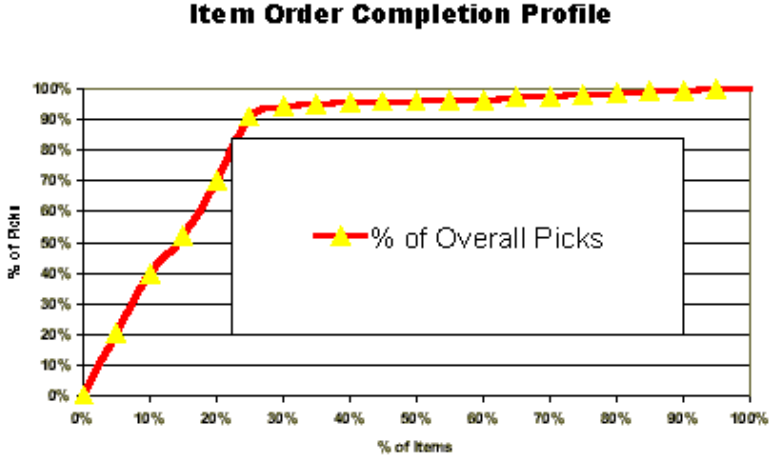
Item activity profiles are beneficial when **analysing products activities** for the purposes of determining **storage mode, product slotting, and facility layout options.**

There are several types of item profiles, the **three most basic** are defined next.

a. **Popularity profile** - is a ranking of the items based on how often they are ordered or picked (frequency).

b. **Volume profile** is a ranking of the items based on how much is ordered (cube movement).

c. Finally, the **item order completion profile** displays the items ranked from most to least popular against the order set. This profile reveals the percentage of the orders that will be completed by a subset of the items and is valuable when conducting cost benefit analysis for improved productivity. The chart in figure 2 shows that 30% of the items complete 90% of all orders. This information is useful because it allows operations to make improvements, such as automation of a smaller area, yet still benefit 90% of all orders.



e. Warehouse Operations - Centralised and Decentralised

In a **multiple warehouse**, the warehousing operations can either be **centralised or decentralised**.

In **decentralised warehousing operations**, each warehouse is considered as a **separate entity.** Therefore each warehouse will have a separate safety stock, there will be orders from the lower warehouse to the upper warehouse and there will be in-transit stocks. Each warehouse will optimise inventory individually.

This type of **decentralising will be advantageous** for the following situations.

Consumption centres are located at different places and at distant places. The transaction of goods is very high. The **advantages** of such a system are

- This prevents obsolescence and also prevents accumulation of surplus material and
- This offers service where it is needed.

But the system has the **disadvantage** of having high running cost due to increased stock and personnel in each warehouse and due to handling of more information.

Alternatively, in a **centralised system** of warehousing operations, order processing, storing of safety stocks and control stock movements will be done centrally by a central warehouse. The important requirement for this centralised system is a well established information system. This system has the following **advantages**:

1. Orders for multiple items on a single source can be bunched together,
2. There will be a reduction in safety stock and
3. Similarly total inventory cost is also reduced.

These **reductions in inventory costs** adequately **justify the cost of information systems**. In such a **centralised system**, the central warehouse will have to do the

additional record keeping and decision making required in a branch warehouse operation. That is, it should keep track of each branch's current stock of each item, its rate of sale at each branch, the amount currently on order and amount in transit.

The **central warehouse**, with the above information, will have to make decisions about when and how much to reorder from the factory. If the decisions are made on the basis of outdated, incomplete and erroneous information, many of the decisions will be incorrect, a consequence that will raise costs and reduce sales.

f. Storage systems

The type of materials passing through **warehouses** varies enormously, with different sizes, weights, shapes, levels of fragility and hazard characteristics. A major benefit of **unit loads** such as **pallets** is that they enable the use of **standard storage systems and handling equipment**, irrespective of what is handled. Variations in throughput and order picking patterns make it appropriate to have different types of **storage systems**, with different operational characteristics, so that the correct **storage system** can be selected that most closely match the needs of the wider system within which they are to operate.

The **key factors influencing the choice of a storage system** are:

- The **nature and characteristics** of the goods and unit loads held;
- The effective utilisation of building volume i.e. horizontal and vertical:
- Good access to stock;
- **Compatibility with information system** requirements;
- **Maintenance** of stock condition and integrity;
- Personal safety;
- Overall system cost.

When comparing the **costs of different storage systems**, it is **not only the storage equipment cost** that should be taken into account. **Other cost elements** that could be affected by the choice of systems include:

- Space i.e. land, building and building services;
- Fire protection;
- Handling equipment including maintenance;
- Staff;
- Information management systems.

One way of **classifying storage systems** could be:

- **Bulk storage for solids**, such as silos, bunkers and stockpiles;
- **Loose item storage**, ex casting and fabrications held loose on the floor;
- **Pallet storage** systems;

- **Small item storage** for individual items or small unit loads;
- **Non-standard unit loads** such as long loads.

The **location of stock** within a store is an important aspect of stock management and can be considered at different levels of detail. For example, the **overall positioning** of stock within particular areas of the warehouse can influence the **total amount of movement required** to get material into and out of stock. It can also affect the efficiency with which order picking operations can be carried out by affecting the distance order pickers have to travel to get to required stock.

Fixed and random stock location

The **effective storage capacity** of a given installation is influenced by whether individual product lines are held in fixed and dedicated locations, or whether any product line can be located randomly in any available storage location.

If a **fixed location system** is used, any specific location can be used for its designed product line, and never for any other product. Consequently the installation must be designed with enough capacity to hold the maximum stock of every product line.

With **random location**, when any empty location can be utilised for any product line as required, the size of installation can be reduced, since the probability of every product being in stock at maximum stock level at the same time is virtually nil. In this case, the required storage capacity can be calculated from the sum of the average stock levels for all product lines, inflated by a factor, say 10%, to account for fluctuations about the average.

Random location is often used for reserve storage, which tends to take up the largest area in a warehouse, and fixed location for order picking stock, which enables the use of concepts such as popularity storage i.e. fast–moving product lines located to minimise picker movement.

Palletised storage systems

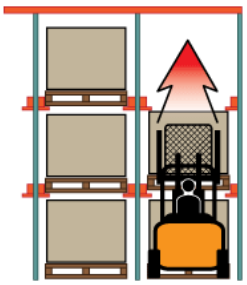
Block stacking

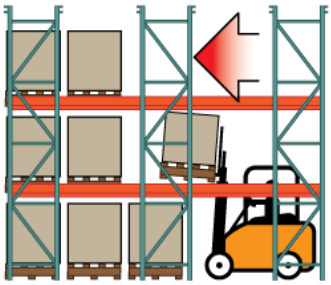
Block storage does not use any storage equipment. **Loaded pallets** are placed directly on the **floor and built up in stacks, one pallet on top of another** to a maximum stable height. The pallet loads must be capable of carrying the superimposed pallets, and the top of each load should be flat enough to provide a stable base for the next pallet.

Block stacking is suitable for that part of the product range where there are few product lines, each with high stock level, and where very strict FIFO (first-in-first-out) movement of stock is not required. The **advantages** are good use of area, flexibility to change the layout of the blocks and quick to stock for rapid throughput.

Drive-in and drive-through racking

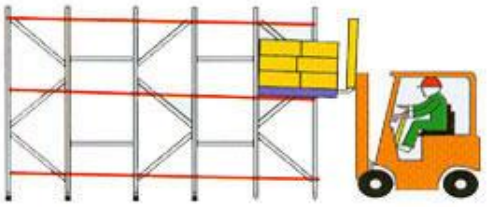
Although this is a **racked storage system**, it is operationally similar to block storage. There should only be one product line in each row, and the effective utilisation of the pallet positions is about 70%. The **racking structure** supports the weight of the pallets so this system is suitable for high stock product lines, where strict FIFO (first-in-first-out) movement is not required, but where the pallet loads are not strong enough or of regular enough shape to carry superimposed loads. This system consists of **vertical support frames**, tied at the top, with cantilever pallet support beams at different heights. In these configurations, a forklift drives into the rows of racks from one side only in a drive-in rack system or from either side in a drive-through system, to add or retrieve movable pallets placed on rails. The pallets are placed on the rails to be stored deep in the system. This method greatly reduces the number of aisles necessary for access and the storage capacity of a drive-in/drive-through pallet rack is often limited only by the size of your facility. In the same footprint of floor space, approximately 75% more pallets can be stored in a drive-in/drive through system than in a selective rack system.

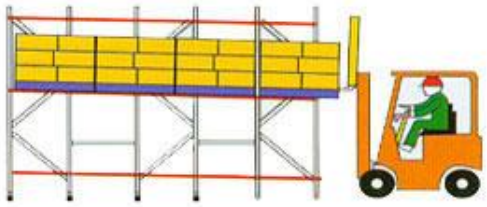




Push back Racking

This type of racking is a comparatively recent development. Like-drive-in racking it gives **high-density storage** and can be **built to any height** up to the **maximum lift height of the lift trucks** accessing it. Pallets can be stored up to about four deep in the racking, on either side of the access aisle. The basic operational difference between this system and block stacking or drive-in racking is the **increased selectivity achieved**. There should be no mix of product lines in any one lane, but there can be **between the lanes in any row**.



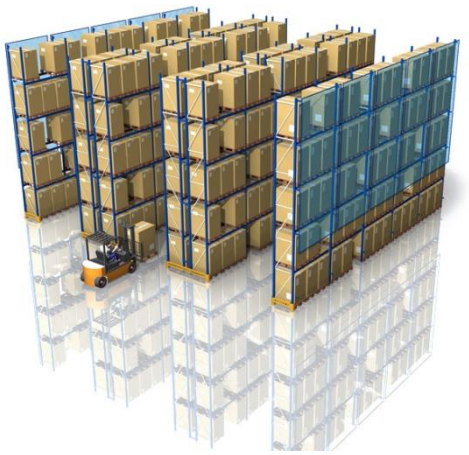


Adjustable Pallet Raking (APR)

Adjustable pallet racking is probably the most widely used type of pallet racking, and offers free access to every pallet held. It can be built to match the lift height of any forklift truck. Unit loads other than pallets can be stored using APR, and there is a range of accessories such as drum supports and channel supports for post pallets to facilitate this.

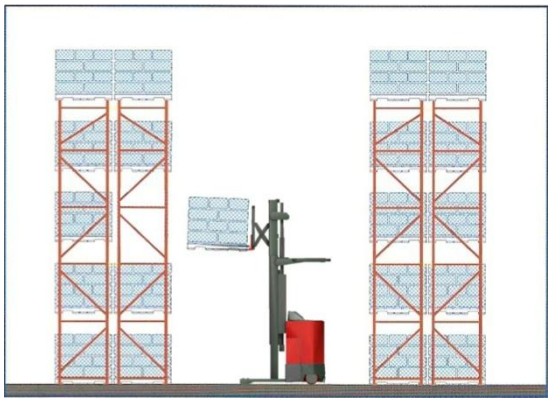
The conventional way of laying out APR is to have one row single deep at each end of the installation, with back-to-back rows in between. This gives every truck aisle access to two rows of racking, and minimises the number of aisles required.

APR is a flexible, versatile storage system, which gives excellent stock access. It is simple in concept, easily laid out, and damaged parts are easily replaced. It can be suitable for fast moving and slow moving stock, and for product lines with high or low levels of palletised stock-holding. However, APR does **not make good use of storage space.**



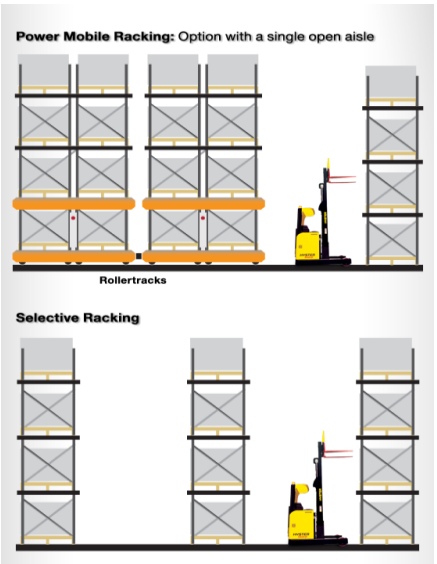
Double deep Racking

If some loss of totally free access to stock can be accepted, although not nearly as severe as in block, drive-in or push back storage, space utilisation can be improved using **double deep racking**. This supports pallets on pairs of beams as in APR, but improves space utilisation by eliminating alternate access aisles, and using a double reach fork-lift truck, which can access not just one but **two pallets deep** into the racking.



Powered Mobile racking

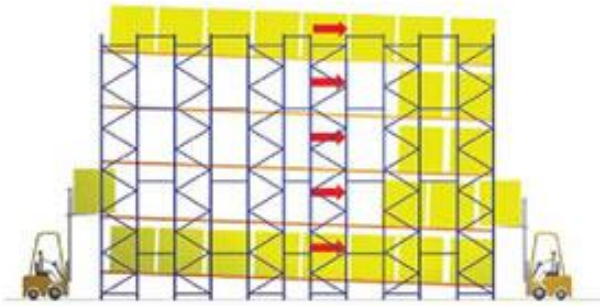
Powered mobile racking is effectively single deep APR, with the racking, except the end or outer rows are mounted on **electrically powered base frames**. Operationally it has similar characteristics to APR, but it is **slower in use**, and the pallet position utilisation is likely to be similar to APR at 90 to 95%. This type of storage is expensive in equipment and floor costs, and it tends to be slow in operation. However it **gives very dense storage**, and is suitable for the typically large number of product lines forming the 'Pareto tail' of a product range, where individual product lines have low stock and low throughput. It also finds use in **cold-storage applications where space costs are especially high**, and however temperature variations are reduced by cutting the air space in the storage area.



Pallet live storage

Live storage systems are made up of **inclined gravity roll conveyors**, laid out side by side and at a number of vertical levels. Pallets are **fed in at the higher end** and **removed as required at the lower.** Such a system imposes FIFO (fist-in-first-out). The only accessible pallets are at the out feed end, so any one lane should only hold pallets of the same product line.

Pallet live storage systems are **suitable for very fast-moving product lines**. They can provide effective order picking regimes, which automatically refill empty locations, and also provide physical separation between picking and replenishment operations.



Small item storage systems

As with palletised storage systems, there is a range of different system types for holding small items. With **small item storage** it often happens that different systems are incorporated into one installation. For example, drawer units and cabinets may be built into a shelving installation. Consequently the concept of standard equipment sizes and modularity is important for small item storage systems.

Below is a list of some of the storage systems used for **small items**:

- Shelving
- Tote bins
- Drawer units
- Dynamic systems –mobile and live storage
- Mechanised systems- carousels and mini loads

Types of conveyors

1. Fixed Path Conveying

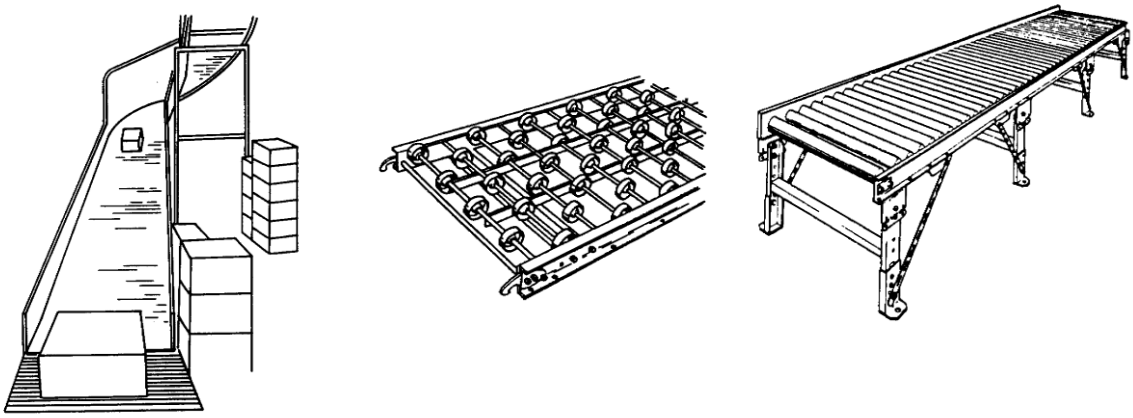
Fixed path conveyances are advantages for periodic and continuous transport of material between locations in warehouses and factories. They are also used to accumulate goods, store packages, change elevations, and provide a continuous work surface on which progressive assembly or processing can be performed.

Conveying systems Planning Criteria

- Product size and weight (or container characteristics if used).
- Distance
- Control requirements.
- Flow Rates.
- Obstructions and facility limitations.
- Human factors, including noise
- Environment.

2. Gravity Conveyors

These **conveyors** are the simplest and usually least expensive. They are useful where material is moved for short distances and movement requirements are simple. Three common types are **chutes, skate wheels, and rollers**. They are often used in conjunction with powered systems.



Above: in order, chute, skate wheels and roller gravity conveyers

Advantages of Gravity Conveyors

- Excellent for elevation drops.
- Low initial and operating cost.
- Quieter operation than powered conveyors.
- Low maintenance
- Low profile.
- Easier to manually move products.
- Unlimited configurations allow use for wide range of product weight.

Disadvantages of Gravity Conveyors

- Less control of products on long runs, including failure to move once stopped.
- Impractical for fragile products that are damaged by bumping or crashing.
- Singulation and non-contact difficult.
- Tend to increase the work in progress.
- High pitch requirements.

- May require manual assistance.

3. Horizontal powered conveyors.

These are used to **move material over moderate to long distances**.

Live Roller

This type of conveyor is used for a variety of applications, loads, and environments, but they are typically used for **14-23 kg loads in warehouses**. They can provide brief periods of product accumulation or dwell points. Live rollers can handle up to 4535 kgs and can carry irregular shaped containers.

Live rollers are classified by their drive method, listed below some disadvantages are:

- Higher cost due to construction materials.
- Product slippage on rollers requires frequent tracking update and diverter timing.
- Products cannot negotiate inclines over 7 degrees without manual assistance.
- Power surges when accumulating on driving rollers; disrupting product spacing.

4. Live Roller Accumulation Conveyors.

These conveyors are used to regulate the flow of products into downstream operations by providing a **temporary buffer for excess products.** Selection criteria depend on specific applications. Proper product alignment is required when using accumulation conveyors. Various releases are available, depending on conveyor speed. Two types of powered accumulation conveyors are:

- Zero-pressure .The line pressure (horizontal pressure between products) is eliminated.
- Non-Contact. Products are always separated from each other.

5. Slider Bed/Roller Bed Conveyors

The **slider bed** consists of a moving belt operated across a steel support bed. The roller bed is a belt supported by rollers. The slider bed is the least expensive powered conveyor, but handles less loading than the roller bed. Roller beds require more power than live rollers. Belt conveyors offer stable support, are used for heavy loads, and can be operated at high speeds. The belt conveyors maintain product spacing to allow excellent material racking. These conveyors are also used for inclines and declines of up to 30 degrees.

Belt conveyors are not used to accumulate products, but they can start and stop and they can be used to metre products at the exits of an accumulator conveyor.

6. Roller Curves and belt Turn Conveyors

Curves and turns are used to change the direction of material flow. Roller curves are less expensive than belt curves and they are the most common. They can be self powered or slave driven. Belt curves are used to maintain product orientation and spacing. The flat surface also allows handling of smaller, irregular sized products.

7. Sortation Conveyors

Sortation conveyors are used to identify packages, present packages to sortation equipment, or sort packages to multiple locations.

8. Powered Overhead Conveyors

Powered overhead conveyors are used when system flexibility is desired or floor space is congested because material flow paths are easily established and altered and obstructions are minimised, enhancing freedom of movement. Additionally, drivers and other equipment are offered some protection from the environment on the floor.

9. Vertical Conveyors

Vertical conveyors are used to lift or lower heavy loads between various levels in intermittent-flow operations and where horizontal space is limited. Of the two vertical types, the reciprocating is simpler, but the continuous supports a higher flow rate.

h. Automated Storage and Retrieval System

An **automated storage and retrieval system (ASRS or AS/RS)** consists of a variety of computer-controlled systems for **automatically placing and retrieving loads** from defined storage locations. Automated storage and retrieval systems (AS/RS) are typically used in applications where: there is a very high volume of loads being moved into and out of storage; storage density is important because of space constraints; no value adding content is present in this process; accuracy is critical because of potential expensive damages to the load. AS/RS can be used with standard loads as well as nonstandard loads

An **automated storage and retrieval systems (AS/RS)** uses **computer-controlled driverless high lift stacker cranes** in high bay warehouses, a concept that has been with us since the early 1960s. In this sort of application the computer is used to manage and control the physical movement of equipment, and hence of the materials being handled and stored. Many of the earlier stacker cranes were operator-controlled, but the facility for on-board operation is now more usually for maintenance purposes only.

During the last 10 to 15 years the pace of technological development and application has increased considerably. This has gone hand in hand with, and been encouraged by, the growth in information technology, and has been motivated by the increasingly tight requirements for accurate and timely customer service, and for inventory and cost reduction. However, there are still many warehousing applications that do not make use of advanced technology, and the view is that **high-tech solutions are not always the answer to every handling or storage problem**. Systems should be designed that best meet the overall system requirements, and in some cases that will be a 'low-tech' solution. One example of this was the building of a new clothing warehouse that had to be able to meet peak seasonal sales of up to three times the volumes experienced at other times of year. In this case the flexibility of a labour-intensive solution, in which the company could 'throw people at the problem 'was seen as a major requirement for meeting seasonality and peak sales volumes. An automated solution would have been underutilised for much of the time.

Advantages

An effective automated storage and retrieval system provides **several benefits for supply chain management**:

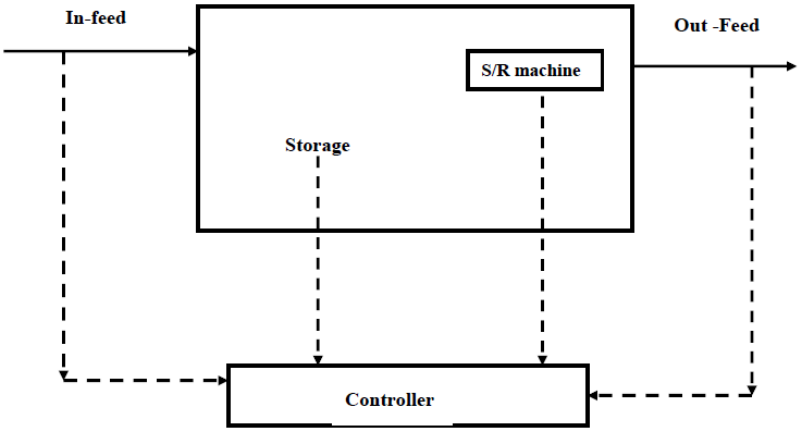
- An efficient AS/RS system helps companies cut expenses by minimising the amount of unnecessary parts and products in storage, and improving organisation of the contents of a warehouse. Due to automated processes, it also allows for more storage space due to high-density storage, narrower aisles, etc.
- Automation reduces labour costs while lowering workforce requirements and increasing safety.
- Modelling and managing the logical representation of the physical storage facilities (e.g. racking, etc.). For example, if certain products are often sold together or are more popular than others, those products can be grouped together or placed near the delivery area to speed up the process of picking, packing and shipping to customers.
- Enabling a seamless link to order processing and logistics management in order to pick, pack, and ship product out of the facility.
- Tracking where products are stocked, which suppliers they come from, and the length of time they are stored. By analysing such data, companies can control inventory levels and maximise the use of warehouse space. Furthermore, firms are more prepared for the demands and supplies of the market, especially during special circumstances such as a peak season on a particular month. Through the reports generated by an AS/RS system, firms are also able to gather important data that may be put in a model for it to be analysed

Automatic Storage and Retrieval Systems (AS/RS) for Unit Loads

The **basic components of an AS/RS system** are:

- Storage medium, eg pallet racking, or shelving for small-item tote bins;
- Storage and retrieval machines that operate in the storage medium;
- In-feed and out-feed systems, eg forklift trucks, conveyors, AGV's (Automatic Guided Vehicles).
- Controlling computer.

The **controlling computer monitors** the status of all the components of the system and, based on the warehouse stock and movement requirements, plans the work to be carried out within the system and instructs the equipment accordingly.



A **typical installation** could consist of high bay pallet racking, with stacker cranes operating in the racking aisles to put pallets away to stock and to retrieve them as required. There are single deep and double deep stacker cranes, enabling the use of single or deep pallet racking on each side of each aisle. Installation heights of 45 metres or more can be achieved, and typical operating aisles for standard pallets can be about 1.5 metres. The computer would control the incoming and outgoing material flows, monitor the status of the pallet racking (what stock is located in each location and which locations are empty), and control the crane movements. Because of the generally tight clearances in such installations and to prevent possible jams in the racking, a strict profile check for incoming pallets is adopted to ensure that loads have not slipped on the pallets during transit, and that packaging material has not come loose. Pallets outside the dimensional specification are rejected, and have to be rectified before being accepted into the system.

A **stacker crane** consists of a vertical mast or pair of masts supporting a unit load handling mechanism, which can be raised or lowered. The crane travels on floor mounted rails running the length of each aisle, and is guided by an overhead rail. The unit load mechanism can pick up and put away pallets from and to either side of the racking aisle. Cranes can be designed for accessing pallets in single deep and double deep racking.

The amount of storage racking required depends on the designed stock-holding capacity of the installation. The overall rack dimensions are then determined by the height of building (allowed by the local planning authority), and by the lift and travel characteristics of the cranes. This then determines the number of racking rows required and the number of crane aisles.

The **number of cranes** required is determined by the total amount of a pallet movement that has to be carried out in a given period of time. If the number of cranes is significantly less than the number of aisles in the racking, a transfer facility can be incorporated into the design to enable the computer to move cranes between aisles as required. This usually consists of a transverse aisle at one end of the tracking, equipped with one or more transfers cars on to which the cranes can be driven and moved between aisles. If the number of cranes required is close to the number of aisles in the racking, it is probably better to have one dedicated crane in each aisle.

Design of Automatic Storage and Retrieval Systems (AS/RS)

The **highly automated AS/RS** has a simple design. A pallet conveyor system transports the heavy unit loads that interface with the AS/RS. Dual induction assures that pallets of product are inducted quickly and easily. A scan clearance tunnel checks for overhanging loads. Product is tracked from receiving to shipping by a "small system" that tracks it from manufacturing and other sites. Software and controls provide information on inventory status, which assist in production planning and customer shipping schedules.

The pallets of product are stored by one of the six AS/RS, without operator intervention. **Reduced handling** translates into increased productivity and efficiency. A unique feature of the AS/RS is its ability to **interface with three different pallet types** on rack load beams in both single and double deep configurations. As product is needed the pallets are retrieved. The AS/RS eliminates fork lift traffic in picking and transportation.

Pallet loads are transported by the **heavy unit load conveyor system** to order picking stations. An ergonomic conveyor lift is used to transfer the load. These lifts make picking easy by positioning the pallet loads at optimal working height.

Once the order is complete, it is dispatched to shipping by an **automated rail guided transfer car**. Pallets with remaining products are returned to the AS/RS automatically by the pallet transport system. Empty pallets are stacked and returned to production.

There are various applications of this principle of automated storage. They include:

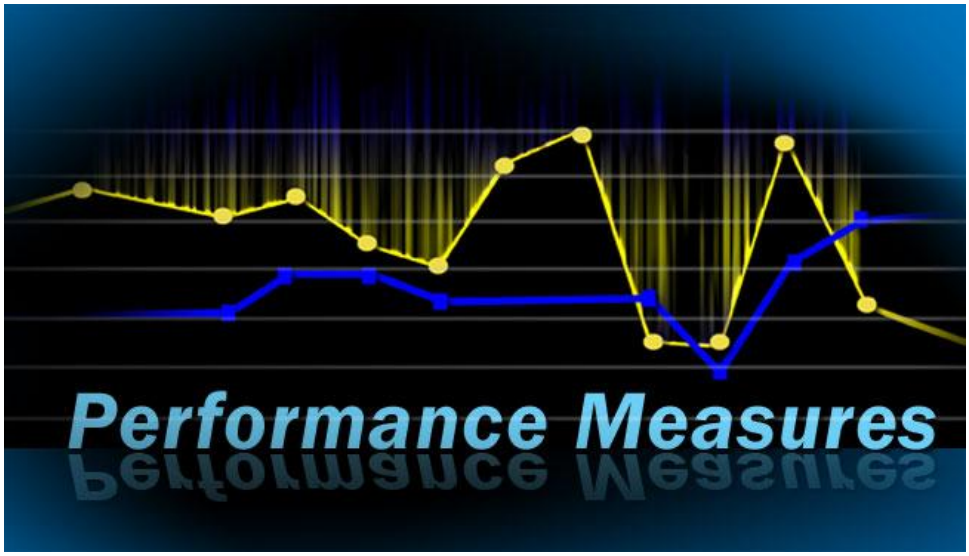
- Small –item storage using 'mini' crane installations
- Long load storage of metal bar and tubing using cantilever racking-often in support of manufacturing operations.
- Paper reel handling using over head travelling cranes fitted with vacuum lifting heads, moving the reels into and out of vertical stack storage.

It should be noted that the term 'automated warehouse' is frequently used to describe installations that in reality are only partially automated. The handling of whole pallets into and out of racking may indeed be automated, but the order picking of cases from those pallets is in many applications still carried out manually. However, such applications will always be supported by a good information and communication system, using such techniques as bar coding and /or radio data communication.

A frequently used term in automated warehousing is **'high bay warehouse'**. Generally this refers to a crane-accessed AS/RS system, and there are cranes designed to lift in excess of 40 metres high. Other terms associated with this sort of installation include **'roof on rack'** and **'clad rack'**. These both refer to the specific building technique in which the walls and roof are supported by the racking steel work, so avoiding the need for a separate enclosed building. This reduces the cost of building .There can also be tax implications according to whether the building is classified as a fixed asset or as 'plant '.

The major benefits of Automatic Storage and Retrieval Systems (AS/RS)

- Reduced order fulfilment time in half while servicing manufacturing operations
- Reduced operations costs
- Maximise utilisation of floor space
- Increase inventory accuracy
- No restocking errors
- Fast and accurate service



f. The Principles and Performance Measures of Material Handling Systems

A number of different **performance measures** have been used in the **design and analysis** of **material handling systems**. These performance measures have measured either:

1. The **entire manufacturing system** (e.g. job throughput), or
2. The **material handling system independently** (e.g. vehicle travel distance).

The following is a review of performance, reliability, and performability measures used in the analysis and design of **material handling systems** in a manufacturing environment.

The **material handling system** in any manufacturing setting plays an important part in the performance of the entire manufacturing system. Research in the design of material handling systems within a manufacturing environment has primarily studied system performance as a function of:

- Guide path design or layout
- Type of flow path
- Number of lanes in each aisle,
- Location of pick-up/delivery points,
- Fleet size,

- Unit load size,
- Vehicle speed and
- Queue capacity at each workstation.

Research in the operation of these systems has primarily studied performance as a function of:

- Vehicle dispatching rules and scheduling,
- Idle vehicle positioning,
- Vehicle routeing, and
- Zone definitions.

A number of different performance measures have been used in **analysing material handling system design and operation**. However, the appropriateness and/or the adequacy of the performance measures used in material handling system analysis are rarely addressed.

A **performance measure** may be defined as a **metric for quantifying efficiency and/ or effectiveness**. As applied to material handling systems, the **effectiveness** of a material handling system describes to what extent the system performs the required handling tasks, whereas **efficiency** describes how economically (in terms of resource utilisation) these tasks are performed. Therefore, it is possible for an **effective system to be inefficient**; it is also possible for an **efficient system to be ineffective**.

Vehicle travel: Distance (or travel time)

Vehicle travel is generally measured as actual path distances, and not rectilinear or Euclidean distances. The total vehicle travel distance consists of loaded and empty vehicle travel. Material flow can then be characterised as either:

1. **Departmental** (within departments) or
2. **intra-departmental** (between departments).

Material flow within departments is usually not modelled in material handling system analysis.

The measurement of vehicle travel may include loaded vehicle travel, empty vehicle travel, or both. Vehicle travel distance is easily calculated when the flow volumes (trips required per unit time) and distances between stations are known.

Vehicle travel time directly corresponds to vehicle distance when:

1. The vehicle speed is constant or may be assumed to be constant,
2. The acceleration and deceleration effects are negligible, and
3. There are no delays due to blocking, queues or other congestion effects.

Another vehicle travel distance measure is the average loaded or empty vehicle travel. This measure is defined as the average time to complete a transportation task. A measure is also taking vehicle travel using the ratio (RLE) of empty versus loaded vehicle travel.

$$RLE = TL/ TE$$

Where TL total loaded travel time,

TE total empty travel time.

Vehicle travel proportions

A vehicle may be in one of three states at any given time:

1. Travelling loaded,
2. Travelling empty or
3. Idle.

Idle time spent in the parking area is used as a performance measure. Then, travel time percentages may be calculated as the fraction of time that a device is travelling loaded, travelling empty, and waiting in an idle state. That is,

$$T = TL + TE + TI,$$

Where

TI total idle time,

T total time,

TL as above (total loaded travel time),

TE as above (total empty travel time).

Vehicle travel: response time

Response time for a pick-up call is also considered as a performance measure. The define response time for a pick-up call is the time from when the pick-up request is made until the vehicle (starting from an idle and empty condition) arrives at the pick-up location. This measure differs from the total empty vehicle transportation time in that it consists of only empty vehicle travel when the vehicle starts from an idle position and does not include empty vehicle travel from a drop-off station to a pick-up station.

Handling time per job

The handling time per job is comprised of the time directly associated with material handling. This time includes:

1. The time the job spends in queues waiting for the material handling vehicle,
2. The total travel time, and
3. The total loading and unloading times, and
4. Total vehicle blocking times.

The total handling time per job includes the time from when a job enters the system until it leaves the system.

Vehicle utilisation

Vehicle utilisation may be used to determine the vehicle fleet size requirements for a system. Vehicle utilisation may be based on:

1. The total vehicle mission time (including loaded and/or empty vehicle travel),
2. The loaded vehicle time and
3. The average of the time-averaged loads carried by all vehicles in the system.

(Note: when the vehicles are able to carry multiple loads, the utilisation value may be larger than one.)

Number of loads completed

The number of loads completed is defined as the number of loads (or deliveries) completed over a period of time by all of the material handling vehicles. The number of loads completed is considered as a performance measure. Some industry measure the time required for the material handling system to deliver a specified set of loads.

Station queues: Mean load waiting times

The mean load waiting time is defined as the mean time loads wait in queues for material handling transportation. These queues are located either at processing stations or at separate load transfer stations.

Station queues: Mean queue lengths

The mean queue length is the mean number of loads waiting for a material handling vehicle over a specific length of time. The variance of queue lengths may also be of interest, as a means of examining the adequacy of the physical space provided for the queue. Blocking occurs when a workstation's output queue (or buffer) is full and the workstation can no longer place completed parts into this queue. Starvation occurs when a workstation's input queue is empty.

Material handling system cost

Material handling system costs may be comprised of variable and fixed costs. Variable costs are generally the operating costs of the material handling system. These costs can include the cost of power, lubricants, and maintenance. The variable costs may also include the routeing or travel expenses, which are proportional to the distance travelled.

Costs associated with idle or waiting vehicles may also be included in the variable costs. Fixed costs include such costs as the construction and purchase of equipment and hardware.

In addition to the use of total cost as a performance measure, cost ratio (C) is also used as a performance measure. This cost ratio is defined as:

C= C in/ C out

Where:

C in - moving cost of one unit load and one unit distance within a department, C out - moving cost of one unit load and one unit distance between departments.

Material handling system flexibility

Industry has identified range and response as dimensions of flexibility. Range refers to how much the system can change. Response refers to how rapidly and cheaply the system can change. It has been defining material handling system flexibility as the material handling system's ability to reconfigure (to handle new material flows) and the material flow capacity. They define material handling system flexibility for a vehicle based system as:

Fmhs = sum xi¹it i²ib i,

ni=1

Where

xi number of equipment of type i,

¹i max unit load quantity factor, based on capacity of the equipment,

t i equipment speed, based on the normal operating speed of the equipment,

e i equipment loaded travel factor,

b i relative rerouting cost, indicates ability of equipment to reconfigure.

Congestion

Congestion prevents vehicles from travelling freely on a guide path. As a result of congestion, vehicles may travel at reduced speeds or may be required to stop. Vehicles may be delayed by other vehicles blocking the path or at intersections.

Congestion levels may be measured by the following quantities:

- Vehicle Blocking Time: the total blocking time of the vehicles is defined as the time where vehicles are unable to move due to other vehicles
- Track Blocking Percentage: track blocking is defined as the blocking time (as a percentage) for track segments due to vehicle interference
- Track utilisation by averaging the utilisation of all track segments and then dividing by the number of AGV's (Automatic Guided Vehicles).
- Vehicle Waiting Time at Intersection: average vehicle waiting time at intersections

Congestion index

The congestion index (Ic) is defined as:

$$Ic = TA/TS$$

Where

TA the actual travel time,

TS shortest travel time if there were no congestion.

Characteristics of effective performance systems

For most systems, the **selection of performance measures** is not simply a question of determining which measures are `good' and which measures are `bad', and selecting the `best' one or the `good' one.

On the contrary, **performance measure selection** is the process of **defining a set of measures that possess the following characteristics**, all of which are found in any **effective performance measurement system**.

- **Inclusiveness:** The performance measure (or performance measurement system) should measure all pertinent aspects of the material handling system. In this way, good performance of one particular component of the system would not be possible without similar performance of other system components.

- **Universality:** The performance measurement system should allow for comparison under a wide range of operating conditions. That is, if two competing material handling system designs must be compared, then the measurement system should allow for this comparison, even if the system characteristics differ significantly.
- **Measurability:** All data required by the measurement system should be readily measurable. Furthermore, the process of measuring the performance of the material handling system should occur with a minimum of measurement errors and at a reasonable expense.
- **Consistency:** The performance measures used should be consistent with the overall goals of the organisation. The value of the performance measure should therefore provide meaningful insights into overall material handling system performance with respect to organisational objectives.

Numerous **performance measures** have been used to analyse material handling systems. Although traditional manufacturing system measures, such as job throughput, have commonly been applied to material handling systems, they do not measure the material handling system independently.

In these instances, the **performance of the material handling system is confounded with the performance of the manufacturing system**. Therefore, these traditional measures are not necessarily effective or appropriate in the analysis and design of material handling systems.

Multiple performance measures provide more comprehensive information about system behaviour. In fact, the use of multiple performance measures results in more efficient and effective system designs and operation. Although multiple criteria decision making has largely been ignored as a decision tool, it has been established as the most appropriate method for the simultaneous consideration of multiple performance measures in material handling system design and analysis.

Material handling systems are unique in the sense that they are degradable systems. That is, a failure of one or more material handling components does not necessarily indicate failure of the entire system. Indeed, system component failures may only indicate that the system will continue to perform its tasks, but at some reduced level of performance.

Therefore, neither traditional notions of performance nor reliability alone are appropriate in this context. Performability measures, then, which simultaneously measure performance and reliability, emerge as appropriate measures for use in the design and analysis of material handling systems.

g. Materials Handling Equipment

"Every time you pick up an article without changing its form, you add to its cost but not to its value" – Mr. Henry Ford.

Materials Handling Systems (MHS) can be defined as **"the set of all pieces of equipment that make possible the physical movement within the distribution chain – including the production chain and the warehouse – of raw material, work in progress and finished goods".** Therefore, materials handling systems perform a wide range of activities. In general, Materials Handling refers to the necessary tasks to be performed in order to move a load around the factory floor as well as to store and freight it. Materials handling takes place one way or another along all the links of the supply chain including production, distribution, and storage and retail functions.

Handling in a warehouse or distribution centre will have a major impact on how effectively **materials flow through the system**, and on the cost, resource and time taken to get orders out to the customer. In addition, handling equipment can be capital – intensive, and the act of movement can be labour – intensive. Material handling equipment eases manual handling chores and **enhances operational efficiency.**

Various methods of handling goods are used in warehousing, from manual through to automated or robotic systems, and a broad categorisation could be:

- Manual handling;
- Manually operated trucks and trolleys;
- Powered trucks and tractors, operator controlled and driven;
- Powered trucks and trolleys, driverless, computer-controlled;
- Crane systems;
- Conveyors;
- Robotics.

Although this chapter will concentrate on powered trucks, cranes, and conveyors, it must not be forgotten that there is a wide range of **non-powered industrial trucks** for pedestrian

use. These include **hand pallet trucks, order picking trolleys, stair climbing trolleys and a wide range of platforms, shelf and cage trolleys.**

Industrial lift trucks are used in warehousing for **moving material over relatively short distances**, for lifting **into and out of storage**, and for **vehicle loading and unloading**. Trucks facilitate load utilisation, speed up movement, can handle large loads and consequently reduce the frequency of movements.

The main types of **powered trucks** used in warehousing and stock yard operations are:

- Powered pallet trucks;
- Counterbalanced fork-lift trucks;
- Reach trucks including double reach and four – directional reach variants;
- Stacker trucks;
- High rack stacker trucks-very narrow aisle;
- Side loaders;
- Order picking trucks;
- Tugs and tractors;
- Straddle carriers-container handling

Non-powered hand trucks

Non-powered hand trucks are used in many situations. They are inexpensively manufactured for diverse and specific applications. Common construction materials include aluminium/magnesium, steel, and wood. Because these trucks are so inexpensive, it makes sense to design them for specific material handling functions. In this way, it is possible to increase the cube utilisation within the truck for material handling optimisation. Aluminium or magnesium trucks generally carry 300-500 pounds of material, while steel or wooden trucks can be used to carry approximately 1000 pounds to 2000 pounds, respectively. The trucks range in weight from as little as 20 pounds for aluminium trucks to as much as 125 pounds for wooden trucks.

Non-powered hand pallet trucks

These trucks are designed to **carry unit loads on pallets** from one location to another, generally in indoor settings. Because unit loads can be quite heavy, the distances transported using this type of equipment is generally short. In many settings, hand pallet trucks are used to supplement motorised truck fleets. They are extremely efficient for transporting unit loads short distances when high lifting is not required. They can be used to position materials very precisely. Generally speaking, nonpowered hand trucks cannot be used to lift more than 8,000-10,000 pounds and cannot lift a unit load to a height more than 8 inches. For heavy duty applications, steel wheels are required while lighter duty applications require only nylon or polyurethane construction. These trucks can range in weight from 200 to 400 pounds.

Pallet Trucks

The full featured **ergonomic pallet truck** is an economical way for one person to move heavy pallet loads without the use of a fork truck. Proven ergonomic design has been tested for providing years of reliable usage.

This pallet truck includes two articulating steering wheels and two front load rollers. Ergonomic design requires only 34 kgs of pulling force when fully loaded. Steering wheels include bearing dust covers for added life. Nose wheels are located on the front edge of each fork to assist in clean pallet entrance and exit. Reinforced triple formed steel forks provide twice the strength of standard single-formed forks.

Equipped with internally mounted solid steel adjustable push rods. Spring loaded loop handle automatically returns to vertical position when not in use. Chrome-plated hydraulic pump piston for long seal life.

Powered pallet trucks

Hand pallet trucks, with capacities up to a maximum of 2 tonnes, are probably the most commonly used trucks for the horizontal movement of pallets. It is not uncommon to see these trucks lifted on to the back of the vehicle for positioning pallets during loading and unloading. However, for frequent movements, and where there are inclines to be negotiated, battery –powered trucks are preferable in terms of operator effort and safety, and these can be pedestrian – or rider- controlled.

Above: Pallet truck and counter scale pallet truck

Counter balanced fork-lift trucks

Counterbalanced fork-lift trucks carry the payload forward of the front wheels, so there is always a turning moment lending to tip forward. To balance this, a counter balance weight is built into the rear of the machine-hence the name. These machines capacity varies from 1000kgs to 45,000 kgs with a lift height of up to 6/7 metres.

Counter balanced truck

Reach trucks

Reach trucks are designed to be smaller and lighter than counter-balanced trucks and to operate in a smaller area. Its capacity varies from 1000kgs to 3,500 kgs with a max fork-lift up to about 11 metres. This is achieved by having a mast that can move forward or back in channels in the outrigger truck legs. When picking up or setting down a load, the truck is turned through 90 degrees to face the load location; the mast reaches forward, places or retrieves the load, and is retracted back into the area enclosed by the wheels.

Above: Reach truck

Double reach trucks

A **conventional reach truck** can only reach one pallet deep into racking. For accessing double deep racking a double reach truck has to be used, which uses a pantograph mechanism to achieve the additional reach. Double reach can also be achieved on some

lighter trucks by the use of telescopic forks. Double reach machines are also used for side-loading pallets on to road vehicles, working only from one side of the vehicle.

Above: Double reach truck

Four-directional reach trucks

On a **conventional reach truck**, the front wheels always face forward, and steering is from the rear wheels. The 4D truck has an additional option of being able to turn the front wheels through 90 degrees and lock them in this mode. This effectively converts the truck into a side loader and is especially useful in stores and warehouses where part of the stock range consists of long loads. For access to say cantilever storage, very wide aisles would be necessary if this option were not available.

Above: Four–directional reach trucks

Stacker trucks

These are **fairly light weighted trucks** with max capacities up to 2000 kgs. Stacker trucks are often used in narrow aisle applications for high stacking of relatively small loads. They can be used for pallets that vary in width, as the straddle width setting is adjustable. Stackers are ideal for moving small loads over short distances, such as in applications involving staging or order pick up and drop off. The machines should only be used on smooth surfaces, and distances for transporting goods should not exceed that which the operator can comfortably walk. Stacker trucks also come as counterbalanced units, if

straddle legs are not desirable. These trucks are usually limited to about a 6 metre lift, but they can operate in 90- degree turning aisles of only 2 metres or less.

Above: Stacker truck

High rack stacker trucks-very narrow aisle

These trucks typically will **lift capacities up to 2 tonnes** and lifting to 12/13 metres are equipped with mechanisms on the mast that can set down or pick up pallets from the racking without the truck having to turn in the aisle. Consequently they can operate in aisles of 1.8 metres or less. The very narrow aisles and high lifts give good space utilisation, but also necessitate very flat floors, which are expensive, to minimise the risk of collision between load and racking when manoeuvring loads. It is also necessary to have a guidance system to keep the trucks centrally positioned in the aisles.

Above: High rack stacker trucks

Order picking trucks

There is a range of **manual and powered trucks** designed specifically for order picking operations. These range from trolleys, such as roll cage pallets, to ground-level pedestrian trucks such as long fork powered pallet trucks, up to multi-level trucks in which the operator is raised for high-level picking.

Above: Order picking truck

Conveyors for unit load handling

Conveyor systems are used for moving material between fixed points, for holding material as short-term buffer, for sortation and for process industry applications such as separation, grading and cooling.

The general characteristics of the **conveyor systems** are:

- High through-put with few operators and low power requirement;
- Suitable for fixed routes, and floor surfaces are not as critical as they are for fork trucks;
- Fast response and suitable for continuous or intermittent movements;
- Can utilise very sophisticated movement control.

Conveyor systems are found in both conventional and automated warehousing.

The less positive aspects of **conveyor systems** include:

- High capital cost;
- Can obstruct working areas and access;
- Inflexibility for future change;
- Hence very careful system design required including safety features.

The **handling of products** is a **key to warehouse productivity** for several important reasons.

1. The **relative number of labour hours** required to perform material handling creates a vulnerability to any reduction in the output rate per labour hour. Warehousing is typically more sensitive to labour productivity than manufacturing since material handling is highly labour-intensive.

2. The **nature of warehouse material handling** is limited in terms of direct benefits gained by **improved information technology**. While computerisation has introduced new technologies and capabilities, the preponderance of material handling requires significant manual input.

Material handling in the logistics system is concentrated in and around the warehouse facility. A basic difference exists in the **handling of bulk materials and master cartons**. **Bulk handling** is a situation where protective packaging at the master carton level is unnecessary. **Specialised handling equipment** is required for bulk loading, such as for **solids, fluids, or gaseous materials.**

Over the years a **variety of guidelines** have been suggested to assist management in the **design of material handling systems**. These are representative:

- Equipment for handling and storage should be as standardised as possible.
- When in motion, the system should be designed to provide maximum continuous product flow.
- Investment should be in handling rather than stationary equipment.
- Handling equipment should be utilised to the maximum extent possible.
- In handling equipment selection, the ratio of deadweight to payload should be minimised.
- Wherever practical, gravity flow should be incorporated in system design.

The factors to be considered when **deciding** on the appropriate type of **handling system** for a particular application include:

- Types of load being handled including the unit load characteristics;
- Quantity of material being handled;
- Frequency of movement;
- Distances to be travelled, horizontal and vertical;
- Numbers and locations of pick-up and drop points;
- Adjacent activities;
- Nature of terrain;
- Flexibility required.

The principles governing the **design and use of handling systems** include:

- Control of position and movement;
- Elimination of unnecessary movement and minimisation of the necessary movement;
- Selection of the most appropriate handling method to meet the system requirements;
- Provision of adequate handling capacity;
- Integration of handling with the storage and other adjacent operations;
- Thorough and effective operator training;
- Effective equipment maintenance for operational availability and safety;
- Safe methods of handling and working practices.

Handling systems are classified as:

- mechanised,
- semi automated,

- automated, and
- Information-driven.

A **combination of labour and handling equipment** is utilised in mechanised systems to facilitate receiving, processing, and/or shipping. Generally, **labour** constitutes a high percentage of overall cost in mechanised handling.

Automated systems, in contrast, attempt to minimise labour as much as practical by substituting capital investment in equipment. An automated handling system may be applied to any of the basic handling requirements depending on the situation. When selected handling requirements are performed using **automated equipment** and the remainder of the handling is completed on a mechanised basis, the system is referred to as **semi automated**. Directed system uses computers to maximise control over mechanised handling equipment. **Mechanised handling systems** are the most common. However, the use of semi automated and automated systems are rapidly increasing. As noted earlier, one factor contributing to low logistical productivity is that **information-directed handling** has yet to achieve its full potential.

General Considerations

	Conveyors	Cranes and hoists	Industrial trucks
General Applications	Moving uniform loads continuously from point over fixed paths where primary function is transporting	Moving varying loads intermittently to any point within a fixed area.	Moving mixed or uniform loads intermittently over various path with suitable surfaces where primary function is maneuvering
Material Volume	High	Low, Medium	Low, Medium, relatively high
Type	Individual item, unit load, bulk	Individual item, unit load,	Individual item, unit load, variety

		variety	
Shape	Regular,uniform,irregular	Irregular	Regular,uniform
Size	Uniform	Mixed,Varialble	Mixed or uniform
Weight	Low,medium,heavy,uniform	Heavy	Medium Heavy
Move Distance	Any, relatively unlimited	Moderate, within area	Moderate,250-300ft
Rate, speed	Uniform, variable	Variable, irregular	Variable
Frequency	Continuous	Intermittent, irregular	Intermittent
Origin, destination	Fixed	May vary	May Vary
Area covered	Point to point	Confined to area within rails	Variable
Sequence	Fixed	May vary	May vary
Path	Mechanical fixed point to fixed point	May vary	May vary
Route	Fixed, area to area	Variable, no path	Variable, over defined path
Location	Indoors, outdoors	Indoors, outdoors	Indoors , Out doors
Cross Traffic	Problems in by-passing	Can be by-pass, no affect	Can be by-pass, maneuver, no affect
Primary function	Transport, process /store in move	Lift & carry, position	Stack, maneuver, carry, load, unload
% Transport in	Should be high	Should be low	Should be low
Operation			
Method Load Support	None, or in containers	Suspension, pallet, skid	From beneath: pallet, skid, container
Load/unload	Automatic , manual,	Manual , self,	Self, any point on

characteristics	designated points	any point	available package
Operator accompany load	No	May not, Usually does	Usually does, may be remote
Building characteristics Cost of floor space	Low medium	High	Medium, High
Clear height	If enough, conveyor can go over head	High	Low, medium, high
Floor load capacity	Depends on the type of conveyor and material	Depends on activity	Medium, high
Running Surfaces	Not applicable	Not applicable	Must be suitable
Aisles	Not applicable	Not applicable	Must be sufficient
Congested areas	Fair	Good	Poor

i. Tracking Inventory

Bar coding Technology and Applications

Introduction

Efficiently run businesses require many operations to flow seamlessly and without hindrance. **Automatic Identification or "barcodes"**, as the industry is more often referred to, makes these steps more efficient and accurate. A barcode does not change how a business operates, but it makes **procedures faster and more accurate,** providing useful management information in a timely manner. Barcodes can be employed in virtually all organisations and all professions to increase the productivity, efficiency and accuracy of specific business processes.

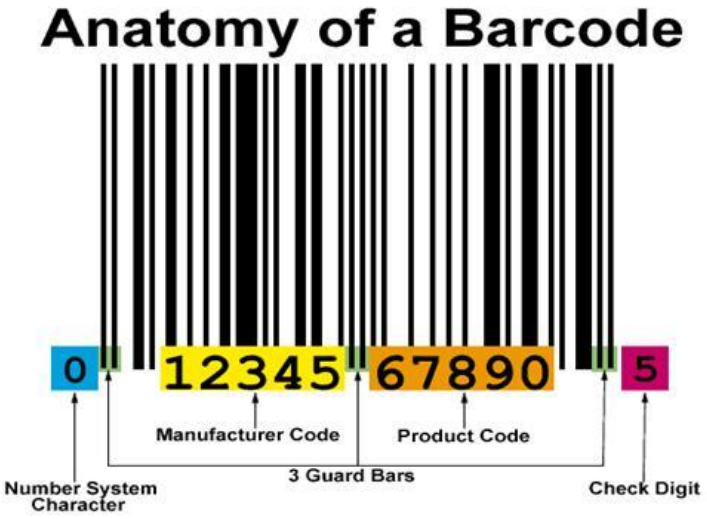
What is a Barcode?

A **barcode** is simply a set of **symbols used to represent alpha-numeric information**. Basically, instead of seeing the number "1", or the letter "A", you would see a series of bars, both fat and thin, used to represent that number.

So, why replace the alpha-numeric characters with a barcode in the first place, you might ask. Humans can easily determine that a strange combinations of lines and curves and dots

are put together to form a letter or number, but computers aren't as quick in deciphering such information. Even though Optical Character Recognition has come a long way in recent years, it's much quicker and much more accurate for a mechanical device to decode and a series of black and white lines than it is to read human text.

A number of barcode standards have been developed and refined over the years into accepted languages called **symbologies**. We would use different symbologies for different application in the same way that we would use a bold or italic font to emphasise a particular line of text in a report. Different symbologies or **"barcode fonts"** are used for different applications. By having standardised symbologies, we ensure that when you print a barcode, I will be able to scan and decode it with my equipment and you will be able to scan and decode my barcodes—as long as we both use the same code and are within the specifications dictated by the barcode standards.



Barcode symbologies come in two basic varieties. They can be either **linear or two dimensional** in their configuration. A **linear barcode** symbology consists of a single row of dark lines and white spaces of varying but specified width and height, as indicated by the example below.

Similarly, a **two dimensional symbology** (2-D) can be configured into a stacked or matrix format. Two dimensional barcodes are special rectangular codes which 'stack' information in a manner allowing for more information storage in a smaller amount of space.

The amount of data that can be encoded in a **linear barcode symbology is more limited** than that of a 2-D barcode symbology. A one inch 2-D matrix symbology, for example, can encode thousands of characters of data, whereas a comparable linear barcode would have to be several feet long to hold the same amount of information.

Benefits of Bar coding

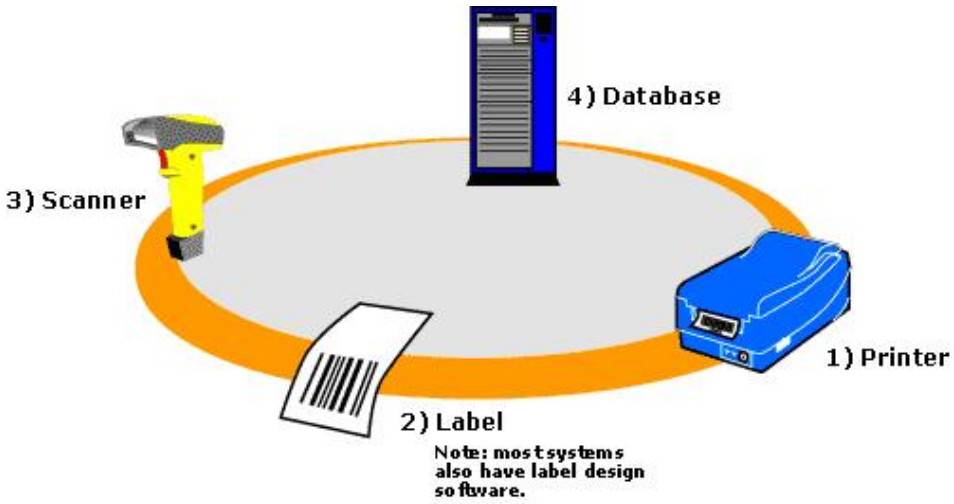
Many people think of **bar coding** strictly as a technology. A broader way of looking at bar coding is viewing it as a **tool for managing information**. Barcodes enable quick, accurate data entry. Having **accurate data available** enables managers to make decisions based on valid information. For example, with a manual system you often must make an educated guess on inventory levels and when to reorder products. On the other hand, the accuracy of **barcode scanning** provides **up to- the-minute information about inventory levels**, including the **value of inventory investment**. This information can help you maintain lower inventory levels and improve cash flow, which is invaluable to your business.

The most compelling **advantages of bar coding** and **automatic data collection** are:

- **Accuracy:** Bar coding increases accuracy by reducing the likelihood of human errors from manual entry.
- **Ease of use:** Barcodes are easy to use as long as the appropriate hardware and software components are in place to maximise the process of automatic data collection.
- **Timely feedback:** Bar coding promotes timely feedback of data captured in real time, enabling decisions to be made from current information.
- **Improved productivity:** Barcodes improve productivity in that many manual activities and tasks become automated, enabling resources to be utilised in other ways to increase efficiencies.
- **Barcode technology can be translated into three primary functions:** tracking, inventory management, and validation. Whether you use one function or a combination of functions, the benefits in cost savings, improved productivity, and quality can be substantial.

Components of Bar coding

Barcode systems come in many different sizes and shapes. The complexity of system required is determined by the application. A **basic scanning system** is fundamentally broken down into the following four components:



Component 1 – The Bar Code Printer

The **barcode printer** provides the first component part in a barcode system. A variety of technologies and methods exist to print a barcode label. You can use laser printers and pre-set templates (often included in label design software such as Wasp Labeller or Zebra Bar One software) to print your barcode labels. They are usually printed onto Avery stock. More commonly, labels are printed using barcode label printers such as those made by Intermec, Datamax, or Zebra. These printers print labels much faster and are of higher quality than those printed using a conventional laser printer.

Component 2 –The Bar Code Label

As mentioned above, you need the barcode printer to print the barcode labels. In addition, you need some **software application that can design your labels**. These are the same labels that you will then attach to a box or an asset for tracking. An item label can contain any combination of text, graphic or barcode information. Many label packages such as Wasp Labeller or Zebra Bar One, have pre-made templates that can easily start you on your way to designing your label. In addition, they have compliance label templates for specific industry labels such as the automobile industry.

Component 3 – Scanning Equipment for Data Collection

The data collection phase occurs through the use of **scanners** that **instantly and accurately read, capture and decipher the information contained in the barcode label**. **Scanners** read information much faster and more reliably than humans can write or type. Therefore, significantly reducing the rate or likelihood of error.

There are **two different types of scanners**:

- contact and
- non-contact.

Contact scanners required **physical contact** to scan as opposed to **non-contact scanners** which can be **several inches to several feet away**. Of these two types of scanners, there is also one other major attribute; they are either **decoded or non-decoded**.

Decoded scanners have built in hardware decoders that interpret the meaning of a barcode **before sending the data to the computer**.

Undecoded scanners simply have light sources that capture the encrypted data and **sends them to a decoder of some sort.**

Decoders are either **in-line hardware units or software decoders** that run on your computer. As you may have guessed, decoded units are usually more expensive than their undecoded counterparts. They do have the distinct advantage of only having one component to worry about if something breaks down instead of trouble shooting many components to find out why your barcodes aren't reading properly.

Component 4 – Capturing the Data to an External Database

The final component to establishing a simple barcode system is **the database**. Just because you've created and scanned barcodes successfully doesn't mean you've completed the loop to creating a complete and effective barcode system. To be able to effectively use the codes you've created and scanned, you need a database of some type to **relay and update information.** Many barcodes can be tied to item numbers for example. These item numbers can then, in turn, be linked to information about the item, such as product description, price, inventory quantity, accounting, etc. For example, let's say you have widget A, with a corresponding barcode that has the value of 1234. When you sell widget A, you scan the barcode. This, in turn, causes a chain reaction that tells your database that you: have one less widget A in stock, that you should charge $.20 for widget A, that this information should be passed onto accounting, that the product needs to be shipped only through UPS ground, etc. All of these actions were caused by scanning the barcode representing Widget A.

There are many other configurations, but this is the fundamental building block for bar coding.

Tracking

Anything that can be identified with numbers (or numbers and letters) can be tracked using barcode technology. However, applications continue to expand to nearly every area to help track cost per procedure. In addition to assuring greater accuracy, **barcodes** help speed the process of recording where and what an item is, or what service is provided. **Barcodes** can be used to track a product throughout the supply chain and workflow. **Bar coded numbers** also can be used to track a particular item back to the manufacturer. For example, if there is a defective item, bar coding can help track the item back through materials management and purchasing to the distributor and/or original manufacturer. Although it is possible to do the same thing manually, the amount of time involved would make the process too cumbersome.

Common Barcode Applications

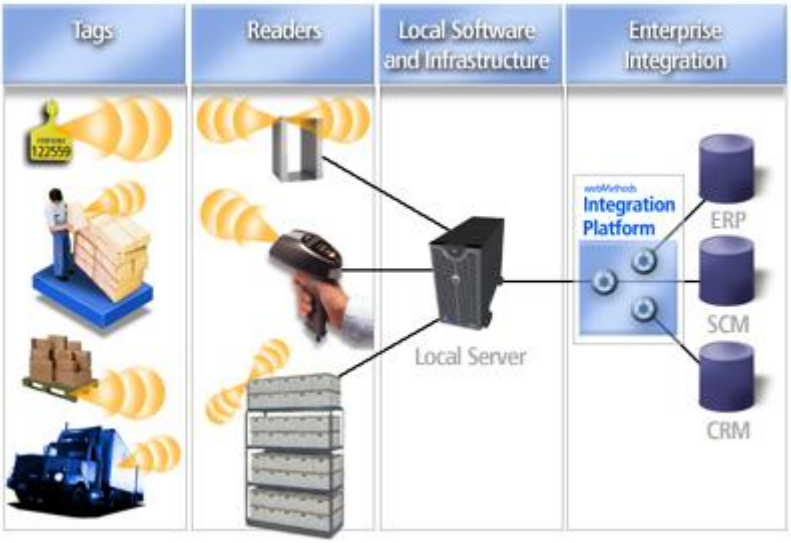
In retail applications, labels adhered or attached to a product or item of clothing contain **barcodes** which are read by a scanner during checkout and interpreted by a computer. The computer recognises the barcode's data bit reference and is able to link the item to its sales

price and description contained in the store's mainframe database. This product information is reflected, not only, on your sales receipt, but is **automatically linked to the store's inventory tracking system** which knows to deduct the quantity of the item purchased from the stores' current level of inventory. This entire process occurs in a matter of seconds with only minimal data entry required by the checkout person in the form of quantity purchased – e.g. one or more.

Similarly, in a package delivery scenario, e.g. common carriers such as UPS® or FedEx®, the **barcode label** enables the package to be tracked as it passes through diverse sorting hubs en route to its ultimate destination. Throughout the package's journey, each sorting hub scans the package to register its receipt before passing it onward. Therefore, if the package's arrival is ever delayed or misplaced, it can usually be tracked by its **barcode tracking number** to the exact point in the process where it may have stalled.

In addition to the retail and packaging industry, **barcode data collection** is used in a variety of industries, including but not limited to manufacturing, healthcare and automotive. Generally any industry or company can utilise bar coding to track and improve their current processes and operations.

Radio Frequency Identification (RFID) Technology and Applications



Introduction

Radio Frequency Identification (RFID) is a fast and reliable means of **automatically identifying and logging just about anything, including retail items, vehicles, documents, people, components and works of art**. Because it makes use of **radio waves**, there is no need for "line of sight" reading of information, which is one of the limitations associated with barcode systems. It means **RFID tags** can be embedded in **packaging or, in some cases, in the goods themselves.**

Information from an **RFID system** – the "data capture" element of an IT system – is passed to management information systems that are used, for instance, to control stock levels and provide details of who is currently in possession of what asset. Apart from its automatic

identification and data capture capabilities, **RFID (Radio Frequency Identification)** can also provide the **electronic article surveillance (EAS) function** – a case of single technology taking the place of two.

A **tiny chip connected to an antenna** – typically a few centimetres square in total – sends information when requested to a reader. By means of anti-collision techniques, many tags can be read practically simultaneously, representing an enormous timesaving over barcode reading, which requires operators to find the right position for the reading of each barcode individually.

An **RFID (Radio Frequency Identification) tag** can work just like a barcode – in other words, it can hold a unique article number which works like a "licence plate", calling the information relating to that number from a separate database. But because it can contain a relatively large amount of digital data, the RFID tag can hold source information itself, as opposed to a mere "look-up" number, therefore making it infinitely more useful for supply chain and many other applications.

In addition, **RFID "readers"** in a read-write system are also "writers", that means information can be written to tags at any point in, for instance, a supply chain, a security and access procedure or a maintenance operation, using a hand-held or fixed reader. With a barcode system, the only way of changing information is to print a new barcode or alter information in the system's database.

The principle of RFID

A **RFID (Radio Frequency Identification) architecture** that leverages the auto ID centre's current set of production ready standards consists of the following building blocks:

- **A passive RFID tag**, which, when exposed to the electromagnetic waves of the RFID reader, broadcasts its electronic product code (EPC) information.
- **An RFID Reader**, which activates the tag and reads its response.
- **The Air Interface**, which can be specified using the Auto ID centre standard or ISO18006.
- **The savant server**, which has a real-time in memory database (REID), an event management services (EMS) and a task-management system (TMS) used to filter the stream of information from the reader to the next higher level.
- The Application server communicates with the savant server via a **Simple Object Access Protocol (SOAP)** interface that leverages secure socket layer (SSL) encryption to transport information over the Internet. The application server middle ware bridges the gap between the savant-based protocols (SOAP) and the (proprietary) protocols used by the business systems. RFID information can also be routed directly to the supply-chain execution systems, such as a TMS, WMS, and point of sale or Supply chain Event Management Environment. However, this puts additional load onto these systems and exposes them directly to the savant deployment strategy in the enterprise.

The **RFID (Radio Frequency Identification) tag** responds to the reader by broadcasting its electronic product code (EPC), which is a 96-bit code consisting of:

- 8 bits of header information.
- 28 bits identifying the organisation that assigned the code
- 24 bits identifying the type of product.
- 36 bits representing serialisation information for the product

RFID Challenges

Is the RFID (Radio Frequency Identification) better than Barcode?

As **RFID technology** reaches greater deployment levels, the cost of tags and readers will drop even further and RFID will become price competitive with conventional barcodes. However, RFID brings several **key advantages** to the table that will make it a relevant competitor to barcodes, even while the cost of a tag is higher than the cost of a printed barcode label:

- Barcodes can be read only in the line of sight; labels must be positioned to be directly visible to the barcode reader. **RFID tags only need to be within the RFID reader's radio reach (about ten feet).**
- Barcodes cannot be read inside other containers, **RFID tags can be read through most materials**. Therefore, the concept of a shipping container can be verified easily without the costly overhead of an "Open Box Inspection" and manual counts and comparisons with shipments manifests.
- Barcodes provide only limited amounts of information –even two-dimensional barcodes are limited in the amount of data they can carry. The Auto ID centre's definition of a product information server (consisting of a distributed repository Infrastructure and naming services) allows us to tie **unlimited amounts of dynamic information to each tag.**
- Barcodes identify classes of products - **RFID tags identify individual products**. The Auto ID centre concept aims at identifying and tracking individual product instances as they move through the supply chain, Therefore achieving greater granularity and better accuracy.
- The migration of supply chains from barcodes to RFID will require significant investments and will not happen overnight, RFID and barcodes will coexist – in fact, they will coexist with human readable labels-for the foreseeable future.

Benefits of RFID

Labour Productivity

Worker productivity levels will increase in the receiving area of the warehouse. Instead of manually scanning each inbound shipment and verifying it with the purchase order, the increased automation from the **RFID (Radio Frequency Identification)** technology permits employees to eliminate manual operations in the receiving function which will allow products to move to storage or the outbound dock faster. Other tasks that receiving can complete more efficiently with RFID are:

- Facilitating the return process of damaged or unsaleable goods;
- Improving quality control (on order integrity);
- Increasing put away rate; and,
- Minimising errors in placement of shipments (cross dock or storage).

Forklift drivers will also have an easier time putting away items in assigned and unassigned slot locations. There would be no need to scan an additional barcode on a pallet at the slot location. Furthermore, **RFID (Radio Frequency Identification)** technology would eliminate the need for physical inventory counts and reduce cycle counting. Moreover, employee's work location can be tracked through RFID technology revealing the amount of activity recorded. These studies will increase work productivity by providing employees with incentives to work more efficiently and effectively.

Inventory Reduction

By installing **RFID (Radio Frequency Identification)** technology into a warehouse, organisations reduce many of the challenges associated with inventories. RFID tags provide more visibility to the products so their **location is more easily determined in the warehouse**. This increased visibility reduces the likelihood of a stock-out occurring because of misplaced inventory or inaccurate inventory levels. Cycle service levels will also improve due to lower safety stock levels and the overall faster throughput of product at a warehouse. According to an inventory management report, RFID technology will reduce total system inventory by approximately 5%.

Facility/Equipment productivity

RFID (Radio Frequency Identification) technology allows more data to be processed faster through a warehouse management system (WMS). The WMS uses the acquired information to improve the operations of the warehouse. If vehicles are scanned as they enter the inbound gates of the warehouse, dock utilisation improves because the WMS can more effectively assign vehicles to unloading doors based on order priority. If the product is not needed right away, the WMS would assign the vehicle a position in the yard. RFID technology also removes the need to manually place bar coded items on conveyors in a specific orientation so that barcode readers can read them.

Other Benefits

There are several other benefits to the warehouse using **RFID (Radio Frequency Identification)** technology. **Shrinkage**, which is product stolen by employees along with misplaced items, will be reduced because the warehouse will have a better understanding of where the products are located and it will be more difficult to move products out of the warehouse without being detected. **Forecast accuracy will also increase** due to higher levels of visibility of product throughout the supply chain. This improvement will positively affect the overall efficiency and effectiveness of the warehouse in areas such as:

- Order cycle times;
- Safety stock levels;
- Fulfilment accuracy; and,
- Cycle service levels.

One of the most serious examples **of misinformation about RFID (Radio Frequency Identification)** in recent years has been the claim that it is generally more expensive than barcode systems. It's true that an individual tag is more expensive than an individual barcode. It's also true that RFID – currently, at least – is inappropriate for the tagging of low-cost items. However, the comparison needs to go much deeper than that. That is particularly so in supply chain applications where containers holding the goods and the dollies on which they stand have a distinct inventory value of their own.

Tags are reusable and have very long lives, so in a supply chain operation where containers (often millions of them) are continually reused, there would be no need to re label the containers, saving on manpower and other costs associated with label production and fixing.

Multiple tags (up to 100 or more) can be **read practically simultaneously**. Using latest breakthrough technology, the Multi Scanner take readings on the move as the dollies supporting containers are pushed through the Multi Scanner portal or gateway. The productivity gains over barcode reading are enormous.

An **RFID (Radio Frequency Identification) system** can track and trace the containers, dollies and other reusable equipment used in the transportation of the goods, as well as the goods themselves. This is highly significant for distribution / logistics companies with container inventories of several million pounds, who need to ensure that their assets are returned regularly. If 10 per cent of assets are lost in a year due to poor or non-existent trace ability by a distributor with £10 million worth of reusable containers, an RFID system could pay for itself in months on this basis alone.

RFID has been proven to be more efficient than barcode systems in terms of read failure rates, even though the speed of read is many times faster. RFID is also less prone to human errors.

In summary, RFID provides:

- Substantial productivity gains
- Elimination of re-labelling costs and effort.
- Greater accuracy
- Flexibility of data on the tag – e.g., goods and containers can be identified and tracked using the same tag
- Ability to write additional or replacement information to a tag at any stage in the supply chain.

RFID's biggest advantage is being a non line-of-sight communication technology. Eliminating the need for line-of-sight communication allows products, cases and pallets to be

automatically scanned in larger volumes and at higher speeds, allowing for greater improvements in efficiency. RFID solutions consist of four basic components:

- Tags;
- Readers;
- Antenna; and
- Software.

Each will be discussed briefly below.

Tags - RFID tag is a device that is placed onto, or in some cases into, the pallet or stock-keeping units (SKUs). Basically, a tag is an electrical device that uses radio frequency antenna to communicate with the **RFID (Radio Frequency Identification)** reader. Information is stored in the tags that describe the object

Tags can be differentiated as being active or passive. These can be seen in the pictures below. The active tags are self-powered whereas the passive tags use the signal from the RFID reader as the source of power. While the distinction between tags might seem minimal, the impact on their capability is significant in both read range and data storage. Active tags use a battery-powered transponder that emits a constant signal containing identification information. Active tags have the greatest range of all RFID tags, including search and read/write capability. Today, they have up to 128 Kbytes of storage space, but could hold more in the future. Passive tags have no battery, but instead rely on an antenna as the power source, drawing power from the reader's electromagnetic signal. Passive tags have a much more limited range (less than 2-3 yards), have limited storage space (as of now, 128 bytes, but could hold more in the future), and lack data manipulation capabilities.

Readers - RFID (Radio Frequency Identification) tag readers are simply devices that scan the RFID tags. RFID tags have an antenna that transmits and receives information. The reader decodes and reads the information. The RFID reader converts the radio waves from the RFID tag into a form that can be passed along to an information system. The cost of the readers corresponds directly to the level of functionality needed. Readers that must scan multiple items, moving quickly on a high-speed conveyor or through a dock door are significantly more expensive than the basic hand held readers.

Fixed Reader

Mobile Reader

Antenna - RFID tag readers use an antenna to communicate to the RFID tag through the tag's antenna. Some readers have integral antenna while other can have various types and sizes of antenna fitted to them. The antenna is a critical component in the RFID system, as it has to be built for the coverage area. The antennas vary depending upon the facility location, size, area, and volume. Usually, an antenna operates in the 3-15 MHz range.

Software - Software and middleware are the most important pieces of an RFID solution. These packages are needed to make use of the information read by the reader to integrate the RFID technology with all the other systems operating in the warehouse:

- warehouse management systems (WMS),
- transportation management systems (TMS),
- event management systems (EMS),
- order management systems (OMS), and
- enterprise resource planning (ERP) systems.

The ability to capture, store, rationalise, and integrate information captured by RFID technology, including product information, location, volume, and transactional data, allows organisations to more efficiently pick/pack, ship, route, track and distribute materials.

This operational improvement can result in lower inventory levels and improved labour and equipment productivity. Integrating the information from RFID tags into an EMS or ERP system allows alerts and alarms to be sent when a certain set of conditions has occurred, e.g., inventory is running low or products have been idle too long.

The information from RFID will also be useful when integrated with reporting software. Companies will be able to quickly target problem areas in their warehouse and identify areas of improved efficiency. However, due to the lack of systems standards, there can be compatibility issues that arise in the software implementation process.

RFID IN Retailing Sector

Operating at razor thin margins in a highly competitive and largely undifferentiated market, top retailers are always on the lookout for opportunities that have a positive impact on the bottom line. Retailers have engaged in several initiatives to operate at higher levels of efficiency. Extensive use of information technology for process automation, supply chain collaboration techniques like CPFR, VMI and efficient data exchange mechanisms like EDI and XML have all enabled leading retailer's Walmart to run a tight-ship and gain competitive advantage.

RFID is an automatic identification and data capture (AIDC) technology which allows for non-contact reading to track and monitor physical objects. There is a tremendous interest in the application of RFID to the manufacturing /retail supply chain, which has gained momentum primarily on the strength of the technological advances that are bringing down the costs of tags and readers and the efforts of the EPC Global Inc. In establishing industry standards, a key benefit of RFID technologies is automatic identification of individual objects coupled with automatic data capture. Automatic electronic identity contributes significantly to enhance supply chain visibility, and the automation brings in data capture and has a direct bearing on operational efficiency in labour intensive Retail Logistics.

Supply Chain Visibility

Physical tracking of merchandise today is a challenge with significant implications across the supply chain for retailers. Visibility into the merchandise pipeline within the enterprise is extremely critical to ensure that an optimal level of inventory is maintained – not too much to lock in excess working capital, and not too little to cause stock-outs. Also, lack of visibility results in insufficient coordination between material flow and information flow often causing a magnification of demand variability in each level up in the supply chain – a phenomenon popularly known as the bullwhip effect. Companies rely on a variety of means for real-time data and process integration to alleviate this problem.

Operational Efficiency

A key element of cost in a retail enterprise is the area of Logistics Management – encompassing all activities that enable the movement of merchandise from vendor/manufacturer premises to the intended point of sale. About 25-30% of the supply chain costs can be attributed to labour costs in the process of distributing merchandise. Retailers extensively use software tools for warehouse management, yard management and transportation management. Industrial automation systems like conveyors, carousels, and unit sorters enable enhanced operational efficiency within the distribution centre. Business

process innovations like multi-order picking, pick-to-light, use of voice and wireless technologies have all contributed significantly to higher productivity in warehouse operations.

Potential Benefits of RFID to Retail Enterprises

Falling prices of tags and readers and the rapid strides in the standards development process is making **RFID (Radio Frequency Identification)** technology an increasingly viable option for pallet and case level tagging. However, retailers stand to gain most when individual items are tagged, with significant opportunities in enterprise inventory management and retail store operations. While the current tag costs rule out the economic viability of item/unit level tagging in most cases, there still could be a good business case in certain specific merchandise categories and applications. Pallet and Case level tagging also has the potential to enhance operational efficiency for the retailer. The likely return on investment from RFID tagging varies largely, and is an inverse function of the current level of process optimisation. Typically, processes that employ lower levels of process automation tend to demonstrate higher returns. For example, the receiving and check in process in warehouses as well as stores is a labour intensive and time consuming process. For a warehouse that currently employs minimal automation in the receiving process, one can expect major benefits by one-step receiving achieved using RFID tagging. On the other hand, the benefits would be much less if one-step receiving is already deployed using state of the art material handling equipment and data capture means.

What follows below is a quick look at the potential benefits from RFID in various functions in the retail value chain, and an assessment of the added value over and above a process that employs the state-of the-art automation.

RFID in Warehousing

Receiving

RFID tags might have the most potential to improve the warehouse's receiving processes. Under current bar coding practices, a worker must scan each product or case before it's moved into the warehouse. RFID technology allows significant improvements in the throughput speed of product at the receiving dock. The RFID scanner reads the shipment within seconds as it passes through the portal readers. Additionally, the RFID technology eliminates the need to physically check the bill of lading and/or the packing slip.

Furthermore, **RFID (Radio Frequency Identification)** will connect with the WMS system to indicate if a product needs a cross-dock movement. Cross docking is one of the most efficient processes for moving inventory through a warehouse without storage. Cross docking is initiated at the receiving dock. When a product is received and scanned, the WMS interfaces with the OMS to determine if this product is needed to fill an open order. If so, the product is moved literally "across the dock" to the outbound dock (or picking/packing) so the order can be completed and placed on the waiting vehicle. If the item is not needed to satisfy an open order, it is placed into storage. RFID will make this "open-order "identification faster

and more reliable than traditional barcode scanners because it will occur when the product is pulled from the delivery rather than after it has been placed on the receiving dock floor.

The benefits from not scanning each shipment, automated bills of lading, and improved cross dock movements reduce labour costs and allow the receiving docks to handle a greater amount of product. For instance, if an incoming load is needed to refill an out-of-stock item or is scheduled to depart on a cross-dock movement, the RFID system designates the load as high priority and communicates this information to the worker. In addition, the RFID system will help manage the flow of damaged goods into the warehouse. The damaged goods that are set aside can be read by the RFID technology as received as damaged. This process will significantly reduce labour hours spent on managing the damaged goods process.

An RFID system also offers greater efficiencies in warehouse systems that rely on conveyors. RFID eliminates the need to ensure that cases/items are placed properly on the conveyor so that the barcode can be read accurately with the barcode reader. Normally, this means that the barcode is “face-up” or on top of the box since many barcode readers scan from above the conveyor. RFID allows for accurate reads regardless of product position, resulting in fewer reading errors. Elimination of product positioning requirements on the conveyors will also improve the speed of overall product flow through the warehouse. This will also reduce labour costs since additional workers will not be needed on the conveyor to reposition products so the barcode is facing the proper direction.

Storage

RFID (Radio Frequency Identification) technology also provides benefits in put-away accuracy and efficiency. Forklift drivers could still rely on the current WMS system to identify the locations for pallets and products. However, an RFID system can eliminate the need to scan the barcode on the pallet and at the slot location in the racks. For example, if the pallet and slot location read by the RFID scanner do not match the WMS specification, the system notifies the driver that the product has been placed in the wrong location. Moreover, the need for additional barcodes on each pallet is eliminated. This pallet identifier barcode is also called a “license plate.” Since a single scanner can identify all of the RFID tags on individual products, the placement of a license plate on the pallet level would not be necessary.

Additionally, RFID has the potential to improve temporary storage at the warehouse. Since the RFID tags can be read from anywhere, products and pallets do not have to be placed in specific or assigned locations. This is called a random location system. It is also operable with barcodes. This random system allows for a much more flexible storage environment and can help to minimise honeycombing (honeycombing is a situation that arises in a racked warehouse where large empty rack slots exist among filled slots). RFID-related applications can also be used to identify product compatibility problems. If non-compatible or hazardous products are stored near each other the RFID system could alert the employees for an immediate removal of one of the products.

Pick / Pack

RFID (Radio Frequency Identification) readers can integrate with the WMS and OMS systems to ensure that the correct items and amounts are picked. Another benefit of RFID is

to help measure productivity in the warehouse. Through a type of RFID-enabled time-motion measurement, management could analyse the process to set benchmarks, evaluate employees and plan labour requirements. This is also enabled by barcode systems. The difference is that with RFID systems, manual scans of products are eliminated.

Shipping

An RFID reader can confirm that each item is placed onto the correct outbound vehicle, which can improve the accuracy of the shipping process. This verification can be made as the product moves through the portal of the outbound dock door. These processes allow for an automatic double check of the items loaded into the trailer against the bill of lading (a bill of lading must accompany each shipment tendered to a carrier; it is, among other things, a description of the shipment) or manifest (a manifest identifies the products and their locations in the outbound vehicle). It should also be noted that the use of RFID could greatly reduce the amount of employee theft in a warehouse. Placing RFID readers at exits of the facility and employee areas ensures that all items leaving the building are accounted for, regardless of the removal method.

Companies can expect savings in labour and other efficiency benefits from RFID.

Part Two

2. Inventory Management and Control

a. Introduction
b. Inventory functions
c. Types of inventory
d. Inventory cost
e. Holding inventory
f. Mechanics of inventory control
g. Selective inventory control

a. Introduction

Inventory is a modern trend. For example, why does every car or a truck carry a spare tyre? It is because, in case of any puncture, the driver can change the tyre and immediately be on his way without being stranded for a long period. To avoid similar circumstances in business, companies carry inventory both for raw materials and finished goods.

Inventory management can be defined as the sum total of those related activities essential for the **procurement, storage, sale, disposal or use of material**. Utilities are created in goods when the right product is available at the right place, at the right time, at the right quantity and is available to the right customer. Inventory management deals with all these problems, placing importance on the quantities of goods needed.

Inventory managers have to keep stock when required and utilise available storage space resourcefully, so that the stocks do not exceed the available storage space. They are responsible in maintaining accountability of inventory assets. They have to meet the set budgets and decide upon what to order, when to order, how to order so that stock is

available on time and at an optimum cost. Inventory managers have acknowledged that some of these objectives are contradictory; but their job is to achieve an **economic balance between these conflicting variables.** But to achieve this economic balance, a clear understanding of many interconnected variables is required i.e. functions, types of costs, problems etc. The following sections provide an insight into these variables. Further, it elaborates upon various aspects of inventory control in physical distribution systems.

Role in the supply chain

Inventory exists in the entire supply chain because of disparity between supply and demand. This disparity is intentional at a steel manufacturer where it is economical to manufacture in large lots that are then stored for future sales. The disparity is also intentional at a retail store where inventory is held in anticipation of future demand. An important role that inventory plays in the supply chain is to increase the quantity of demand that can be satisfied by having product ready and available when the customer wants it. Another significant role of inventory is to optimise cost by exploiting economies of scale that may exist during both production and distribution.

Inventory is spread across the entire supply chain from raw materials to work in process to finished goods that supplier, manufactures, distributors, and retailers hold. Inventory is a most important source of cost in any supply chain and it has an enormous impact on responsiveness. If we think of the responsiveness range the location and quantity of inventory can move the supply chain, from one end of the spectrum to the other. For example, an apparel supply chain with high inventory levels at the retail store has a high level of responsiveness because a consumer can walk into a store and walk out with the shirt he is looking for. In contrast, an apparel supply chain with little inventory would be very unresponsive. A customer wanting a shirt would have to order it and wait several weeks or even months for it to be manufactured, depending on how little inventory existed in the supply chain.

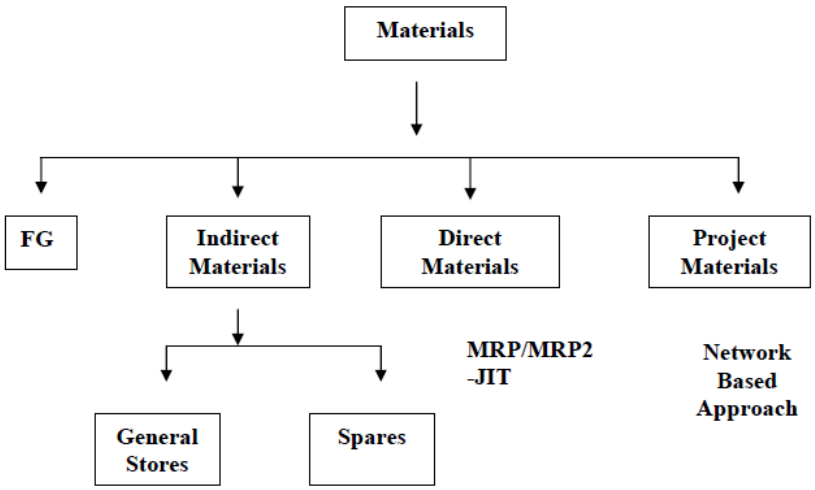
Inventory and flow time are synonymous in any supply chain. Managers must use measures that **lower the amount of inventory needed without increasing cost or reducing responsiveness**, because reduced flow time can be a significant advantage in a supply chain.

Role in the competitive strategy

Inventory plays an important role in a supply chain's ability to support a company's **competitive strategy**. If a company's competitive strategy requires a very high level of responsiveness, a company can use inventory to achieve this responsiveness by locating large amounts of inventory close to the customer. Conversely, a company can also use inventory to make it more efficient by optimising inventory through centralised stocking. The latter strategy would support a competitive strategy of being a low-cost producer. The trade-off implied in the inventory driver is between the responsiveness that results from more inventories and the efficiency that results from fewer inventories.

Role of inventory control

Achieving the **objectives of inventory control** will result in more return on capital which is the prime objective of an organisation, whether commercial or industrial. The formula given below is useful in arriving at the return of investment.



$$\text{ROI} = \frac{\text{PROFIT}}{\text{TOTAL ASSETS (FA+CA)}}$$

- Materials account for nearly 50% of total costs
- Inventory accounts for nearly 75% of CA

Another measure of healthiness of inventory control is **Inventory Turnover Ratio (ITR)**. It is the ratio of total sales during a specific time period (generally 1 year) to average inventory on hand during that time period.

Inventory Turnover ratio (ITR) (Finished Goods)

= Annual Sales/Average Inventory

Inventory Turnover Ratio (ITR) (Raw Material)

= Annual Consumption/Average inventory

Example

The following table shows the sales and inventory details (in millions) of 3 sub assemblies A, B and C of a project.

Particulars	A	B	C	Total
Sales	320	40	2	362
Raw Material	31	5	4	40
Finished Goods	22	9	8	39
WIP	10	4	2	16
Others	17	2	2	21

ITR (A) = 320:80 = 4:1

ITR (B) = 40:20 = 2:1

ITR (C) = 2:16 = 1:8 (Very Poor)

A very high inventory ratio is vital for the healthiness of an organisation.

b. Inventory functions

Inventories have **four functions.** They are:

1. Minimise costs at acceptable inventory levels: Replacing inventories in exceptionally small quantities result in low investments but high ordering costs. Therefore, a point has to be set where the total inventory carrying cost is bare minimum but the level of inventory is such that it does not affect the production or customer base.

2. Provide desired customer service level: Inventories offer service in terms of satisfying customer demand. Inventory influences the time and costs of service. The location of inventory determines the time in which the customer will be served while a company policies concerning the economic order quantity, safety stocks, placement procedures and time will determine the cost at which the customer will be served.

3. Couple successive operations or functions: The decoupling effect of inventories is apparent throughout manufacturing and distributions systems. Normally in the absence of inventories in a system, a demand by a customer triggers a chain reaction of demand at each preceding level, i.e. manufacturing and purchasing. But the customer does not have time or patience to wait for the chain reaction.

A small inventory requires frequent response rather than instant response from the transport system, whereas, a large inventory reduces the need for frequent response and cost of transport systems. The decoupling effect of inventories allows a physical distribution manager to choose amongst various inventory management policies.

4. Stabilise production and the labour force, thereby trying to reduce capital requirements: This function of inventories is more associated to the manufacturing process, though it influences the distribution function as well. If an inventory management system takes responsibility of finished goods storage, then it has to provide storage facilities for higher levels of inventories. For example, seasonal products in many cases are produced all year round to decrease investment in capital equipment. The stocks which come into existence are called anticipation stocks. But to produce or not to produce anticipation stocks is a manufacturing decision rather than a distribution decision.

c. Types of inventory

There are various types of inventory:

- Raw Material Inventory
- Work-in-Progress (WIP) Inventory
- Finished Goods Inventory
- Maintenance, Repairs and Operating Inventories (MRO)

Raw Material Inventory

The **materials**, from which the final product of the company is made, are the **raw materials**. The **material does not include any material that supports production**; these materials are called **indirect materials**.

But raw material is limited to the **direct material (or) component** that actually becomes a part of the final product. The steel used for automobile production is a good example of a raw material, however the raw material of one industry is usually the finished product of another. Some of the raw materials may be available only seasonally, like cotton, sugar cane etc.

The **size of the raw material inventory** is dependent upon factors such as:

- internal lead time for purchase,
- supplier lead time,
- vendor relations,
- availability of raw materials,
- government import policy in the case of imported material,
- the annual consumption of the materials and

- The criticality of the material.

Some of the examples of **raw material inventory** are steel, wood, cloth or other materials used to make components of the finished product.

The reasons for keeping this inventory are:

1. **Seasonal factors** of availability and price advantage.
2. As **protective buffer** against:
    - Delays in supply
    - Change in production rates due to market fluctuations for the finished products, etc.

Work-In-Process Inventory (WIP)

All materials that have been **transformed from their raw materials stage** by some **manufacturing process** but are not final products are **work in-process goods**. Sometimes, what may appear to be a final product is still really an in–process good if the final production step is a packaging one. It is an **in-process** until it is in the form that can **leave the plant.** WIP can be found on the conveyors, trucks, pallets, in and around the machines and in temporary areas of storage waiting to be worked upon or assembled.

In building a ship or boiler the raw material is held as in-process stock until the complete ship is made. This is true in most of the heavy engineering industries like cement plant and chemical plant. Sometimes they are dispatched sector by sector to the site to reduce the in-process inventory. In continuous process industries the amount of in process held is optimum, which cannot be reduced or increased like in petroleum refining, cement manufacturing and chemical industries. Whereas in medium size industries where batch production is predominantly adopted, the **in-process inventory is very high**. After each production process the materials wait for the next operation.

The size of the inventory is dependent on the production cycle time, the percentage of machine utilisation, the make/buy decision of the company, and the management policy for decoupling the various stages of manufacturing.

The reason for keeping **In-Process inventory** is:

- ✓ As liquid stock to cater for variety and shorten the manufacturing cycle.
- ✓ As protective buffer against production breakdowns, rejections etc.
- ✓ For economic lot production.

Finished Goods Inventory

Finished goods inventory consists of **all the stock that is ready for dispatch**. In a bottling plant for example, the finished products are the bottles of beverages that are in their cartons or cases and are ready for shipment. This finished goods inventory acts as a buffer between the production department and the marketing department. The higher the stock levels of finished goods results in a higher inventory cost. If the stock level is low or nil then the customer service will be affected. The purpose of this inventory is to reach the market by constant supply through distribution channels. This is controlled by the marketing department. The stock that is to be held at the warehouses, with the distributors and with retailers will be different depending upon the sales rate.

In pharmaceutical industries, the finished product stock will be very high at the distributors and retailers level as they have to stock all types and brands of medicine with the risk of expiry dates. In case of daily newspapers there should be absolutely nil finished stock as its life is only one day.

The spares stock is also an important inventory. In this case, we may not know when and what part will be required and we have to stock all of the items. Statistical methods and good forecasting techniques only will help us in deciding the type and quantity of spares to be held in stock for sale.

The **size of the finished goods inventory** also depends on

- the ability of the marketing department to push the products,
- the company's ability to stick to the delivery schedule of the client,
- The shelf life and the warehousing capacity.

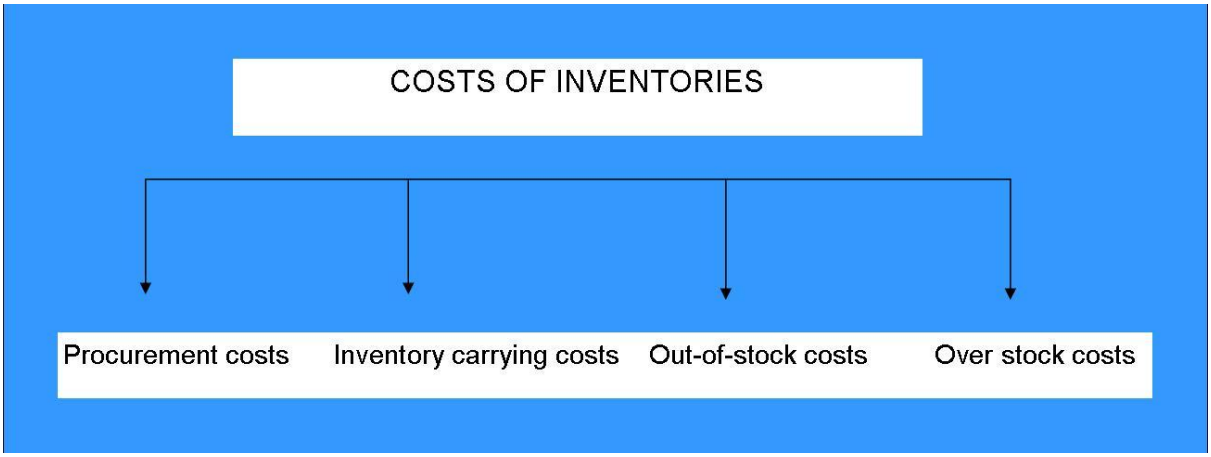
The other reasons for holding this inventory are

- To provide a protective buffer against sales rate changes.
- To absorb economic production lots.
- To stabilise the level of production and employment when the sales are of a seasonal variety.

Maintenance, Repairs and Operating Inventories (MRO)

Maintenance, repairs and operating supplies which are consumed during the production process and generally do not form part of the product itself (e.g. oils and lubricants, machinery and plant spares, tools and fixtures, etc) are referred to as **MRO inventories.**

d. Inventory Cost



Inventory or stock refers to the goods and materials that a business holds for the ultimate purpose of resale or repair.

Inventory cost is the cost of holding goods in stock. **Inventory cost** is made up of:

- Procurement or ordering cost
- Inventory carrying costs
- Our-of-stock costs
- Over stock costs

Procurement or ordering costs

Procurement cost is the total cost incurred during the ordering of an item. These costs are not connected with the quantity ordered but primarily with **physical activities required to process the order.**

For **purchased items**, these would include the **cost to enter the purchase order and/or requisition, process involved in getting the approval of the purchase order, the cost to**

process the receipt, raw material inspection, invoice processing for vendor payment, and in some cases a portion of the inbound freight may also be included in procurement cost. It is important to understand that these are costs associated with the frequency of the orders and not the quantities ordered. For example, in your receiving department the time spent checking in the receipt, entering the receipt, and doing any other related paperwork would be included, while the time spent repacking materials, unloading trucks, and delivery to other departments would likely not be included. If you have inbound quality inspection where you inspect a percentage of the quantity received you would include the time to get the specs and process the paperwork and not include time spent actually inspecting, however if you inspect a fixed quantity per receipt you would then include the entire time including inspecting, repacking, etc. In the purchasing department you would include all time associated with creating the purchase order, approval steps, contacting the vendor, expediting, and reviewing order reports, you would not include time spent reviewing forecasts, sourcing, getting quotes (unless you get quotes each time you order), and setting up new items. All time spent dealing with vendor invoices would be included in procurement cost.

For the most part, **order cost** is **primarily the labour associated with processing the order**, however, you can include the other costs such as the costs of phone calls, faxes, postage, envelopes, etc.

Inventory carrying costs

Also called **holding cost**, **carrying cost** is the cost associated with having **inventory on hand**. It is primarily made up of the costs associated with the **inventory investment** and **storage cost.**

Carrying costs should **only include costs that are variable based upon inventory levels**.

If you are running a pick/pack operation where you have fixed picking locations assigned to each item where the locations are sized for picking efficiency and are not designed to hold the entire inventory, this portion of the warehouse should not be included in carrying cost since changes to inventory levels do not affect costs here. Your **overflow storage areas** would be **included in carrying cost**. Operations that use purely random storage for their product would include the entire storage area in the calculation. Areas such as shipping/receiving and staging areas are usually not included in the storage calculations. However, if you have to add an additional warehouse just for overflow inventory then you would include all areas of the second warehouse as well as freight and labour costs associated with moving the material between the warehouses.

Inventory carrying costs are made up of Direct costs and Indirect costs:

Direct costs

- **Capital costs**, or opportunity cost, which is the return the company could make on the money that is has tied up in inventory.

- **Storage space costs**, includes storage requirements for all categories of inventories, an excess of stocks requires additional capacity, storage space and inventory level are interrelated, storage and maintenance etc.
- **Inventory service costs**, which includes insurance and taxes on inventory
- **Inventory risk costs** - vary with the nature of the business, obsolescence, damage, pilferage and shrinkage, related to the overall role of inventory within a logistics system

Indirect costs

- **Business Risk**, situation 1: a company carrying insufficient inventory – unable to meet and satisfy demand, situation 2: reverse – satisfies demand but increases direct costs by increasing capital cost, service costs, storage costs and risk costs., related to the overall role of inventory within a logistics system
- **Opportunity costs**, range of investment alternatives, lack of capital availability to invest in alternatives, related to the overall role of inventory within a logistics system
- **Incremental increases in infrastructure costs**, excess inventory can increase cost, facilities, transportation, service companies

Out of stock costs

These are the **third category** of cost associated with **inventory**. These are incurred when a customer places an order and the **order cannot be filled from the inventory** to which it is normally assigned. Out of stock costs are divided into two main categories

- Lost sales costs
- Back-order costs.

Lost Sales Costs: These occur when the customer, faced with an out-of-stock situation, chooses to **withdraw his order for the product**. The cost is the profit that would have been made if the sale had occurred and the cost of negative effect that the stock out may have on future sales. The higher the degree of substitutes available in the market, the higher the cost. The lost costs are intangible and difficult to measure and usually estimated on the basis of personal perceptions of executives.

Back order costs: Back order costs assume that a customer will wait for his order to be filled so that the sale is not lost, only delayed. But these back-orders create **clerical and sales costs for order-processing and additional transport**, which have to be incurred to fulfil these back-orders out of course of normal distribution channel. These costs are fairly tangible and therefore measurement is simple.

Over stock costs

The **fourth category** in which a company can incur costs is when the company is left with some stock on hand even after the demand for the product has terminated. The interpretation of this cost is proportional to whether the inventory is **static or dynamic**.

Static inventory is one which is replenished only once a year for example, a merchant who wishes to sell specialised Diwali crackers, with very short shelf life, has a very limited sales season. The season is only a few days long and therefore the replenishment of stock will have a next to zero salvage value. Therefore if he has too much stock he will suffer loss equal to cost of over stock. This will be the cost of over stock for a static stock.

Dynamic stock is one which can be replenished throughout the season for example; a departmental store which has dynamic stock will have a different over stock value. Let us say ABC departmental store sells various household items. For example towels, any stock left can be carried forward to the next period and for an indefinite period. Therefore there will be no over stock cost. But if the product is a woollen fashion accessory then the product life cycle will be shorter. If only one order can be placed, then the problem will be of a static demand but if multiple orders can be placed then there will be no overstock cost until the last order period of the season. At this point of time, any stock will undergo drastic devaluation, and this will be termed as overstock cost. It is to be remembered, however, that a company can incur either overstock cost or under stock cost at a given point of time, but not both simultaneously.

e. Holding Inventory

There are a number of reasons why a company might **choose or need to hold stocks of different products.** In planning any distribution system it is essential to be aware of these reasons, and to be sure that the consequences are adequate but not excessively high stock levels.

The **main reasons for holding stock** can be summarised as follows:

- **To keep down productions costs:** Often it is costly to set up machines so production runs need to be as long as possible to achieve low unit costs. It is essential, however, to balance these costs with the costs of holding stock.
- **To accommodate variations in demand:** The demand for a product is never wholly regular so it will vary in the short term, by season, etc. To avoid stock outs, therefore, some level of safety stock must be held.
- **To take account of variable supply leads:** Additional safety stock is held to cover any delivery delays from suppliers.
- **Buying costs:** There is an administrative cost associated with raising an order, and to minimise this cost it is necessary to hold additional inventory. It is essential to balance these elements of administration and stock-holding, and for this the economic order quantity (EOQ) is used.
- **To take advantage of quantity discounts:** Some products are offered at a cheaper unit cost if they are bought in bulk.
- **To account for seasonal fluctuations:** These may be for demand reasons whereby products are popular at peak times only. To cater for this while maintaining an even level of production, stocks need to be built up through the rest of the year. Supply variations may also occur because goods are produced only at a certain time of the year. This often applies to primary food production where, for example, large stocks result at harvest time
- **To allow for price fluctuations/speculations:** The price of primary products can fluctuate for a variety of reasons, so some companies buy in large quantities to cater for this.
- **To help the production and distribution operations run more smoothly:** Here, stock is held to 'decouple' the two different activities.
- **To Provide Customers with immediate service:** It is essential in some highly competitive markets for companies to provide goods as soon as they are required.

- **To minimise production delays caused by lack of spare parts:** This is important not just for regular maintenance, but especially for breakdown of expensive plant and machinery. Therefore spares are held to minimise plant shutdowns.
- **Work in progress:** This facilities the production process by providing semi finished stocks between different processes.

f. Mechanics of Inventory Control

Inventory control consists of finding answers to three questions:

1. **Should this item be stocked at all**?
2. **If so, when to order it**?
3. **How much to order**?

The **last two questions** are the most important, as what to **stock is the question of sales forecasting for the target market.** No item, not even the cheapest item, should be stocked without careful review. This should be a continuous process as the environment which dictates supply of inventory and the demand environment keep changing continuously.

In many cases, managers answer these questions through guessing based on past experience. Often they prove to be wrong.

For example, a manager using guess work decides to buy 5000 items of a product once a month mainly because the item costs only 10 pence.

Error:

- Increased order and acquisition cost
- Increased cost of transportation and packaging
- Increased receiving and inspection cost.

The cost will be twelve times higher compared to ordering the product once a year, i.e. British Pounds 6 000 per annum

Another example. If the unit cost was high, i.e. British Pounds 1, 000/- and the company needed on an average 500 units per month what should the manager do?

He has two options - first he can order a larger lot sizes for a couple of months so that transport and order processing costs cheaper. Secondly, he could order on a monthly basis. However the second option would increase the transport and order costs and therefore he will select the first option i.e. order in lots for six months.

Error:

- ✓ Increased inventory carrying cost
- ✓ Increased risk of obsolescence and deterioration

Therefore **unplanned decisions** could lead to **stock-out, over stocking** and therefore in **reducing profits of the company**.

These examples prove that inventory control is a very sensitive area. The decision should be taken in relation to the overall environment of inventory management rather than on the basis of hunches or rule of thumb.

This is because **inventory management is very complex**. For example, demand for a product can be predictable or unpredictable. Customers may be small, medium or large and there may be total uncertainty about whether they will buy from you or someone else. Considering this uncertainty of the environment, **quantitative tools** must be used to exercise inventory control and answer the above questions.

When to Order?

Under the modern concept, **inventory** should directly contribute to profitability of the company and should be concerned with such matters as **flow, lead times, storage costs, and acquisition costs, material handling equipment, preservation and packaging**.

General levels of stock should be related to sales and production policies of the firm, in the same way specification is related to technical needs.

The various **levels of stocks** are:

1. **Deficiency Level:** This means stock in hand is inadequate to meet the needs. Existence of this level indicates an actual or potential out-of-stock situation. Orders are placed through a faster alternative source of supply.

2. **Exhaust bin level:** This is a point popularly known as out of stock. At this point, the storage bin is empty. Emergency measures are taken to stock the bin.

3. **Buffer stock or minimum stock level:** This is the level at which any further demands upon the bin will necessitate withdrawals from the reserve or buffer stock, especially when demand is immediate and fresh deliveries will take time to arrive.

Usually the goods are ordered through normal channels as soon as the inventory reaches this level.

4. **Danger warning level: It is the point of no return.** After this point, a stock-out is inevitable if delay occurs. A computer program can readily include warning levels. The level should be such that if there is a possible delay, the processing should reveal this in time and the manager should take one of the following actions:

a. Find an alternative source of supply

b. Request the sales department to warn their customers of possible delay in supplies.

c. Put extra pressure on the supplier

g. Selective Inventory Control

One would find that **20 percent of the total stock contributes** to **80 percent of the value**. And this 20 percent is most crucial as far as companies' production is concerned. Realising this phenomenon, **inventory control** in its attempt to reduce the cost of inventory, adopts the policy of **selective control**.

In **selective control**, inventory of **high-value items** is controlled because they give the **greatest returns**. Also, not much care is assigned for the low-value items, because the returns are low.

Very broadly, selective control is divided into eight categories as **ABC, HML, VED, SDE, GOLF, FSN, SOS, XYZ.**

These are summarised below:

Classification	Stands For	Criteria
ABC	Always Better Control	Annual value of consumption of the items concerned
HML	High Medium Low	Unit Price of material(Opposite of ABC
VED	Vital Essential Desirable	Critical nature of the component in respect to production
SDE	Scare, Difficult to obtain and easy to obtain	Purchasing problem in regard to availability.
GOLF	Government, Ordinary, Local, Foreign	Source of material
FSN	Fast, moving, slow moving or non moving	Issues from Stores
XYZ	----------	Inventory Value of items stored

Reorder Level: The reorder point determines when a resupply shipment should be initiated. If the reorder point is set too low, a stock out position might occur and if it is set too high over stock costs will be high. Moreover, a high reorder point will lead to increased investment in inventory and increased inventory carrying cost.

Maximum stock level: This is the level above which the stock should not be permitted to rise. If permitted, it would increase the risk of loss due to deterioration, evaporation and obsolescence. It will also increase the capital tied up in the inventories.

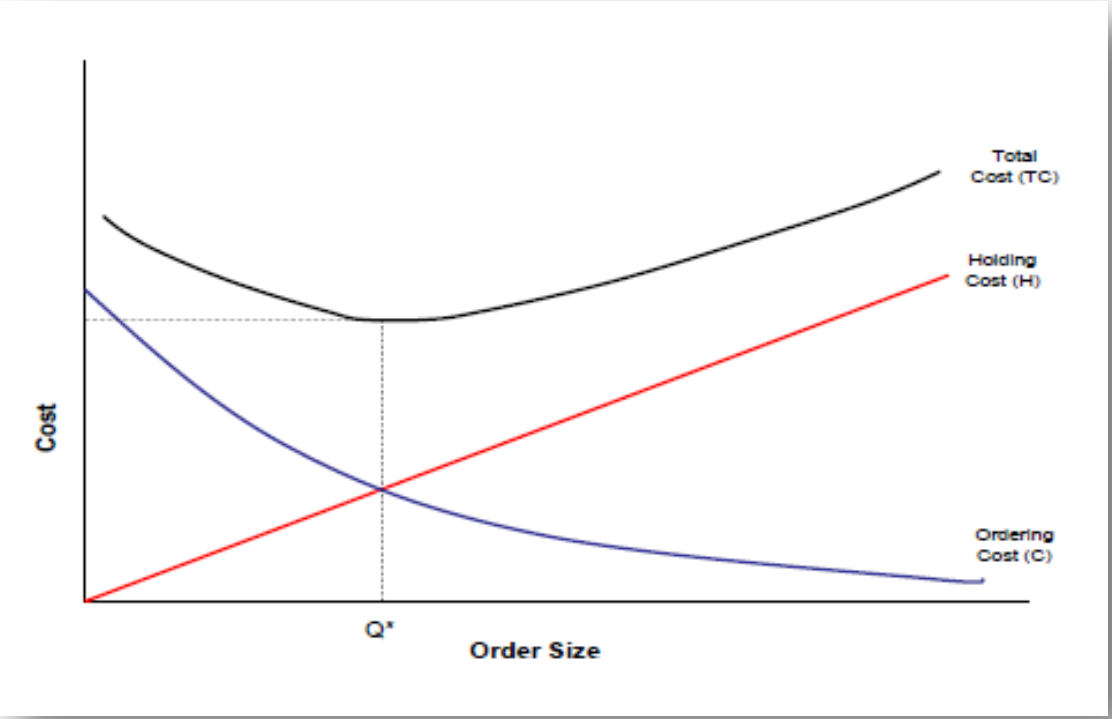
Therefore, when to order will be dependent upon the level of stock is in the bin. But knowing the level of stock is not enough. Efficient inventory control dictates that inventory level should be controlled.

How much to order?

This is a concept which tries to **balance inventory and ordering cost**. Practically, the two costs have **inverse relationships.**

If the order quantity is **larger**, the **order cost will be low** but the **inventory carrying cost** will be **high.**

The point at which the **two costs are at a minimum is the optimum point**; in the below figure the **total cost is minimum**. Every company should try to order this much quantity



Economic order quantity (EOQ) is the most useful method for determining "how much to order". This method aims at determining the right quantity so as to ensure that the sum total of the two costs, i.e. carrying cost and procurement cost are at the minimum point possible.

EOQ is that quantity at which the cost of procuring the annual requirements of an item and the inventory carrying cost are equal, i.e. the total of the two costs is at a minimum. Mathematically, EOQ is represented by the equation

$$EOQ = \sqrt{2AP/UC}$$

Where

A = Annual Consumption in units.

P = Procurement cost per order.

C= Inventory carrying cost expressed as percentage (of value)

U = Unit price

EOQ calculations are most helpful in establishing **optimum inventory levels** and **effectively conserving the working capital** invested in inventories. But in actual application EOQ faces certain objections.

These are as follows:

1. Often the inventory holding costs and the ordering costs cannot be identified accurately and sometimes cannot be even identified properly.

2. The EOQ as calculated is often an inconvenient number.

3. The use of EOQ usually leads to orders at random points in time so that suppliers receive an irregular stream of orders.

4. EOQ applied without due regard to the possibility of falling demand can lead to high value of obsolescent inventory.

5. EOQ may not be applicable when the requirements are irregular, or where there is an impending price rise.

This is where human judgment comes in. The management techniques are not 100 percent accurate. Every decision has to be taken into consideration of variables like volume, transportation rates, quantity discount, production lot size, capital limitation etc.

Selective Inventory Control is an essential part of Materials Management. Selective control is emphasised on variations in methods of control from item to item based on selective basis. We cannot apply uniform control since it's expensive and gives diffused effect. For this purpose we can use some criterion such as lead time, consumption, criticality, cost of the items, procurement difficulties etc. The following classification can be used for selective treatment of various types of materials.

Classification of Inventory Control

No. Classification	Full Form	Criterion Employed
1 ABC Analysis	Always Better Control	Usage Value (i.e. Consumption per period x price per unit)
2 VED Analysis	Vital Essential Desirable	Loss of Production or Criticality of the item
3 HML Analysis	High Medium Low	Unit Price i.e. does not take consumption into account
4 SDE Analysis	Scarce Difficult Easy	Procurement Difficulties
5 GOLF Analysis	Government Ordinary Local Foreign	Source of procurement
6 SOS Analysis	Seasonal Off Seasonal	Seasonality
7 FSN Analysis	Fast Slow Non Moving	Issues from stores
8 XYZ Analysis		Inventory Investment

1. ABC Analysis

Based on very important principle: ” Vital Few: Trivial many”

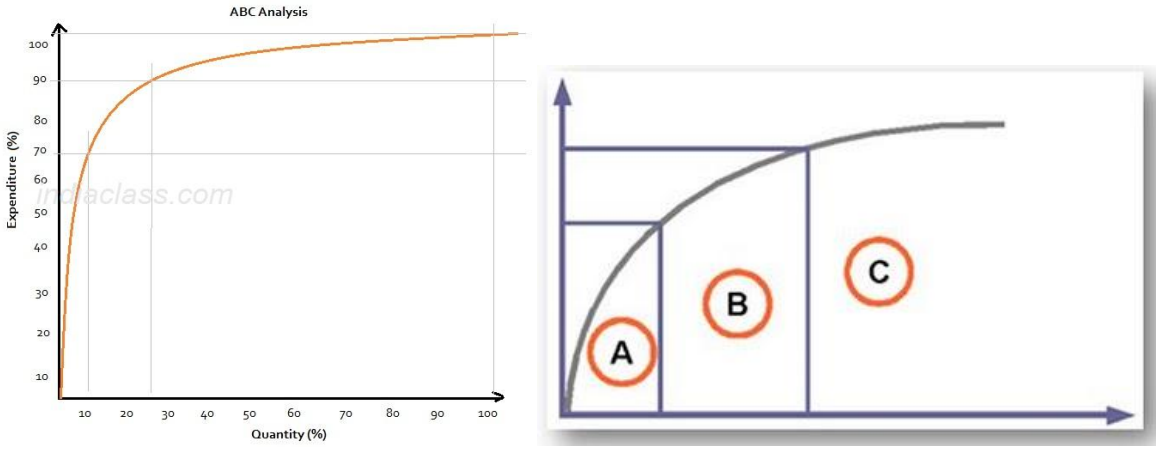
Type Account for (Quantity) Account for (Expenditure)

A Items 5-10% 70-75%

B Items 10-20% 10-20%

C Items 70-80% 5-10%

Figure 1



A Items

Quantity: Hardly 5-10% of the total items

Expenditure: 70-75% of the total money spent on the materials

Control: Require Maximum, detailed and rigid control

Control by top executives

Procurement: Need to be procured frequently, the quantity per occasion being small.

Need to be stocked in smaller quantities

The inventory can be kept at minimum by frequent ordering

Supply: Contract with the manufacturers (more than one supplier) to supply in staggered lots according to production programme of the buyer

Require Value Analysis

B Items

Quantity: Generally 10-20% of the total items

Expenditure: Represent 10-20% of the total expenditure on the materials

Intermediate items

Control: Require Minimum control, need not be as detailed and as rigid as applied to A items

Supply: More items from same supplier, Bulk Orders

C Items

Quantity: Numerous: 70-80% of the total items

Inexpensive: hardly 5-10% of the total annual expenditure on materials

Insignificant Items: do not require close control

Procurement policy: exactly the reverse of A items

Procurement: infrequently and in sufficient quantities

Price discounts and reduced work load for buyer

Chart: ABC Analysis

	Item A	Item B	Item C
Quantity	10%	20%	70%
Expenditure	70%	20%	10%

Control	Maximum	Medium	Low
Supply	Many Suppliers or manufacturer	Single or Few Supplier	Single Supplier

2. VED Analysis

Classification of items based on their criticality

Initial	Stands For	Description
V	Vital	Those items for want of which production would come to stop
E	Essential	items whose stock outs cost is very high
D	Desirable	items which do not cause any immediate loss of production or stock outs entail nominal expenditure and cause minor disruptions

An item may be vital due to following reasons

- Non availability of item may cause serious production losses

- Procurement lead time is very high

- It's non standard item and is procured to buyer's design

- Single source of supply and located far off from buyers location

Steps for VED analysis

1 Identification of factors essential for VED analysis - lead time, nature of the item, source of supply

2 Assign points or weightage to the factors as per the importance - may be 30,30,20 and 20 points

3 Divide each factor into 3 degrees and allocate points to each degree - First degree is allocated points equal to the weightage of its factor, second degree – twice the weightage and third degree – thrice the weightage

4 Prepare categorisation plan - provides basis V E D

5 Evaluate items - one by one against each factor and assign points

6 Place the items into V, E and D categories - depending on points scored by them and basis of classification

Applications:

Best suited for spares inventory

Also can combine with other method e.g. ABC analysis and VED analysis

3. HML Analysis

Price criteria is used

Categorised into three groups

H: High

M: Medium

L: Low

Management will decide the cut off lines

For Example:

All items of unit price above Rs. 10000: H Category

Unit price between Rs. 1000 to Rs. 10000: M Category

Unit Price below Rs 1000: L Category

Use/ Applications of HML Analysis

1 To assess storage and Security Requirements - High priced items in cupboards e.g. bearings, worm wheels

2 To keep control over consumption at the departmental head level - Authority to indents of High and Medium priced items to departmental head after careful scrutiny

3 To determine the frequency of stock verification - Checking frequency: more for high priced items and less for L category

4 To evolve buying policies to control purchases - Excess supply: Not accepted in case of H and M category, Acceptable in case of L category

5 To delegate authorities to different buyers to make petty cash purchase - H and M by senior and L by junior buyers

In closing

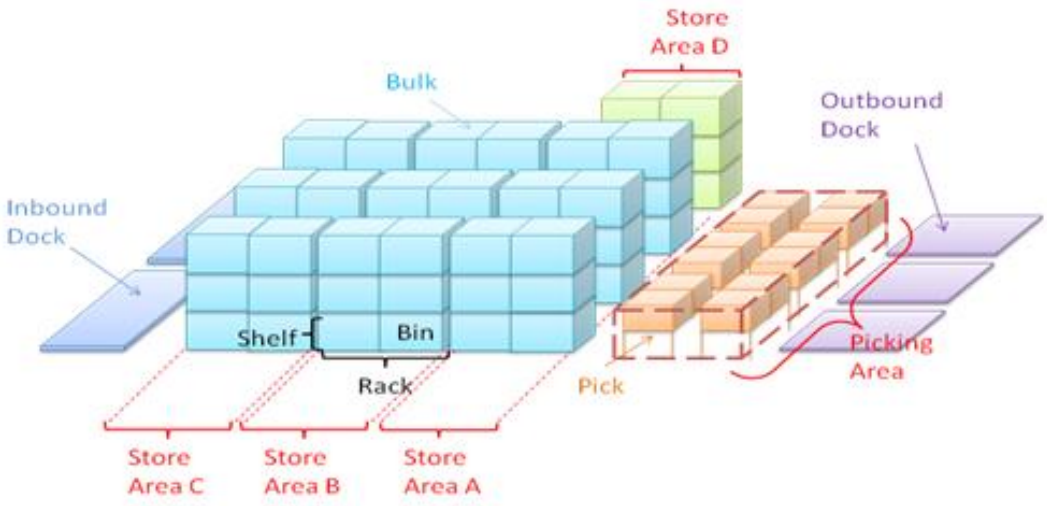
The future of inventory management

The advent, through altruism or legislation, of **environmental management** has added a new dimension to **inventory management-reverse supply chain logistics**. Environmental management has expanded the number of inventory types that firms have to coordinate. In addition to raw materials, work-in-process, finished goods, and MRO goods, firms now have to deal with **post-consumer items such as scrap, returned goods, reusable or recyclable containers, and any number of items that require repair, reuse, recycling, or secondary use in another product.**

Retailers have the same type of problems dealing with inventory that has been returned due to defective material or manufacture, poor fit, finish, or colour, or outright "I changed my mind" responses from customers.

Supply chain management has had a considerable impact on inventory management. Instead of managing one's inventory to maximise profit and minimise cost for the individual firm, today's firm has to make inventory decisions that benefit the entire supply chain.

End of course notes.



Warehouse 23

Thank you for completing the **Warehousing and Inventory Management Certificate** course with **ShippingCollege.**

The course can be completed as a **standalone certificate course** or may be used as **credits towards obtaining your Global Logistics Diploma.**

Students who have completed the **Warehousing and Inventory Management Certificate** course may choose to continue with the **Global Logistics Diploma**.

The **Global Logistics Diploma** consists of **11 Pilot Certificates** which includes **Warehousing and Inventory Management Certificate.**

To further your **Global Logistics** knowledge obtained in **Warehousing and Inventory Management Certificate** we suggest you consider enrolling for the **Purchasing and Materials Flow Management Certificate** course. The course includes the following modules:

1. Purchasing in the Supply Chain
   a. Introduction
   b. Purchasing Activities
   c. Purchasing Research and Planning
   d. Purchasing Cost Management
   e. Managing Supplier Relationships
2. Materials Management and Control
   a. Introduction
   b. Packaging
   c. Methods of Controlling Stock Levels
   d. Movement and Storage of Materials in a Warehouse
   e. Material Management Systems
   f. Forecasting

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These courses will cover the global logistics industry with a particular focus on supply chain and international trade and payments. All our courses are online courses.

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You may either complete your Diploma as a single course (at a lower cost) or complete the Pilot Certificate courses individually to accumulate all your credits to attain your Diploma over a longer period. If you intend to obtain your Diploma we recommend you attempt the Pilot Certificate courses in the order they are listed below.

1. Logistics Terminology Certificate

- Glossary of industry terms

Over 70 pages of industry terminology.

Read more and Register

2. Logistics and Global Trade Certificate - USD60

- Origins of Logistics, Global Logistics, Global Trade Routes, International rules and regulations for importing and exporting, Importance of Global Trade, World Trade Policies.

Read more and Register

3. International Trade Law and Sales Contracts Certificate - USD60

- What is International Trade, Law in International Trade, Preparing an International Sales Contract, Model Sales Contract.

Read more and Register

4. Incoterms Certificate - USD60

- Introductions to Incoterms, Selecting Terms, 2010 revision, Terminology, Rules for any Mode or Modes of Transport, Rules for Sea and Inland Waterway Transport.

Read more and Register

5. International Payments Certificate - USD60

- Methods of Payment, Documentary Collection, Letter of Credit, Uniform Customs and Procedures (UCP 600).

Read more and Register

6. Logistics in the Economy and Organisation Certificate - USD60

- The importance of Logistics, The Role of Logistics in the Economy, The Role of Logistics in the Organisation, Green Logistics, Future Challenges and Opportunities for Logistics.

Read more and Register

7. Importing, Exporting and Transportation Certificate - USD60

- Procedures for Importing and Exporting, Transportation, Multimodal versus Intermodal, Sea Transport, Airfreight and Airfreight Terminology, Road Transport, Rail Transport, International Documentation.

Read more and Register

8. Warehousing and Inventory Management Certificate - USD60

- Warehousing - types of warehouses, location of warehouses, functions of warehouses and more, Inventory Management - inventory functions, types of inventory, holding inventory and more.

Read more and Register

9. Purchasing and Materials Flow Management Certificate - USD60

- Purchasing in the Supply Chain - purchasing activities, purchasing research and planning, purchasing cost management and more, Materials Flow Management - packaging and more.

Read more and Register

10. Management and Control of Logistics Certificate - USD60

- Information Systems for Logistics - customer order cycle, advanced order processing and more, Logistics Efficiency, Logistics Performance Control - importance of accurate cost data, total cost analysis and more.

Read more and Register

11. Supply Chain Management Certificate - USD60

- Supply Chain Management, Implementing Logistics Strategy, Supply Chain Security.

Read more and Register

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Kind regards

The Shipping College Team

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