

MATERIALS MANAGEMENT

Course Objectives:

The primary purpose of the course is to introduce students to the concept and techniques of acquisition of materials, control of inventory and storage as well as handling of materials already on hand. Different techniques of independent demand will also come under review. One of the principal cost factors in any economic enterprise is associated with materials and the concern should be to make available the most economic quantity (and quality) of materials at any time i.e., minimum quantity of materials (with the right quality) which would allow continued production and bring no risk of significant stock-out situations.

UNIT 1: NATURE OF MATERIALS MANAGEMENT

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1.0 AIMS AND OBJECTIVES

The aim of this unit is to introduce the basic concepts associated with materials management function. After completing this unit, students will be able to:

- ✎ identify the different definition of materials management
- ✎ see how materials management is evolved
- ✎ canvass what materials management embraces
- ✎ examine the organization of materials management
- ✎ identify the two forecasting models.

1.1 INTRODUCTION

Materials management problems are common to every organization. Material management problems are often identified by the specialized Materials Mgt. sub-functions viz. Purchasing; Inventory Control; Production Control; Traffic Mgt.; Warehousing; Materials handling and other related activities. The basic reason for this is that the formal materials

management organization is much younger than any of its sub-functions. Materials mgt. is a basic part of any organizations that produces a products or services of economic value.

Materials are important determinant of the total costs of production as it occupies 30% to 40% of the total cost which in certain cases may be more than 50% of the materials required serious attention in any work of production. Materials mean raw materials, components, sub-assemblies and finished products. Materials management is a specialized, systematic and scientific function of a group of people for better procurements/storage and distribution of materials.

1.2 SCOPE OF MATERIAL MANAGERMENTS

Materials mgt. covers all aspects of materials, costs, materials supply and utilization. It covers the whole or rang of functions involved in converting raw materials and ancillary supplies in to finished products. It is concerned with the planning & programming of materials and equipments, market research for purchase; pre design and value analysis, procurements of all materials, packaging and packing materials stores control and inventory control; transportation of raw materials and materials handling, disposal of scrap and operation research for materials.

Materials mgt. covers that aspect of industrials mgt. which concerned with the activities involved in the acquisition, storage and flow of all materials directly and indirectly employed in the prediction and marketing of finished goods.

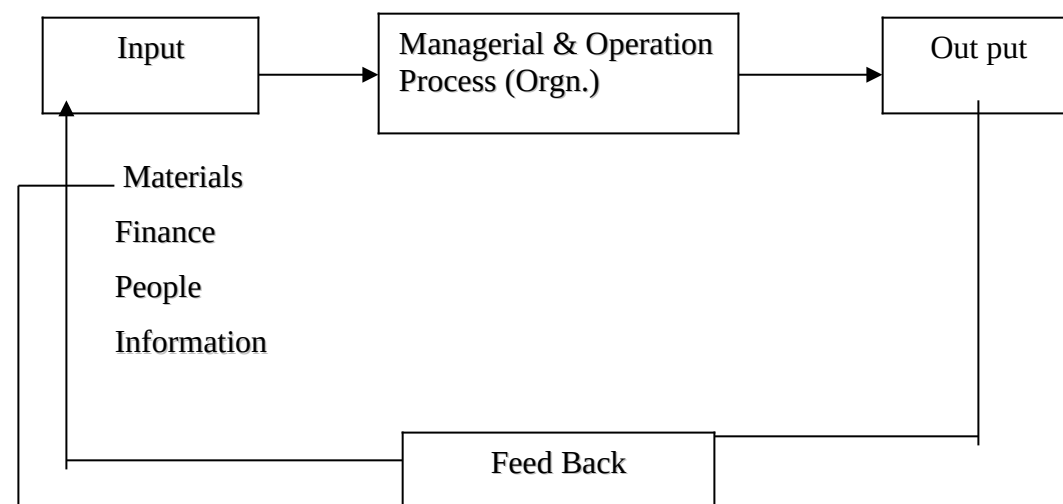
1.3 DEFINITION OF MATERIALS MANAGEMENT

- ⇒ Materials Mgt. is the planning, organizing and controlling of the flow of materials from the initial purchase through internal operations to distribution of finished goods.
(American production and Inventory Control Society)
- ⇒ Materials Mgt. can be defined as an organizational concept of the foster and total system approach to plan, acquire, store, move and control materials (raw materials, supplies, work-in-process, and semi finished goods) inorder to optimize

all company resources (includes materials, people, money and facilities) and provide customer service consistent with company policy. (Magnd & Amos)

- ⇒ Materials Mgt. is a process of coordinating all resources through the process of planning, organizing, staffing, directing leading and controlling to achieve desired objectives with the use of human beings. (By GEROGER TERRY)
- ⇒ Materials management can also be defined as a body of Knowledge which helps the manger to improve the productivity of capital by reducing materials costs, preventing large amount of capital being locked up for long periods and improving the capital turnover ratio. Materials Managers. Must derive its objective by understanding of local environment and at the same time, looking in to consideration the human factor, their attitude, sense and approach to new ideas. [By HAROLD KOONTZ]

The basic concepts in the above definitions of Materials Mgt. can be summarized as follows:



▼ **Includes**

Raw materials
Work-in-process
Finished Goods
Component parts
Semi-finished parts
Fixed assets etc.

1.4 WHY DO WE STUDY MATERIAL MANAGEMENT?

The basic reason /objective of learning materials management is economic. It is concerned with minimizing the cost of materials in organizations without hampering the operation and efficiency of the organizations.

In most cases more than 50% of the total expenditure of an organization or a typical manufacturing organization is spent on materials. For example, organizations in news paper and fertilizers spend 30-40% of their total expenditure on materials, pharmaceuticals and chemical spend about 40-50%, in textile they spend 60-70%, & in sugar they spend more than 70% on materials. Here the magnitude of expenditure on materials in developing countries can be even more than the developed countries. Therefore, the study of materials mgt. should be taken seriously.

Organizations can get better benefits by reducing cost from materials than trying to reduce costs from other sources such as wages and salaries of people for different reasons. This is because reducing benefits/rewards from people will dissatisfy them and the benefit that will come to the organization in terms of cost saving is also small. Consider the following example:

Sales	80 Million Birr
Materials Cost	50%
Profit Margin Before Tax	10%

By what percentage material cost should be reduced to attain and profit increase/gain as a result of a 25% increase on Sales?

	25% (80 Million Birr)	=	Birr 20 Million sales increase
	10% (20 Million)	=	Birr 2 Million Profit Margin increase
Cost	50% (80 Million Birr)	=	Birr 40 Million

So, in order to get an equivalent increase in profit margin (for a 25% sales increase) we need to reduce costs only by 5%

$$\left[\frac{2 \text{ Million}}{40 \text{ Million}} \right] \times 100$$

Hence, instead of increasing sales by 25%, it is easier to reduce costs of materials by 5% in a competitive market economy.

The other reason for studying materials management is attitude. I.e. Peoples have and feel less concern for materials. Once money is converted into materials they don't consider that there is money in the materials. They will show less concern and probably may neglect the materials. But materials are money. They are acquired through exchange of money. The attitude of people is not less only to materials but also on those people who are related to materials. People working in relation to materials are considered as having less status and less importance. This attitudes must be changed by studying various aspects of materials mgt.

1.5 OBJECTIVES OF MATERIALS MGT

The objectives of materials mgt. as such should be supported in every way by:

- i. Maintaining continuity of productive operations by ensuring a uniform flow of materials.
- ii. Reducing materials costs by systematic use of scientific techniques.
- iii. Releasing working capital for productive purpose by efficient control of inventories.
- iv. Increasing the competitiveness of end products by ensuring right quality at the right price especially in foreign market.
- v. Saving foreign exchange through economic use of foreign purchases and import substitution.
- vi. Establishing good buyer –seller-relation.
- vii. Ensuring low departmental cost and high efficiency.
- viii. Setting high ethical standards. In this way it is clear that materials mgt covers all aspects of materials, including flow of materials cost, quality, supply, conservation and utilization.

The prime objective is to supply the user department with the required quantity at a constant rate with uniform quality so that production or service rendered is not held up. At the same time materials manager has to ensure the optimum usage of facilities like capital, storage space and other aspects of materials management. Increased production and sales are

necessary to bring about the same increase in profit, which result in reducing material costs or increasing production and sales to the extent of 30% to 40% which is not easy.

The primary task of modern materials mgt. with an integrated view in purchasing materials of; Right Quality, Right Quantity, at the Right Price from Right Source, at the Right Time, using Right mode of Transport.

1.6 FUNCTIONS OR ACTIVITIES OF MATERIALS MANAGEMENT

The function or activities of materials mgt. depend on the size of the organization, type of the organization and complexities of the products and process.

The following are essential components of materials mgt. activities:

A. *Forecasting & Planning of material demand*

The basis for material demand is sales forecast. Sales plan will depend heavily on long term plan of operation. The material manager in consultation with sales manager must develop a detailed long term plan of operation. Development of the plan must include:

- i. Translation of sales projection of the marketing department in to long term production plan based on opening inventory level plus optimum operation level to provide and ship products and at same time maintaining the required inventory level.
- ii. Projection of data required to determine materials, facilities, capital funds, and human resource to fulfill production on plan.

B. *Inventory Control*

This includes activities and ethics required to maintain material at the desired level. Moreover, the activities are expected to include:

- i. Determining how much material will be required to satisfy company operational demands.
- ii. Maintaining detail records of all materials available, ordered and consumed.
- iii. Determining optimum order quantities and issuing requisitions. And

- iv. Providing appropriate reports to aid in decision making with regard to inventories

C. Make or Buy Decision

D. Production control

Regarding the flow of materials throughout the entire manufacturing process. (from the raw materials to finished products).

The major activities of the production control includes the following:

- i. Utilizing long term plan and sales forecasts to develop short term requirements.
- ii. Preparing schedules for producing parts, sub assemblies, sub products requiring lead-times and special orders.
- iii. Dispatch orders to various departments to fulfill production requirements.
- iv. Expediting production orders, when required, to ensure on time completion & preparing timely reports to evaluate the efficiency of production and status of various orders.

E. Purchasing

This is responsible for procurement of materials and /or parts from outside suppliers in accordance with purchase requisition requirements like quantity, quality, and time specification. The fundamental activities include:

- i. Selection of acceptable supplier or vendor & negotiation of terms to secure the lowest total acquisition cost.
- ii. Placing or issuing purchase order for new reorder materials, parts, and expediting on time receipt of materials, when required.
- iii. Acting like liaison between company department and suppliers to solve problems involved with purchased materials.
- iv. Keeping a breast of market conditions or maintaining an ongoing knowledge of current market condition, new materials, new processes, & other procurement factors that can affect company operations and costs.

F. Receiving, Inspecting and Warehousing/Stores

This is responsible for activities related to receiving, storing, handling, issuing, and controlling materials. Major activities include;

- i. Receipt of material, verification of quantity & preparation of receiving reports.
- ii. Storing received and inspected materials with efficient or optimum usage of space, equipment personnel and with ease of identification.
- iii. Issuing materials with authorized requisition & also accepting returned materials.
- iv. Maintaining control of physical count to assure materials assure material available and performing periodic and annual physical inventories.

G. Physical Distribution/ Transportation

These activities encompasses all activities involved in the movement and flow of materials & finished products from the time they are received to the time they are shipped to customers.

H. Material Requirement Planning

This is the computer based planning & control system used to plan & control internal production and material flow.

1.7 HISTORICAL ASPECTS OF MATERIAL MANAGEMENT

Organizations in which materials mgt. play its roles have rarely been created with a single stroke of the organization builders. They have evolved gradually and in many cases have not yet matured. The scope of materials management in any particular industry is at least as much a product of historical development as it is of economic logic. The evolution of materials mgt. have followed the following pattern in phased manner.

First phase: Executives who are primarily concerned with other functions have carried on almost unconsciously all materials mgt. functions as sidelines.

Second phase: The major materials mgt functions are recognized formally, but these activities report to variety of executives and are not centralized organizationally.

Third phase: Materials mgt functions concerned with purchased materials are grouped together under a senior executive, who behave like a line manger.

Fourth phase: Materials mgt functions become a genuine value adding activity for purchased materials.

The studies have reveled that companies who claim to have reached the Fourth phase of evolution have yet to achieve the performance.

1.8 ORGANIZING FOR MATERIALS MANAGEMENT

Here materials mgt. is an essential activity to the firm with 10 to 105 employees as it is to the larger corporation with more that 30, 000 employees. The larger size corporations have full time specialists in every phase of materials mgt. In a small firm the owner manger handles all the administrative jobs but as small business grows the works load of the owner manger gets heavier. As the organization continues to expand, it becomes more complex. The job is eventually dispersed among a number of executives working at different organization levels, who report to executives interested in other functions particularly manufacturing and finance. Most compaies enjoy unified materials mgt only in their infancy: unfortunately they are then still too small to enjoy the benefits of specialist in the field. As the company continues to grow and reaches the stage where it has around hundred or more employees, the functional specialist becomes necessary and full time mangers finance, production, sales and engineering eventually appear. Finally a separate purchasing department is formed. At first, it may be run by some one who holds another job viz finance controller; company secretary; personnel manager or the like but eventually a full time purchasing agent is definitely a second string manager. As the organization becomes progressive management realizes that their purchasing, production control and traffic management have jobs closely related that they can work together more effectively to achieve common objective if they are linked

organizationally. With this integrated approach to materials management all the jobs encompassed by these function would be under the over-all control of a materials mgt.

Based on the above concepts the organizational structure of materials mgt. can be either fragmented or integrated organizational Structure. In case of small size organization, using integrated organization structure is unwise because its running cost is expensive so these type organization use fragmented organizational structure as shown below:

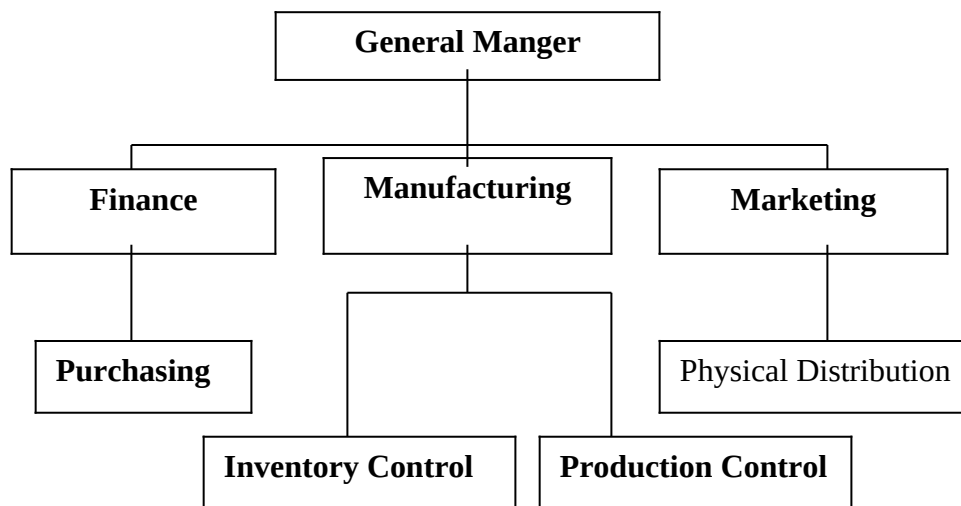


Figure (1.1) Fragmented Organizational Structure

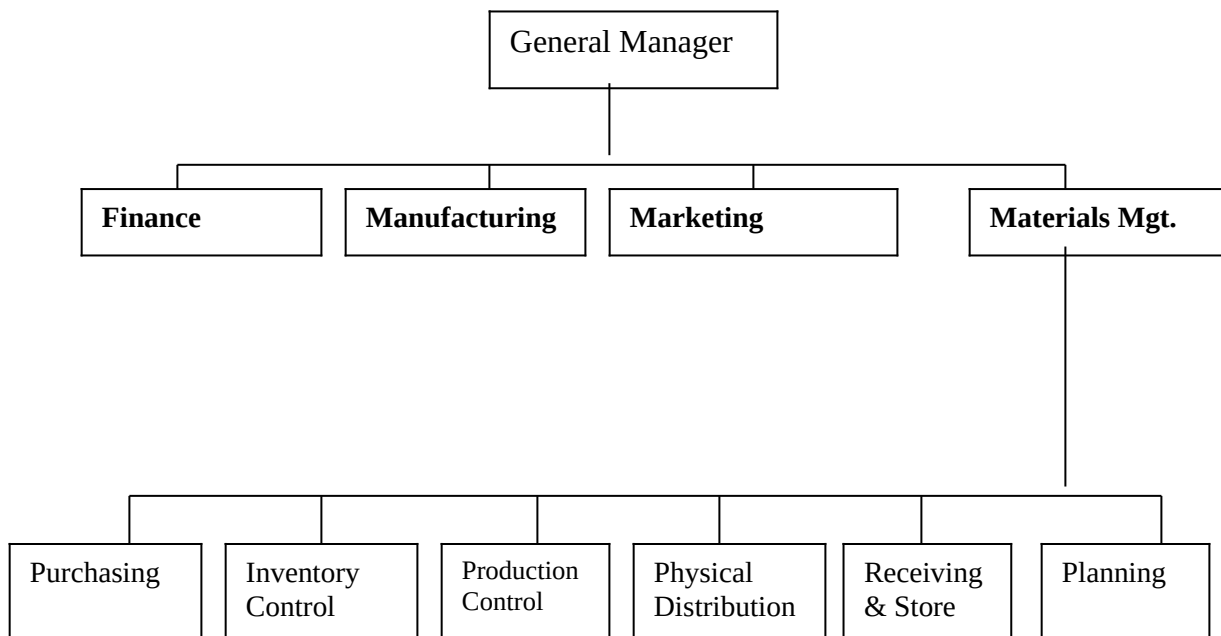
Draw Backs of Fragmented Structure

1. Unclear responsibility:- no clear cut responsibility for the overall flow of materials.
2. Low status and lack of representation:- these functions are scattered and assigned at a lower level in the organizational structure, and there is no representative of them in the mgt. meeting to show their problems.
3. Lack of integrity:- the materials activities that are scattered are not under the control of their integral or fundamental areas, and there is no mutual understanding & coordination of activities.
4. Lack of Motivation:- Persons that are assigned to lower hierarchy are not much motivated to perform in a good way and there may not be future prospect to get promotion under those functional areas.

e.g. a purchaser under finance can not expect to be finance manager

In large organization we usually have an integrated Organizational Structure because on dept. should be responsible for materials mgt. To consolidate the whole material activities under one department (manager) who has the responsibility to assign them may overcome the above draw backs.

The integrated materials mgt. organization structure can be shown diagrammatically as follows:



1.9 RELATIONSHIP BETWEEN MATERIALS MANAGEMENT AND OTHER FUNCTIONAL UNITS

Generally the materials mgt unit is related to other functional units in a number of ways. Inorder to use the synergic effect all organizational units have to work together.

Materials Mgt. and Finance

The finance section is responsible for maintaining cash flow and providing advice in preparing operating budgets. It also supplies the finance to buy the materials & control how well the money is used. To have smooth relationship between finance and materials mgt. the later should spend only reasonable costs for ordering, handling & inventory.

Materials Mgt. & Manufacturing

In this case the material mgt. section supplies all the necessary materials to manufacturing section. So there is a need to have smooth relationship between them. The materials mgt. section should supply the right quantity materials/part with the right of quality at the right time and at a reasonable price. The materials mgt section fails to accomplish its task the over all production of the organization will be collapsed. So, this section should develop its plan based on the plans of the manufacturing section plan.

Marketing and Materials Mgt.

The marketing section is the key section for the overall operation of the organization. In order to meet customer needs /wants we should have close cooperation between them. The basis for manufacturing section work is the sales forecast.

In sum, the services of the materials mgt. section is essential for all functional units of the organization. So it is a dynamic activity that ensures the small flow of supplies through the entire organizational activities.

1.10 MATERIALS DEMAND FORECASTING

The success of an organization depends on how well the organization see the future environment which is full of risks and uncertainties. In order to make prediction about the future, we must use the past and present data. These data helps in minimizing risk and/or uncertainties about the future.

Forecasting is one of the techniques which helps to see the future. It is also a basic tool to help managerial decisions making. Managerial decisions are seldom made in the absence of some form of forecasting. Every day managers have to take decision in the face of uncertainty without knowing what would happen in the future. For example, to keep inventory of items without knowing future demand or sales, making investment in shares without knowing their future return. In this case it is possible to reduce the level of uncertainty by making better estimate of what is likely to happen in the future through forecasting. Forecasting can be made for any thing but the focus here is demand forecasting.

Type of Forecasts

Forecasts can be obtained by variety of techniques. The two type of forecasting models are:

- 1) Qualitative
- 2) Quantitative

1) Qualitative Forecasting

The qualitative model uses personal judgment and involves qualities like intuition and experience as the bases of forecasts and are subjective by their very nature. On the other hand quantitative models are objective in their very nature and they employ numerical information.

Qualitative models of forecasting

Some of the common qualitative methods of forecasting are:

1. Delphi method

This method involves judgment. It is an interactive group process and employs a group of experts, not an oracle to obtain forecasts. The experts are usually not known to each other and their interaction takes place through a coordinator. The other participants in the delphi process are the staffs who are involved in collecting and analyzing data. The respondents are the subjects whose judgment is being sought.

In this model, the coordinator obtains the forecast from the experts and then assimilates each of their forecast. Each of the experts whose estimate is not included in the middle of 50% of the forecast are asked to explain the analysis underlying their forecast. The coordinator disseminates to each expert a summary of all the forecasts and of the explanation of forecasts that lies outside the middle 50%. Based on this additional information, each of the experts may be **reliable** his/her original forecast. The process will be repeated appropriately, then the experts tend to reach a consensus forecasts.

2. Sales force composite-

In this method sales force members will be asked to estimate the likely sales in their respective areas. The estimates are then received to ensure that they are realistic. Finally, the estimates are combined at the district, regional and national level to obtain the overall forecast.

3. Consumer Panel Survey

Under this method consumers are questioned about their purchase plan in a consumer panel. The aim of this method is to forecast product and service demand on the basis of subjective judgment of consumer purchase.

There is one basic assumption to this model. i.e. the consumer in the panel are the representatives of the ultimate/final purchasers.

2) Quantitative Forecasting

This model includes time series model and causal models.

The time series models attempt to predict the future values using the historical data. Here the demand forecast is done on the basis of the past demand value. This prediction is based on the premise that the future is a function of what has happen in the past.

Causal models are used when one variable is related to and therefore, depend on the values of some other variable(s).

For example, the demand of sugar may depend on the consumption of tea.

1. Time series models.

They use time based data. A time series is a collection of readings belonging to different time periods, usually equally spaced (which can be a month, Week or year) of some economic variable.

Decomposition of time series:- A time series is the result of number of movements which are caused by economic, political, natural, and other factors.

This analysis involves decomposing the past data in to components and then projecting them forward.

A time series has four components.

1. Secular trend

Over a long period, time series will have an overall tendency either to move upwards or downwards, though the actual movement will not be regular.

2. Seasonal variation

The fluctuation occurs periodically, the movements recurring within a definite period may be every month or every Week.

3. Cyclical movement

They are caused by business cycles. For example, the sales of company may be high because the level of economic performance may be high.

4. Random movement

They are residual or erratic movements that have any set pattern and are usually caused by some unpredictable reason.

The time series model deal first with projections of values without decomposing and then relating to trend also making adjustment for the seasonal variation.

The following part time series models. Discuss the most commonly used

A. Moving Averages

It attempts to forecast values on the basis of the average of the values of past few periods. Successive values are calculated by considering the new values and dropping the old one.

Example:

The demand for A is observed for 10 months & it is given below.

<u>Month</u>	<u>Demand (in unit)</u>
1	420
2	380
3	456
4	412
5	429
6	366
7	392
8	440
9	452
10	396

Question:

What is the forecast for month 11 using a 3 month forecast & a 4 month Forecast?

Solution:

A three month moving average can be obtained by adding the demand during the past three months & dividing the sum by three, with each passing month the recent month data is added by dropping the old to get new forecast.

∴ By using three months moving average, the demand in month 11 will be 492 units.

$$\frac{396 + 452 + 440}{3} = \underline{429 \text{ units}}$$

⇒ when a four months moving average is used, the forecast of month 11 will be 420 units.

Which can be obtained as follows:

$$\frac{392 + 440 + 452 + 396}{4} = \underline{420 \text{ units}}$$

B. Weighted moving average

A careful analysis of the moving average method reveals the moving average with a base of **n** periods is in fact an equal weighted average of **1/n** to each of the preceding **n** values and a zero weighted to all the previous values. Thus in a three month forecast, the immediately last three months' values are given a weight of 1/3 each & the remaining values a weight of zero.

Here it is possible to assign a differential weight to the values entering in to a moving average calculation.

Assume that the weight of the three months forecast given above is 3:2:1 then,

$$\begin{aligned} \text{Weighted moving average} &= \frac{3 \times (440) + 2 \times (452) + 1 \times (396)}{6} \\ &= \underline{436.6 \text{ units}} \end{aligned}$$

C. Trend Projections

In this method, a trend line is fitted to the given time series data and then projections are made in to the future by using this line. The trend line may be linear or curvilinear in nature. In order to obtain the trend line, the historical data are plotted on the graph, representing time scales on X- axis. Then a line is drawn through these points in such a way that

- i. the sum of deviations above & below the line are equal.
- ii. The sum of the squares of these vertical deviations is minimum.

In essence the trend line is drawn based on the principle of least square. Such a line is represented by

$$y = bx + a$$

where

y = is the trend line to be predicted

b = the slope of the trend line

a – the y intercept

x – independent variable (in this case time)

So far the trend line the value of b & a can be obtained as follows

$$b = \frac{\sum xiyi - n(\bar{x})(\bar{y})}{\sum xi^2 - n(\bar{x})^2}$$

$$a = \bar{y} - b(\bar{x})$$

Example:

Consider the following demand pattern of ABC Company for iron ore.

<u>Year</u>	<u>Demand for iron sheet in '000 tons</u>
1989	13
1990	17
1991	16
1992	16
1993	21
1994	20
1995	20
1996	23
1997	25
1998	24
1999	25

Required:

- A. Forecast the demand of the iron sheet for the year 2000 for ABC Company.

Using 1984 as base year.

- B. Forecast the demand of the iron sheet for the year 2000 for ABC Company.

Using 1997 as base year.

Solution:

Here by using the square method we can develop the estimating (regression) equation.

By using the last square method we can develop the line of the best fit.

$$y = bx + a$$

The line of the best fit always pass through the two points $\bar{X}$ & $\bar{Y}$ i.e. $(\bar{X}, \bar{Y})$.

Now in order to develop the equation of the line we need to have a base year to see the deviation of others from it. Most of the time the base year is the middle observation. In the case of even observations we use the mean of the two middle observations as base year by multiplying the mean by any number. for simplicity in calculation.

- A. When we use 1994 as a base year.

<u>Year</u>	<u>Xi</u>	<u>yi</u>	<u>xiyi</u>	<u>xi²</u>
1989	-5	13	-65	25
1990	-4	17	-68	16
1991	-3	16	-48	19
1992	-2	16	-32	4
1993	-1	21	-21	1
1994	0	20	0	0
1995	1	20	20	1
1996	2	23	46	4
1997	3	25	75	9
1998	4	24	96	16
1999	<u>5</u>	<u>25</u>	<u>125</u>	<u>25</u>
	$\sum xi = 0$	$\sum yi = 220$	$\sum xiyi = 128$	$\sum xi^2 = 110$

The equation of the estimating line,

When the base year is 1994 $\Rightarrow x = 0$. The value of b & a for trend line can be obtained as follows:

$$b = \frac{128 - 11(0)(20)}{110 - 11(0)^2} = \frac{128}{110} = 1.1636$$

$$a = \bar{y} - b(\bar{x})$$

$$20 - 1.1636(0) = \underline{20}$$

$$(y = bx + a)$$

The trend linear equation will be;

$$y = 1.1636x + 20$$

Therefore, the forecast for the year 2000 will be as follows;

$$x = 6 \text{ (because it is six years after the base year 1994)}$$

$$y = 1.1636(6) + 20$$

$$y = \underline{26.9816} \text{ tons of iron sheet}$$

B) if we take 1997 as a base year

<u>Year</u>	<u>Xi</u>	<u>yi</u>	<u>xiyi</u>	<u>xi²</u>
1989	-8	13	-104	64
1990	-7	17	-119	49
1991	-6	16	-96	36
1992	-5	16	-80	25
1993	-4	21	-84	16
1994	-3	20	-60	9
1995	-2	20	-40	4
1996	-1	23	-23	2
1997	0	25	0	0
1998	1	24	24	1
1999	<u>2</u>	<u>25</u>	<u>50</u>	<u>4</u>
	$\Sigma xi = -33$	$\Sigma yi = 220$	$\Sigma xiyi = -532$	$\Sigma xi^2 = 209$

$$\bar{x} = \frac{\Sigma xi}{n} = \frac{-33}{11} = -3$$

$$\bar{y} = \frac{\sum y_i}{n} = \frac{220}{11} = 20$$

$$b = \frac{-532 - (11)(-3)(20)}{209 - 11(-3)^2} = \frac{128}{110} = \underline{1.1636}$$

$$a = \bar{y} - b(\bar{x})$$

$$= 20 - 1.1636(-3)$$

$$= \underline{23.4908}$$

Then the equation will be

$$y = 1.1636x + 23.4908$$

the forecast for the year 2000 will be ;

$$x = 3 \text{ (because it is 3 yrs. after the base year -1997)}$$

$$y = 1.1636(3) + 23.4908$$

$$\underline{26.9816} \text{ tons of iron sheet.}$$

N.B. The forecast for the year 2000 will be the same even if the base year is changed i.e. irrespective of the base year the forecast will be the same.

Whenever there is a change in the base year, there is no need of calculating the slope of the equation. We need to calculate the y – intercept only & we can use the slope calculated in the previous base year as it is.

Example:

$y = 20 + 1.1636x$ when the middle year is used as a base year, when the base year is changed by adding /subtracting from the value of x i.e. from 1994 to 1997 there is a 3 yrs. time gap.

So the value of x will be $x + 3$. The trend equation by using 1997 as a base year is

$$y = 20 + 1.1636(x+3)$$

$$y = 20 + 3.4908 + 1.1636x$$

$$y = \underline{23.4908 + 1.1636x}$$

2. Causal Models of Forecasting

The causal model considers two types of variables the dependent and independent variables. E.g., the sales of a company is depend on & is related to the price changed.

* By using regression analysis it is possible to develop a statistical relation ship b/n the dependent and independent variables.

Simple regression analysis;

It is used when there is one independent variable/ explanatory variable. Here an estimate of the dependent variable is made corresponding to a given value of the independent variable by putting their relationship in the form of regression line. Like the tend projection, the regression line is obtained by plotting paired observations of x and y variables. The regression line is then represented by the following equation.

$$y = a + bx \quad \text{where,}$$

a- y intersect of the regression line

b- slope of the regression line

x- the independent variable

y- the predicted value of the dependent variable

$$b = \frac{\sum xy - n \bar{x} \bar{y}}{\sum x^2 - n \bar{x}^2}$$

$$a = \bar{y} - b \bar{x}$$

Here parameter b is also called the regression coefficient.

Parameter a and b of the trend line drown on the principle of vast square are obtained using the following pairs of normal equations.

$$\sum y = na + b \sum x$$

$$\sum xy = a\sum x + bx^2$$

$$b = \frac{\sum xy - n \bar{x} \bar{y}}{\sum x^2 - n \bar{x}^2}$$

$$a = \bar{y} - b \bar{x}$$

Here

$\sum y$ – Summation of the value of the dependent variable

$\sum x$ – Summation of the value of the independent variable

$\sum xy$ – Summation of moderate of x and corresponding y value

$\sum x^2$ – Sum of the square of the value of the independent

variable

n- Number of date points

When the values of x are stated in the above equation we are going to consider the time sale associated with the year of projections.

Illustration on Regression analysis

Consider a large firm organization engaged in producing barely. The organization feels that the demand for its product (barely) is dependent or related to the number. of cans of beer of 1 liter consumed every year in a certain locality. To establish the demand forecast for its product, the organization has collected the following historical data of hectares of land that had been sawn & the number. of quintals of barely harvested.

<u>Year</u>	<u>Consumption of beer in '000 of liters</u>	<u>Demand for barely in '000 of quintals</u>
1990	36	54
1991	26	30
1992	12	28
1993	40	48
1994	24	36
1995	18	30
1996	30	38
1997	30	46
1998	14	16
1999	34	42

Required:

If the numbers of liters of beer to be consumed in the coming period is 48000 liters (orders already received from clients). Forecast the number of quintals of barely that could be demanded in the year 2000.

Solution:

The first step in regression analysis is to identify the dependent and independent variables usually denoted by x and y respectively. In this illustration the dependent variable is barely and the independent variable is beer.

<u>Bear (x)</u>	<u>Barely (y)</u>	<u>x²</u>	<u>xy</u>
36	54	1296	1944
26	30	676	780
12	28	144	336
40	48	1600	1120
24	36	576	864
18	30	324	540
30	38	900	1140
30	46	900	1380
14	16	196	224
<u>34</u>	<u>42</u>	<u>1156</u>	<u>1424</u>
$\sum x_i = 264$	$\sum y_i = 368$	$\sum x_i^2 = 7768$	$\sum y_i x_i = 10556$

$$\bar{x} = \frac{\sum x}{n} = \frac{264}{10} = 26.4$$

$$\bar{y} = \frac{\sum y}{n} = \frac{368}{10} = 36.8$$

$$b = \frac{10556 - 10(26.4)(36.8)}{7768 - 10(26.4)^2} = \frac{840.8}{798.4} = \underline{\underline{1.05}}$$

$$a = 36.8 - (1.05)(26.4) = \underline{\underline{9.08}}$$

$$\therefore y = 1.05x + 9.08$$

The demand for barely is in the year 2000 = $1.05 (48000) + 9.08 = 50.4$ tons of quintals.

1.11 SUMMARY

Materials management is common to every organization. Materials mgt. is essential not only to manufacturing but also to service industries and it exists not only in profit making enterprises but also in private non – profit sectors of the economy. Materials bgt. Process adds value by getting materials in to the hands of manufacturing and other using departments. In materials management capital is employed and costs are incurred to purchase some thing of economic value.

There are a numbers of activities under materials mgt. Some of them are Purchasing, Inventory control, Production control, Traffic, Warehousing, Receiving, Materials handling and related activities. We can also organize the materials mgt. function as a fragmented or integrated structure. Finally, organizations should forecast their materials demand because the future is full of risk and uncertainties.

Check Your Progress Questions

1. Define Materials management.

.....
.....

2. Identify and explain the basic activities of materials management.

.....
.....

3. Differentiate a fragmented structure from an integrated materials mgt. structure.

.....
.....

4. The following data represents annual shipments (in tons) of weld – tube by an aluminum producer to machinery manufacturers.

<u>Year</u>	<u>Aluminum Shipments (in tons)</u>
1989	2
1990	3
1991	6
1992	10
1993	8
1994	7
1995	12
1996	14
1997	14
1998	18
1999	19

Required:

- A – Use the least square method to develop a linear trend equation for the data and forecast the trend value of the year 2004.
- B – Develop an equation for the same data by using 1996 as a base year and forecast for the year 2004.
- C– What difference do you see between A & B.
5. The general manger of a building materials production plant feels that the demand for plasterboard may be related to the number of construction per mite issued by the municipality. The manager has collected the following information

<u>Construction Permit</u>	<u>Demand of Plasterboard</u>
15	6
9	4
40	16
20	6
25	13
25	9
15	10
35	16

Required

If it has been forecasted that the permit for construction for the next year is 30.

What would be the demand for the plasterboard?

1.12 ANSWERS TO CHECK YOUR PROGRESS

1. Refer section 1.3
2. Refer section 1.6
3. Refer section 1.8
4. a) Here we have no information about the base year so we assume the middle year as a base year.

$Y = 1.65x + 10.27$ is the trend line and for year 2004 the forecast will be 26.77

- b) When 1996 is the base year, the value of x will increase by 2 i.e. $x + 2$ and the trend line is $y = 1.65(x + 2) + 10.27$

$$Y = \underline{1.65x + 13.57}$$

- c) The forecast will be the same irrespective of the base year
5. Let x be the construction permit y be the demand of plasterboard.
The regression line is $Y = 0.3953x + 1$ and the demand of plasterboard will be around 13

UNIT 2: PURCHASING MANAGEMENT

Contents

- 2.0 Aims and Objectives
- 2.1 Introduction
- 2.2 Definition
- 2.3 Importance of Purchasing
- 2.4 Purchasing Objectives
- 2.5 Relationship between the Purchasing Department and other Functional Units
- 2.6 Purchasing Procedures
- 2.7 Important Issues in Purchasing
- 2.8 Value Analysis
- 2.9 Summary
- 2.10 Answers to Check Your Progress

2.0 AIMS AND OBJECTIVES

This unit gives a brief explanation of purchasing and also on the issues involved purchasing.

After reading this unit, you should be able to:

- ✎ explain the purpose of purchasing
- ✎ discuss the purchasing procedure
- ✎ examine different methods of describing quality
- ✎ demonstrate methods of selecting supplier(s)
- ✎ discuss the concept of value analysis.

2.1. INTRODUCTION

The scarcity of raw materials has practically put the people in purchasing department in a very tight positions. The purchasing department can be in a better position if the designer take a little pain to consult the purchasing personnel about the technological capabilities of the

vendors. The main outset of company's cash goes in material purchase thus purchasing people should take greater responsibilities and should analyze the existing procurement policy and should tune with the overall organizational objectives and policies.

The improvement in purchasing management by the help of standardization, value analysis, material substitution, transport saving, cost reduction by packing modification and scrap reclamation all can contribute to the profitability of an organization.

2.2 DEFINITION

Purchasing in its narrow sense, refer merely to the act of buying an item at a price. A broader meaning of purchasing makes it a managerial activity that goes beyond the simple act of buying and includes the planning and policy activities, research and development, service selection etc.

Purchasing is, therefore, the procurement of raw materials, supplies, machines, tools, and services required for equipment, maintenance and operation of a manufacturing plant.

Purchasing function also involves procurement by purchase of the proper materials, machinery, equipment and supplies for stores of used in the manufacture of a product adopted to marketing in the proper quantity at the proper time and at the lowest price consistent with quality desired.

2.3 IMPORTANCE OF PURCHASING

Purchasing management best reflects the role of purchasing in corporate operation and organization. There is a trend towards introducing materials mgt. in industry today, but to say that it has superseded purchasing would be to anticipate the future more than we feel is warranted. Purchasing is still a clearly identifiable function in most business organizations. The term "Management" suggests that purchasing decision involve the weighting of alternative possibilities, and many of these alternatives involve the influence of other functions on the purchasing decisions. No organization can operate without materials, supplies and equipments. The efficiency of any business activity is contingent up on having materials, supplies and equipment available in proper quantity with proper quality at proper place and time, and at proper price. Purchasing is a managerial activity that goes beyond the

simple act of buying and includes the planning and policy activities covering a wide range of related and complementary activities such as research and development; proper selection of materials and sources from which those materials may be bought.

2.4. PURCHASING OBJECTIVES

The objectives of purchasing is to conduct purchase function so as to minimize or eliminate disruption in production resulting from lack of any materials, equipment or supplies. Furthermore, this objective must be achieved with a minimum investment in reserve inventories. Another objective of purchasing is the maintenance of adequate standards of quality for items purchased. The purchasing objective is *lowest ultimate cost rather than lowest initial cost*. Another objective of purchasing is the avoidance of duplication, waste and obsolescence with respect to the various items purchased. The mission of purchasing organization is the effective commitment of the company's funds. Its objective is the economic success of the business organization. In other words the objective of purchasing is not so much to procure the raw materials at the lowest price but to reduce the cost of the final product.

According to A.G. Pearson the prime objective of purchasing organization is "Effective Commitment of company's fund" and having goods of the right quality, from right source at right price and right quantity and time. These objectives of purchasing are known as 5R's of purchasing.

i. Right Quality

Cost and quality are critical dimensions. The interaction between the two is very complex. A right quality is not necessarily best quality. To a large degree manufacture's determine the quality of goods by the desired quality of a product to make. The considerations are basic materials, grades, size, design, colors, patterns and durability.

The quality must be described precisely so that vendors should understand what is exactly needed. The exact specification of item should be given, preferably in terms of market grades, brand or trade names, commercial standards, on blue prints or physical characteristics, materials and method of manufacture.

ii. Right Quantity

Quantity to be purchased varies with the production strategy and planning. Right quantity is the level of quantity which is not too much or too few. This can be made possible through the techniques of E.O.Q (Economic Order Quantity), which save the producer from the danger of stock outs as well as carrying cost of surplus inventory. Other strategical considerations in determining quantities are combination of items to reduce transportation costs, anticipation of market conditions both of raw materials/spares as well as the minimum quantity of finished goods.

iii. Right Source

The source of supplier is determined normally by calling quotations and the lowest bidder is selected provided he has quoted as per the requirement of producer in terms of quality and period of delivery. But such ideal situations do not appear in all cases and selection of supplier involves a strategic consideration of various factors. It is always prudent to select a manufacturer in case of patented standard products even if it means a little extra transportation. Secondly, the past records, financial capacity, technical ability and other resources play important role in selection of supplier.

The purchasing department has to maintain a vocabulary of suppliers of different goods and develop it further from the knowledge or data collection through journals, bulletins and news papers, trade directory, and exchange of information through buying associations.

iv. Right Price

The right price is the worth in terms of quality, time and adequacy of supply of an item obtained. It is no doubt easy and safe to go for standard products at a higher price but one has to keep in mind the utility of item in the ultimate worth of product.

v. Right Time

The ideal time of purchase period would be the minimum time for which the goods remain unconsumed. This could be achieved if the stockiest or manufacturer of raw materials supplies the day-to-day requirements in regular installments. This would save the storage. But the geographical and market conditions do not permit and it is where the ordering system comes into existence. The timing policies will depend up on fluctuating prices as well as problems arising out of monopolistic trade and sellers' maturity.

2.5. RELATIONSHIP BETWEEN THE PURCHASING DEPARTMENT AND OTHER FUNCTIONAL UNITS

All of an organizations department can have a relation with the purchasing department.

2.5.1. Engineering Department and Purchasing Department

It can stipulate technical specifications of the final product of the company and the technical specification of materials to be used in the process of production. This technical specification determines the prices of materials costs of assembly/fabrication and number of suppliers. From this points we can say that what is economical to procure is also economical to fabricate.

2.5.2. Production Department and Purchasing Department

The production schedule is the starting point for the procurement schedule. The procurement schedules could be workable when the production schedule arrives on time. If the production of schedule is late due to various reasons the following risks are expected to occur.

1. Premium price (higher price)
2. Premium transportation costs and costly special production runs (over time work)
3. Production stoppage (shut down) – it may not be possible to get the materials required for production purpose under the first two conditions, then the management will decide to shut down the production process.

Good relationship between engineering and production and purchasing as well would avoid minimize other above problems.

2.5.3. Marketing Department and Purchasing Department

Sales forecast is the bases for production schedule and thereby for purchasing. Purchasing people can have frequent contacts with suppliers and gets information. And they should give these information to sales personnel and the to the management as well.

Reciprocity – Purchasing materials from organizations that can buy finished products of the company. Reciprocity should be accepted as far as it does not affect/discourage other suppliers. Purchasing personnel could tell the sales personnel that which behavior or what things would irritate purchasers, and sales people should consult purchasing people instead of going to the library for further reading.

2.5.4. Finance Department and Purchasing Department

Purchasing schedule or any change in procurement should be communicated to finance department inorder to get sufficient fund at hand when required.

2.6. PURCHASING PROCEDURES

Purchasing procedures refers to the way in which a purchase transaction is carried through from its inception to its conclusion. Purchasing policies outline the broader objectives to be accomplished and guidelines within the desired results. Procedures outline in detail the function to be performed by the people involved in the purchasing operation. Forms and records used to implement procedures and policies. Therefore, procedures are chronological sequence of activities, wile rules are statements that do not require chronological sequence and aside to perform it.

Object of Purchasing Procedures

- ▶ It should facilitate accomplishment of task with minimum effort and directive.
- ▶ It should facilitate accomplishment and coordination (should be in written)

- ▶ Responsibility must be assigned clearly for accomplishment of each stage of each procedure. There should not be an assignment of more than one procedure to some one to avoid overlap of responsibility.
- ▶ Procedure permit management by exception; management should give their attention if clear procedures are forwarded to subordinates, managers, superiors can follow these responsibilities easily.

Steps In The Purchasing Cycle

- 2.6.1. Origination of Purchase Requisition.
- 2.6.2. Verification of Authority and Budget.
- 2.6.3. Request for Quotation or Bids.
- 2.6.4. Evaluation of Bids and Selection of Suppliers.
- 2.6.5. Placing the Purchase Order.
- 2.6.6. Follow-up and Expediting.
- 2.6.7. Receiving, Inspecting and Storing
- 2.6.8. Closing the order

Each of these steps will be discussed as follows.

2.6.1 Origination of Purchase Requisition (PR)

Purchase Requisition is a document generated by the using department or by the store that authorize material purchase. Here, if the policy of the organization states, “All the materials have to be made available to using department through the Store.” then the store department is the only one which is authorized to fill the Purchase Requisition. From this we can infer that the need for purchase originates in the inventory control section or in the operating (using) department. This need for purchase is transmitted to the purchasing department by Purchase Requisition. This Purchase Requisition is a serially numbered internal document by which the need for purchase is transmitted or communicated. It is prepared by a minimum of two copies.

Information that a Purchase Requisition contains include:

1. Description of the materials

2. Quantity
3. Date of requires
4. Date of issue
5. Estimated unit cost
6. Operating account to be charged
7. An authorized signature

2.6.2 Verification of Authority and Budget

The responsibility of indenter (who fills the Purchase Requisition) is to incorporate of details items with full descriptions. However, the responsibility of the buyer (who receive the Purchase Requisition) is to check whether the PR is within the budget limit or not and also checking the accuracy of the document. In addition, he/she checks the stock level and see if cheaper material can equally do the same purpose,

2.6.3 Request for Quotation or Bids /Price Quotation/

This refers to identification and analysis of possible sourced of supply. A Quotation is a statement (perform) acquired from potential suppliers. Requests for Quotation is a process of initiating potential suppliers that are willing to compete to supply the required material. The request depends on the type of materials because some materials need price quotations and other not.

Items which are purchased repetitively, from known suppliers, with small quantity and with low value doesn't require price quotation.

There are two types of Bids.

1. Open Bid – It is a type of bid where all potential suppliers are invited through mass media and advertising agents to participate in the bidding.
2. Closed Bid – In this case selected suppliers are approached (invited) to participate in the bid. Here, the invitation can be made through personal contact, telephone or formal letter.

Issuing of Enquires and Tender Collection

In the case of closed bid we use letters or printed enquiry form because we know the bidder. But in the case of Open tender, we use mass media.

Preparation of the tender involves;

- Bidding Notice
- Bidder's instruction
- Description of Materials
- Samples and blue prints (when required)
- Tender Documents

In order to give general description of the materials; delivery time and point, term of payment, last date of submitting bids, general term and condition should be included.

In the process of collecting tenders we need to set up separate boxes & seal the boxes on the due date & time. After collecting the tender, we need to open the tender. Tender opening involves the following activities.

- Earnest money deposit
- Time, date & place should be specified
- Representatives of purchasing department, suppliers, finance and using department should be present.
- These and other things should enter the tender opening register or minuted.
- The minute should contain price, delivery date, discount, delivery point, & others if any.

Here suppliers that do not pay bid bonds should get back their letters unopened and bid letters arriving between the closing date and the opening date should also be returned to the supplier unopened.

2.6.4 Evaluation of Bids & Selection of Suppliers

This is analysis of the potential supplier who fulfill the criteria of the organization. Suppliers are evaluated /reviewed by the following factors or selection criteria.

- Interm of price proposed by the suppliers.
- Interm of discount they offer.

- ▶ Interms of the shipping terms.
- ▶ Interms of delivery date.
- ▶ Interms of reliability of the supplier by analyzing past performance.
- ▶ Interms of reciprocity (this refers to mutual interchange of favors, privileges in good sense)
- ▶ Interms of quality of work & other services

Here the lowest bidder usually wins the tender, but some times this bidder may be denied or not awarded to supply. This happens because of the following reasons;

1. A higher bidder may provide better after sale service.
2. A higher bidder may have better plant facilities and be able to offer quality provided than the low bidder.
3. The low bidder may not be reliable.
4. The reciprocity may favor some company other than the low bidder.
5. The low bidder may be located so far from the company.
6. Exceptional goodwill may exist between higher bidder & the buyer.
7. The organization (buyer) may adhere to the policy of dealing with local suppliers.

2.6.5 Issuing of Purchase Order

The Purchase Requisition gives the purchasing agent authority to order the materials described in the requisitions. The purchasing agent should maintain or have access to an up-to-date list of vendors, which includes price, available discounts, estimated delivery time, and any other relevant information. From this list, the purchasing agent selects a vender from whom high quality materials can be obtained when needed at competitive cost. Then the purchasing agent then completes a Purchase Order which is a buyer's documents that formalizes a purchase transaction with the seller. So a Purchase Order is a serially numbered external document that is used to make purchases.

The Purchase Order should contain the following information. (See figure 2-1)

1. Suppliers name and address.
2. Quotation reference and date.
3. Description of items.

4. Quantity Ordered.
5. Unit Price.
6. Terms of Payment.
7. Date of the order.
8. Delivery date and
9. Signature of the purchasing agent

General terms and Conditions are included in the purchase order as a legal protection for the buyer. In addition, Engineering designs & other drawings shall accompany the purchase order.

Figure 2-1 Purchase Order (Prepared by Purchasing agent & sent to vendor to order materials.)

PURCHASE ORDER		Order N°. 1982
XYZ Company		
To: ABC Corporation Nazreth, Ethiopia	Mark order N°. on invoice and on all package. Date: Jan. 6, 2003 Term 3/10 eom n/60 Ship via Track / to arrive on Jan. 25,2003	

Quantity	Description	Price
20,000 Gallon	Adhesive Compound Grade A	Br. 31,000
By: <u>Alem</u> Purchasing agent		

The purchase order should be prepared in a multiple snap out format; most generally it has 7 copies.

First Copy }
Second Copy } These two are sent to the supplier. one as an acknowledgment.

Third Copy: to accounting department to inform fund be available.

Fourth Copy: should be sent to the store to intimate that shipment is arriving soon.

Fifth Copy: to the using department to enable them act accordingly.

Sixth Copy }
Seventh Copy } These two copies are retained by the purchasing unit, of which the 6th copy is used for follow-up of purchase.

After the purchase order is prepared and distributed, if adjustment is required a letter or printed format called “Change Order” should be filled in the same copies as the purchase order and be distributed accordingly.

2.6.6 Follow-up and expediting the Order

Follow-up refers to reminding the supplier to insure the timely arrival of the Order. And expediting is speeding up or accelerating the receipt of the item before the agreed-up on time. The later requires good relationship between the purchasing unit & the supplier.

Here, we need to have the system which shows the date at which delivery check should be made.

These systems could be:

A. Manual - We may use a calendar file. This is keeping the follow up order on the required date when the next follow –up is scheduled. Or suppliers list. This is filling orders alphabetically on the top we are going to use a number running from 1 to 30/31 and we put a visible colored mark on the date the next follow-up is made.

B. Automated System - This is normally using a computerized system.

C. Communications - This may be through

- Letters or telephone

- Printed form & Pcs. for routine work
- People: Purchasing people or other people to follow these duties.

2.6.7 **Receiving, Inspecting and Storing**

When the items are received, the following receiving procedures are usually adopted.

1. Unloading and checking the consignment /shipment. Compare the consignment with the freight whether there is any damage or not.
2. Unpacking and checking the material – Compare for the right material that the packing ship contains with the materials received. Here, we need to check for the right quantity and General Condition of the material.
3. Completing the receiving report and distribute this report to:
 - First copy - to purchasing; if all orders are received the document will be closed
 - Second copy- to accounting department for effective payment.
 - Third copy-to the requesting department to intimate the items are received
 - Fourth copy – it should be retained by the receiving department.
4. Delivery of materials: these materials may be handled to the using department to the internal delivery system or to the Store. Finally, whoever is receiving the material will sign on the receiving report.

Inspection Report: whenever it is necessary to take technical inspection, we may make sample/all inspection. This depends on the nature of material and/or on the description of those materials. Based on this technical report, if the material is not useful (partly or wholly) the purchasing people will notify the supplier how to handle those items. In this case the possible courses action would be:

1. Return the material to the supplier.
2. Keep some of the more acceptable material and return the rest.
3. Keep all and rework it to the point where it is acceptable.

When is Inspection Justified?

This depends on economies of scale, which is based on two basic costs.

1. Cost of Inspection
2. Costs resulting from defectiveness entering the production operation and/or reaching customers.

Here the intention is to minimize the process average of these costs.

Example: A firm is buying a widget in lots of 1000/Week. The cost of inspection of a widget is 0.20Br. & the cost of defective to correct is Br.10.00. Finally, the process average (defective) 3%

The decision could be **100% inspection** or **No inspection**.

Solution:

Let N - be the N° of widgets
 CI - be the cost of Inspection
 CD - be the cost of defectiveness
 P - be the process average

$$\begin{aligned}
 \text{Total (100\%) Inspection Cost} &= NCI + NPCD \\
 &= 1000(0.20) + 1000(0.03)(0) \\
 &= \underline{200.00} \text{ Birr}
 \end{aligned}$$

$$\begin{aligned}
 \text{No Inspection Cost} &= 1000(0) + 1000(0.03)(10) \\
 &= \underline{300.00} \text{ Birr}
 \end{aligned}$$

Now it is possible to identify the cost of inspection and no inspection at different values of P .

<u>P</u>	<u>100% Inspection</u>	<u>No Inspection</u>
1%	Br. 200.00	Br. 100.00
2%	Br. 200.00	Br. 200.00
3%	Br. 200.00	Br. 300.00

Hence value of P that make the buyer indifferent would be found by equating the two equations as follow:

$$NCI = NPCD; \quad \frac{NCI}{NPCD} = 0$$

$$P = \frac{CI}{CD}$$

When $P > CI/CD$, 100% inspection is desired. Because total costs of inspection is less than costs of no inspection.

When $P < CI/CD$, 0% inspection is preferred.

Even though it is taken 100% inspection, there might be damages or unwanted items found, and therefore, inspection ranges from 85-95% accurate. On the other hand when taking sample inspection the summation of the sample average cost is taken in to account.

2.6.8 Closing the Order

After making the necessary payment to the vendor, Closing an order simply entails a consolidation of all documents and correspondence relevant to the order in filling them in closed order file which include a purchase requisition, the open order file of the purchase order, the acknowledgement, the receiving report, the inspection report and any note or correspondence pertaining to the order.

2.7. IMPORTANT ISSUES IN PURCHASING

2.7.1 Make or Buy decision

How a make or buy decision originates? This decision may originate in any one of the following events.

- i. When we are planning to produce a new product or modifying the existing product.
- ii. When the current performance of supplier is unsatisfactory.
- iii. Changing demand in the external environment. (increase or decrease of demand.)

Now before buying or making the parts the costs should be evaluated. The relevant costs of buying are; purchase cost of the parts, transportation costs and receiving and inspection costs. The cost of making includes; In general,

- Delivered raw material costs
- Direct labor costs

- Incremental managerial costs
- Inventory Carrying costs
- Costs of Capital and
- Opportunity Costs.

Inorder to make a sound managerial decision, we should have to consider the factors specifically favoring the making or buying decisions.

Factors that specifically favor the making decisions

- When the cost to make is substantially lower or less than the cost to buy.
- When the demand for the product is stable & at a higher value, so that the investment in equipment can be returned.
- When the companies manufacturing experience & equipment are well suited to the manufacturing of the product.
- When the suppliers are unable to meet specifications interms of quality & performance.
- When the company has idle capacity like, idle space, skilled human resource, equipment to be utilized in manufacturing the product.
- When transportation costs can be saved by gathering local materials to make the products rather than having made at a distant plant.
- When research break through occurs & the company wants to maintain trade secrets concerning the product, materials in it & the process involved.

Considerations that favor buying than making.

- When the cost to buy is substantially lower or less than the cost to make the item.
- When the demand for the product is fluctuating, creating production problem.
- When the quantities of item required is small.
- When other companies hold trade secret or patents on a required product so that it is not possible to make it.
- When obsolescence makes machine worthless or substantially reduce their value.
- When high scrap or spoilage rates are inherent in the manufacture of the product and when the company is assured of getting the same from suppliers.

Illustration on Buying & Making decision

ABC metal work company produces parts that are shipped nation wide. It has an opportunity to produce plastic packing cases which are currently purchase at 0.70 Br. each. Annual demand for the product depends largely on economic conditions & this has been estimated at 45,000 units. If the company produces the cases itself, it must re-innovate on existing area & should purchase a molding machine which will result in an annual fixed cost of 12,000 Br. Variable costs for labor, material & factory overhead are estimated at 0.65 Br./case.

Required:

- a) Should the company Make or Buy the cases.
- b) At what volume, it is more profitable to produce in house rather than purchase from an outside suppliers.

Solution:

$$\begin{aligned} \text{a) Expected cost of making} &= \text{Total variable costs} + \text{Fixed Cost} \\ &= 0.65(45,000) + 12,000 \\ &= \underline{41,250.00 \text{ Birr}} \end{aligned}$$

$$\begin{aligned} \text{Expected Cost of buying} &= \text{Unit Price} \times \text{Annual Demand} \\ &= 0.70 \times 45,000 \\ &= \underline{31,500.00 \text{ Birr}} \end{aligned}$$

Since the cost of buying is less than cost of making the company should buy the cases because there is a cost saving of 9,750 Birr.

Note that the fixed cost is avoidable i.e. when we buy the item from the external supplier there will be no fixed cost of 12,000 Birr.

- b) In order to calculate the quantity level that favors making we need to first compute the breakeven point.

The breakeven point is the point where total revenue equals total cost.

i.e. $TR = TC$

$$P \times Q = VC(Q) + FC$$

$$P \times Q - VC(Q) = FC$$

$$Q = \frac{FC}{P - VC}$$

$$Q = \frac{12,000}{0.70 - 0.065} = \underline{240,000} \text{ units}$$

At this level of quantity cost of making is equivalent to cost of buying

$$0.65(240,000) + 12,000 = 0.70(240,000)$$

$$\underline{168,000} = \underline{168,000}$$

Therefore, it is more profitable to produce the items in house rather than purchase at any volume of greater than 240,000 units. Here you can check the answer by taking a quantity level that exceeds 240,000 units. For example the cost of making 245,000 units is 171,500 but the cost of making these units is 171,250 Birr.

2.7.2 Organization of Purchasing

The organization of purchasing is usually identified as centralized or decentralized purchasing.

i. Centralized Purchasing

This occurs when the authority and responsibility to handle the material needs of the organization is given to one department.

Merits of centralized purchasing (Compared to decentralized organization) includes the following

1. In centralized purchasing all orders go to one office as a result a better control can be achieved over purchasing and inventories. It can also take advantage of cash discount & EOQ (which results in reduced carrying cost and ordering costs).
2. Since orders are consolidated a quantity discount can be taken. i.e.

Order by one department for the entire organization $\Rightarrow$ Large Quantity order $\Rightarrow$ Quantity discount $\Rightarrow$ Reduced Cost

3. There is more opportunity for the purchaser to specialize and concentrate on few products.
4. The quantity of orders processed in centralized purchasing may make electronic data processing feasible which may not be profitable in smaller or decentralized purchasing department.
5. More purchasing power is represented which enables the purchaser to have a better negotiating position and purchasing power.

ii. Decentralized Purchasing

This occurs when the various departments in the organization are established to satisfy material needs. It is usually used when branches are located in different parts of a country.

Merits include the following

1. It offers fast action since decision is made close to the using department.
2. It helps to satisfy the differing local needs.
3. Though negotiating with several suppliers has problems in terms of quantity discount and quality, this does considerate the risk and avoid it in case of breakdowns, strikes and natural catastrophes which may cut-off one source of supplier.
4. Transportation cost may be lower by buying locally from suppliers which are near to each of the branches.
5. Local goodwill may be generated when buying from suppliers located in the same community.

iii. Computerization Purchasing

This occurs when both the centralized and decentralized purchasing are operated in an organization. Items of high value and those that require high technical analysis and knowledge of experts are purchased under centralized purchasing. But those items of low value and of routine use are purchased under decentralization.

2.7.3 Who will determine Quality?

The quality of product is usually determined by the engineering/production department and purchasing department as follows.

Engineering/production people are responsible to specify the technical aspects of quality (in collaboration with sales personnel) of material which is meant for production. And other material using departments should also specify the quality/specification of materials they require.

The purchasing department then also determine the economical aspect of these materials.

Here the right to challenge should be given or exercised by the purchasing department. This can be the right to question all materials that are required, to reconsider (reevaluate) the technical specification for economic reasons. This can be by giving information to the concerned people which helps to revise the specification. On the other hand this challenge with one department make the other department to be alert while preparing quality specifications. Therefore, since the purchasing department personnel have an exposure to the outside environment it is better to communicate with them while preparing specifications.

2.7.3.1 How to Describe Quality

Quality description performs three main purposes.

- i. It makes it possible to describe the items listed on the Purchasing Order.
- ii. It makes the supplier know exactly what type of material, and
- iii. It serves as a basis of inspection.

2.7.3.2 Methods of Quality Description

There are various methods of describing the quality of a product. Some of these are:

- A) **Market Grades:-** Grades are a position in scale of qualities and the grade of a commodity is determined by comparing that product with pre-established agreed upon standards. (e.g. cotton, coffee, tobacco, hide, etc...)
- B) **Trade/Brand names:-** A brand name is a pledge/promise to customer, because once a customer can adapt to a particular product, he can not shift unless he found a change in taste, and other things in it. Sales of a products under a trade/brand name is easy to describe and is also easy to inspect. Therefore, inspection and description time will be reduced.

Limitation of a brand name

- A material that is bought under a brand name is higher in terms of price compared to those without brand name.
- It tends to exclude other suppliers with similar products. These limitations can be minimized by ordering those materials based on the purpose for which the materials are intended for. For example OMO or equivalent.
- There is lack of consistent quality unless the manufacturer has a good production and quality control mechanism.

- C) **Commercial Standards:-** A Standard is uniform identification that is agreed upon. Commercial standards are complete descriptions of a standardized materials.

Advantage of Commercial Standard

- They are cheaper than those purchased without commercial standards.
- Materials like bolts, nuts and electrical supplies that are produced per specification can fit to standard application, irrespective of where they are made
- Avoids mis understanding (leaves no room between the buyer or the seller). They have the same understanding as to quality of the material.

One limitation of Commercial standard is that its inspection cost is high, it is very hard to inspect all of the materials ordered and received, because it should be checked against commercial standards.

- D) **Physical/Chemical Specification:-** Specifications are detailed descriptions of the general features/ characteristics of a particular items that are used to define a specific

product quality. These are listing of materials, components used in making a product. It is verbal and/or quantitative description. It is one means of communication between the buyer and the sellers.

The materials under this category may not be specified by market grades, trade/brand name or it may not be standardized to be specified. Hence, it could be described by physical/chemical property.

Advantages

Describing quality by physical/chemical specification, an organization can save premium prices that would be paid on branded materials.

Here, these materials could have a unique feature as compared to those materials available in the market. Therefore, these special order products may have additional prices to be produced. Hence addition or deletion is possible.

Limitations

- The buyer can assume complete responsibility as far as it is made as per specifications.
- Require special inspection by comparing with the specification of those materials received.

Physical specification is a detailed physical condition, sizes or dimensions in measurable things. Chemical specification involves specifying the products in terms of chemical composition and it explains the products reaction to exposure.

E. Performance Specification:- Theoretically it is the best type of specification. It describes an item in words in terms of what the item is required to perform. For example an electric wire having a specific degree of resistance.

Advantages

- Ease of preparing specification
- Assurance of obtaining the precise performance described
- Inclusion of all applicable new developments.

Potential Disadvantages

- ***In appropriate use;*** users choose these because it is easy and they tend to overuse.
- ***Poor supplier selection;*** it is not known in advanced from what materials it have been made and the supplier may not technologically capable unless he is honest.
- ***Unfair pricing;*** Overhanging of prices

F) Materials and Methods of Manufacturers Specification:-

Here the buyer dictates the supplier, by telling what type of materials are required, what type of technology we need for our process of production, etc. In this case the buyer is assumed to have full knowledge of technological progress.

- ✧ Material specification describes the material from which the product is made such as plastic made, wood made or metal etc...
- ✧ Method specification describes the method of manufacturing such as hand made, machine etc...

Advantages

- Widest competition is possible
- Good pricing is assured

Disadvantages

- It puts great responsibility on the buyer.
- It can deny a company the latest advancements in both technological developments and manufacturing process.
- Expenses to prepare and expensive to inspect for compliance.

G) Engineering Design and Prints:- This method can be used with other methods of describing quality. Specially, precise shape, dimensions and special relationships are requirements, then this method can be used. It is applicable to the purchase of construction, electronic and electrical assemblies, machine parts etc...

Advantages

- They are accurate and precise.

- They are the most practical way of describing mechanical items requiring extremely close technologies.
- They permit wide competition.
- They clearly establish the standards for inspection.

Disadvantage

- High cost that is associated with the design and drafting work of the item required.

H) Combination method:-

When any one of these methods is not adequate to describe a material that is required, a combination of these methods is necessary to be used. Regardless of the method or methods used to describe quality only the minimum quality needed for the product to perform the function intended should be specified.

2.7.4 Type of Purchasing

This is the right time aspect of purchasing. The quality of materials affect the price and time of purchase. Organizations should have time of purchase for their production process, because materials could have increase/decrease in price seasonably depending on the circumstances.

Here based on time dimension, there are four time based types of purchasing. These are

1. Hand to mouth
2. Current Requirement
3. Forward buying
4. Speculative buying

1. Hand –to-mouth buying

Hand to mouth buying policy is a practice of buying materials to satisfy immediate operating requirements smaller than those normally considered economical.

Some of the reasons for exercising this method are:

- o When there is no enough cash - flow in the organization.

- When there is too much inventory & insufficient storage space.
- When a drop – in prices is expected in the future.
- When an engineering changes are expected in the future.

Advantages:

- It saves money when prices are dropping
- It prevents inventory losses that result due to technological change and
- It provides the firm required additional cash for operating purposes.

Limitations:

- It leads to higher buying and administrative expenses. (ordering costs, price discounts, etc.)
- There is a risk of running out of stock.

2. Current –Requirement Buying

This is a buying practice in excess of a hand –to mouth quantity. This is the most common method of buying to satisfy short range requirements. The method obtains the most economical quantity by using EOQ models which balances the costs, quantity discount, inventory cost, obsolescence cost... in to account.

3. Forward Buying

This is a buying practice in excess of current requirement by taking in to account the supply and demand interaction of the operation. It does not include purchases with a view to make a profit out of it.

Advantages:

- It helps to fulfill known needs at a best price, quantity discount, volume, freight rate etc.
- To achieve the expected profit level, if an organization has a contractual agreement to supply its products for a specific period, it should have enough inventory inorder to get constant profit level for its operation.
- It reduces the risk of stock outs.

Limitations:

- Price risk is involved, it may fall.
- Added inventory carrying charge.

There are also various reasons for forward buying.

- To provide a margin of insurance for possible strikes from the side of the supplier or similar developments like carrier interruptions.
- To take advantage of quantity discounts and favorable transportation rates by consolidating shipments
- To protect the company against risk of forecasted shortage of materials.

4. Speculative Buying

Strictly speaking speculative is buying materials with the intention of making a profit out of the transaction by selling the material at higher price later. On the other hand it may also be bought for own use believing that the foreseeable future need of this material arises.

Responsibilities of Speculative Buying

Buying and selling materials later at higher price is the major source of the company's income, and hence the responsibility should also be towards the top executive (GM), because the survival of the company and the risk associated to these operations is based on such speculations. On the other hand buying materials to use in the process at later times should be the responsibility of the top executive depending on the time the material is to be used and the risk associated to it. If the risk diminishes the lower level executive can have the responsibility, as the risk increases the responsibility shifts to the higher executive.

Under all buying policies there is a speculation of price to rise, and look for future reduction of price. In hand to mouth and forward buying we are speculating in order to protect the company from paying higher prices in the future, while in speculative buying we are expecting generate profit out of it.

2.7.5 Discount in Purchasing

The other important factor which can influence the buyer in supplier selection or tender evaluation is discount. A discount is a reduction allowed by a seller to a buyer when the buyer meets certain stated condition in buying. The following part will provide the detail explanation of the most commonly used types of discount in purchasing.

i. Cash Discount

These are given to purchaser who pays their bill on time. It is used as a means of encouraging early payment before the expiration of the discount period. For example, if the cash discount is 2/10,net 30. It means the buyer can get a 2% discount when he settles his bills within 10 days; if not he can settle the bills within 30 days without any discount.

ii. Quantity Discounts

This is given to a buyer for purchasing increasingly larger quantity of materials; these can be obtained because of;

1. For purchasing a specific quantity of item at one time, or
2. For purchasing a specified birr total of any number of items at one time.
3. For purchasing a specified birr total of any number of items over an agreed –up on time period. (Cumulative discount).

Here the purchaser should take the inventory purchasing policy in to consideration with the quantity discount, because of the inventory carrying cost of large quantity.

iii. Trade Discounts

These are reduction from list price allowed to various classes of buyer and distributors to compensate them for performing certain marketing function for the Original seller of the product.

iv. Seasonal Discounts

This is granted for purchasing seasonal nature products during the off-season period. For example, a winter discount may be given to all summer products.

2.7.6 Selecting the Source of Supply

The essence of purchasing process is the rational selection of sources of supply. In selecting sources of supply the purchase officer makes decision that influence not only his firms economic success but livelihood of the supplier and the efficiency of the entire economy.

After the list of possible supplier has been compiled the next step is to evaluate each suppliers so that the list may narrowed be down the predetermined number with whom the buyer chooses to place his business. This process of evaluation is conducted by comparing the supplier it terms of their ability to provide the desired quality, quantity, price and service.

As selection is the essence of the purchasing process it is imperative that final authority rest with the purchasing department. In some companies improper selection causing inferior goods and services has resulted in authority being shared with the using department.

The procedure for source selection involves the preparation of an extensive test of prospective supplier and the successive elimination from the list on various grounds until the number has been reduced to one or few to be favored with the business. Some of the possible sources of potential suppliers are. Sales man, trade journals, trade directories, the yellow pages, mail advertisements, trade exhibitions, other purchasing department/people, supplier catalogues and supplier information file/won record.

After identifying the prospective suppliers, the next step is selection and evaluation. Now we can apply both qualitative (subjective) approach and quantitative approaches. The subjective evaluation approach compares suppliers based on the suppliers ability to provide the desired quality and quantity, price, and services of the suppliers.

The objective (quantitative) approach stats with identifying the evaluation criteria and quantifying them. Here there are two methods of quantitative evaluation methods. These are:

- A. Weighted Point method
- B. Cost ratio method

A. The weighted point method;

In this method the number of factors such as the objectives of the organization, its product and economic conditions of the organization are included. The relative worth of these factors as

compared to each other will give a composite performance index. The relative worth of these factors vary from products to products, organization to organization.

The following are the maximum but average points for the best performance.

	<u>Factor</u>	<u>Average Points</u>
A.	Quality	35
B.	Price	30
C.	Delivery	20
D.	Service	15

The points are allocated based on the nature of the products for example, for toys quantity is less important but the attraction and price are of main considerations while for air craft components quality aspect is more important as compared to price.

Note:

This method is used for suppliers who have past relations with the firm because it take past records in to consideration.

Example;

Assume that an organization has chosen the following evaluation criteria along with their relative weights as a basis in the evaluation process.

<u>Criteria for evaluation</u>	<u>Relative Weights</u>
Quality of shipment	40
Accuracy of delivery premises	30
Frequency of cost – reduction suggestion	20
Price	<u>10</u>
	<u>100</u>

The organization has also set acceptable and unacceptable rang for the composite rating where at least 85% is excellent, 70-84% is acceptable and 60% or less is unacceptable. The

following hypothetical performance figures were also provided about three suppliers or vendors.

Vendor	Total Shipment Received	Percentage of shipment Arrived on schedule	Cost reduction suggestion	Quality of good shipment	Price (in Birr)
A	100	80	20%	90%	40
B	60	90	20%	80%	50
C	50	100	60%	70%	60

Given the above information which of the vendor stands best? Use the weighted point method.

Solution

The composite rating comparison will be as follows:

Vendor	Quality Rating (% of Quality x 40 pts)	% of shipment arrived on time x 30pts)	Cost reduction rating % x 20 pts)	Price rating % x 10pts	Composite rating
A	$0.9 \times 40 = 36$	$0.8 \times 30 = 24$	$0.2 \times 20 = 4$	$1.0 \times 10 = 10$	74
B	$0.8 \times 40 = 32$	$0.9 \times 30 = 27$	$0.2 \times 20 = 4$	$0.8 \times 10 = 8$	71
C	$0.7 \times 40 = 28$	$1.0 \times 30 = 30$	$0.2 \times 20 = 12$	$.67 \times 10 = 6.7$	76.7

Note:

- The quality rating can be obtained by multiplying the percentage of quality shipment by the weight of quality given in the evaluation criteria.

Example:- The quality of good shipment for vendor A is 90% so the quality rating will be $90\% \times 40$ (weight of quality) = 36

- The delivery rating & cost reduction rating will also be computed like the quality rating.
- The computation of price rating involves two steps.

Step 1-Develop the percentage for the different unit prices as follow

<u>Average price Per unit</u>	<u>Percentage</u>
40	100 %(because it is the lowest price)
50	80%
60	67%

We can develop the percentages by dividing the lowest price by the prices offered by the vendors.

$$\begin{array}{rclclcl}
 \therefore & \text{For} & A & = & 40/40 & = & 100\% \\
 & & B & = & 40/50 & = & 80\% \\
 & & C & = & 40/60 & = & 67\%
 \end{array}$$

Step 2- Multiply these rates by the weight of price.

Based on the above analysis vendor C is selected as best supplier with the overall highest point of 76.7.

B. The Cost – Ratio method

In this method a list of suppliers service is established in relation to the price. In this method the objective is to evaluate the suppliers on the basis of proceeding considerations. Here the highest the ratio of costs to the value of shipment, the lower is the chance of selection for the supplier and the lower the rating for a supplier. The cost categories that may be used in the evaluation process will depend upon the type of firm or products.

We should identify elements which express quality, delivery, service and price in order to evaluate supplier by finding the cost ratio of each factor. i.e.

$$1. \text{ Quality –cost ratio} = \frac{\text{Total Quality Cost}}{\text{Total Dollar of Purchase}} \times 100$$

$$2. \text{ Delivery cost ratio} = \frac{\text{Total Delivery Cost}}{\text{Total Shipment}} \times 100$$

$$3. \text{ Price Ratio} = \frac{\text{Total lowest Price}}{\text{Actual Price}} \times 100$$

4. Service cost Ratio - In this case we need to establish a norm or standard of service requirements and then we can evaluate the supplier to see whether they fall above or below the standard. Finally we should relate it to the quoted price.

How to integrate the service ratio to the cost-ratio method?

In order to integrate the service ratio to the cost ratio method we may apply the following procedure;

1. Determine the important subjective service factors & assign numerical weights to each factor according to its importance to the buying firm.
2. Establish a premium over quoted price that the total subject service package worth.
3. Determine an acceptable norm.
4. Rate the suppliers according to the service factors.
5. Determine by what percentage the supplier being rated is above or below the acceptable norm.
6. Apply this percentage to the total value of the total service package to determine the service-cost ratio.

Example:

Suppose you are a purchasing head of a company & you are required to select the best supplier from among four suppliers named Mr. A, Mr. B, Mr. C & Mr. D by evaluating their

last year performance. Factors of analysis include quality, delivery, service & price. Given the following data on supplier performance, forward your proposal to higher officials the cost-ratio method.

Delivery Costs:

	(Birr)			
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
Telephone Call	400	100	200	300
Telegrams	475	275	425	200
Expediting	875	300	975	750
Premium shipment	750	225	900	950
Miscellaneous	500	300	700	600
Total Delivery Cost	<u>3000</u>	<u>1200</u>	<u>3200</u>	<u>2800</u>

Data related to Quality

	(Birr)			
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
Visite Vendor Plants	300	500	400	200
Sample approval	400	700	800	600
Incoming Inspection	100	275	250	225
Manufacturing Losses	0	100	325	700
Reworking Cost	0	425	450	400
Value of rejects parts	<u>200</u>	<u>1600</u>	<u>975</u>	<u>675</u>
Total Delivery Cost	<u>10000</u>	<u>3600</u>	<u>3200</u>	<u>2800</u>

Service Rating

		(Service Point)			
<u>Factor of Evaluation</u>	<u>Maximum Point</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
A. Financial Stability	20	20	18	15	15
B. Field Service	25	20	21	15	12
C. Labor Relation	10	8	10	10	8

D. Geographical Location	15	10	15	6	0
E. Flexibility in Providing the Item with in short period	5	5	5	3	5
F. Expansion Capacity of the supplier	10	10	8	7	9
G. Warranty Provision	10	8	10	8	0
H. Miscellaneous	5	3	4	0	0
	<u>100</u>	<u>84</u>	<u>91</u>	<u>56</u>	<u>49</u>

Assume that the service rating is 60 points and the maximum value of service package is 20% of price.

Additional information

The total value of shipment (purchase) & the quoted prices are given as follows.

Vendor	Total Value of Purchase	Quoted Price
A	100,000	Br. 85
B	120,000	Br. 86
C	80,000	Br. 82
A	140,000	Br. 83

Given the above data, which supplier is the best based on the cost-Ratio method.

Solution:

1. Compute the Quality Cost Ratio (QCR) as

$$\text{QCR} = \frac{\text{Total Quality Cost}}{\text{Total Value of Shipment}}$$

Supplier		QCR
A	$(1,000/100,000) \times 100$	1%
B	$(3,600/120,000) \times 100$	3%
C	$(3,200/80,000) \times 100$	4%
D	$(2,800/140,000) \times 100$	2%

2. Compute Delivery Cost Ratio (DCR) as

DCR = $\frac{\text{Total Delivery Cost}}{\text{Total Value of Shipment}}$		
Supplier		DCR
A	$(3,000/100,000) \times 100$	3%
B	$(1,200/120,000) \times 100$	1%
C	$(3,200/80,000) \times 100$	4%
D	$(2,800/140,000) \times 100$	2%

3. Calculate the Service Cost - Ratio (SCR)

<u>Supplier</u>	<u>Present rating</u>	<u>SCR (% rating x Value of Service)</u>
A	84	$(84/60)100 = 140-100 = 40\% \times 20 = 8\%$
B	91	$(91/60)100 = 151.6-100=51.6\% \times 20 = 10.3\%$
C	56	$(56/60)100 = 93.3-100 = -6.7\% \times 20 = -1.33\%$
D	49	$(49/60)100 = 81.6-100 = -18.3\% \times 20 = -3.67\%$

N.B. The acceptable service rating is 60 points & the service package is valued at 20% of price. In order to calculate SCR, first determine the percentage by which the rated supplier is above or below the acceptable norm. For example, for supplier A the percentage is 40% which means the supplier A is 40% above the acceptable norm. Then apply this percentage to the total value of the service package to determine the SCR.

A positive sign of SCR indicates advantages. i.e. they will reduce quoted price & a negative sign indicates under performance. i.e. they will increase the quoted price.

Finally combine QCR, DCR SCR with the quoted price to determine the vendors Net Cost.

	1	2	3	4		
Supplier	QCR	DCR	SCR	Total	Quote	Net adjusted price
	%	%	%	Cost	d Price	
				adjusted		
A	1	3	-8	-4	85	$85+(85 \times 0.04) = 81.6$
B	2	1	-10.33	-6.33	86	$86+(86 \times -0.063) = 80.56$

C	3	4	1.33	9.33	82	$82+(82 \times 0.0933)= 89.6$
D	4	2	3.67	7.67	83	$83+(83 \times 0.0761)=89.37$

Conclusion- The best candidate is B , Nest is A , 3rd D and 4th C.

2.8 VALUE ANALYSIS

This is an attempt to see any material or any component can be substituted or eliminated so as to achieve the proper function at a lower cost. Value analysis is concerned with scrutiny of the design function and cost of any product, material or service with the object of reducing cost by modification of design material specification, more efficient process, change in source of supply or possibly the elimination of an item or its incorporation in to a related item without sacrificing reliability and quality.

The two basic conceptual tools in the operation of value analysis are:

1. *Design analysis of the required material* design analysis in tails a methodical step by step study of all phases of the design of a given item in relation to the function it performs. Decomposing on item to its parts so as to see and examine each parts in relation to their function avoids or eliminate redundant or idle ones.

This can be examined by:

- Can any part be eliminated without impairing the operation of the other unit?
 - Can the design of the part be simplified to reduce its basic cost?
 - Can design of the parts be changed to permit the use of simplified and less costly production method?
 - Can less expensive, but equally satisfactory materials be used in the part?
2. *Cost analysis of the required material* cost analysis involves the investigation of the supplier's probable cost of producing a given materials.

To get actual selling price of a supplier.

- Construct estimated elemental cost for labor, material, manufacturing overhead and general overhead.

- Total these cost, to arrive at approximate actual costs of producing for an efficient producer.
- Make-up reasonable profit and arrive at selling price.

Possible procedure in value analysis

1. Select the material that is right for value analysis.
2. Gather information about the material which includes, drawings, costs, scrap rate etc.
3. Define the prime functions; prime function of a material can be defined using two words; verb and noun.

Example: A barrel Contain fuel.
 A drill makes hole.

4. Estimate the present cost of each function.
5. Generate alternatives, using brain storming-insist people to give new ideas.
6. Evaluate alternatives interms of cost, feasibility, undesirable consequence, etc...
7. Present proposals.
8. IF approval is secured implement the plan; translate the approved proposal to engineering change order.

In sum, the purpose of value analysis is to bring together the combined talents of purchasers and its vendors as well as engineers and other operating personnel to review the components of materials used in the making of the product with the view to improve its function and lower its cost.

Check Your Progress Exercises

1. Discuss the 5 R's of purchasing.
.....
.....
2. Identity and explain the steps in the purchasing process.
.....
.....
3. Identity any three factors favoring the making decision of an item or product.

-
-
4. Nazeth Tractor company has extra capacity that can be used to produce gears, that it has been buying for Br. 10 each. If the company makes the gears, it will incur material cost of Br. 3 per unit, labor cost of Br. 4 per unit, and direct overhead cost of Br. 1 per unit. The annual fixed cost associated with the unused capacity is 8,000 Br. and the demand per year is estimated to be 4,000 units.

Required:

- A) Would it be profitable or economical for the company to make the gears?
- B) Suppose the capacity could be used by another department for the production of some sports equipment that will cover its fixed and variable costs and contribute 3,000 Br. to profit. Which would be more advantageous, gear production or sports club production?

2.9 SUMMARY

Purchasing is the procurement of materials, parts, equipments, supplies from external sources. The objective of any purchasing activity is too meet the 5R's of purchasing. It is also possible to generate mutual benefits by maintaining goods relationship between the purchasing unit and other functional units of the business. Making or buy decision, quality description, discounts, time of purchase and supplier selection are some of the most important issues that need to be considered before buying the item from external source.

2.10 ANSWERS TO CHECK YOUR PROGRESS

1. Refer section 2.4
2. Refer section 2.6
3. Refer section 2.7.1
4. a) Yes, because cost of making is less than buying
b) Sport equipment production or buying gears.

UNIT 3: INVENTORY CONTROL (MANAGEMENT)

Content

- 3.0 Aims & Objectives
- 3.1 Introduction
- 3.2 Meaning of Inventory
- 3.3 Types of Inventory
- 3.4 Motivation for Holding Inventories
- 3.5 Objectives of Inventory Management
- 3.6 Interest of the Functional Units in Inventories
- 3.7 Nature of Demand in Inventories
- 3.8 Inventory Analysis
- 3.9 Inventory Control
- 3.10 Inventory Costs
- 3.11 The EOQ Model
- 3.12 Economic Production Quantity (EPQ)
- 3.13 Summary
- 3.14 Answers to Check Your Progress

3.0 AIMS & OBJECTIVES

The major portion of this text is devoted to presenting and analyzing several mathematical models that can assist with controlling the replenishment of inventories for independent demand.

By the time you have finish this unit, you will be able to:

- ✎ define & identify the types of Inventories
- ✎ understand the application ABC analysis and Economic Order Quantity models.

3.1 INTRODUCTION

The fundamental problem of inventory management can be succinctly described by the two questions:

- 1) When should an order be placed?
- 2) How much should be ordered?

In general, the model that we discuss can be used interchangeably to describe either replenishment from an outside vendor or internal production. This means that from the point of view of the model, inventory control and production planning are often synonymous.

3.2 MEANING OF INVENTORY

Inventory is an idle resource (physical stock of goods) possessing economic value which is awaiting (kept) for future use. Here the responsibility of materials management is to maintain sufficient inventories to meet demand for goods and at the same time incurring the lowest inventory handling costs.

3.3 TYPES OF INVENTORIES

When we consider inventories in the context of manufacturing and distribution, there is a natural classification scheme suggested by the value added from manufacturing or processing. Based on this concept there are five types of Inventories. They are;

1. Raw Materials

These are the resources required in the production or processing activity of the firm.

2. Components

Components correspond to items that have not yet reached completion in the production process. Components are some times referred as Sub-assemblies.

3. Work –in-process

Work-in-process (WIP) is inventory either waiting in the system for processing or being processing. Work-in-process inventories include component inventories and may include some raw materials inventories as well. The level of work-in-process inventory is often used as a measure of the efficiency of a production scheduling system.

4. Finished goods

These are also known as end items, these are the final products of the production process. During production, value is added to the inventory at each level of the manufacturing operation, culminating with finished goods.

5. Supplies

These are items that facilitate the production and administrative functions. They are not part of the final item. (eg. Tools, office supplies, lubricants, stationary items etc...).

The appropriate level to place on inventory depends upon the context. For example, components for some operations might be the end products for others.

3.4 MOTIVATION FOR HOLDING INVENTORY

Organizations may hold inventories with the various motives as stated below.

1. Economies of Scale

This means that it could be economical to produce a relatively large number of items in each production run and store them for future use. This allows the firm amortizes fixed set up costs over a large number of units.

2. Uncertainties

Uncertainties often play a major role in motivating a firm to store in inventories. Uncertainty of external demand is the most common.

For example, a retailer stocks different items so that he/she can be responsive to consumer preferences. If a customer requests an item that is not available immediately, it is likely that the customer will go elsewhere. Worse, the customer may never return.

Inventory provides a buffer against the uncertainty of demand.

Other uncertainties provide a motivation for holding inventories as well. One is the uncertainty of the lead-time. Lead-time is defined as the amount of time that elapses from the point that an order is placed until it arrives. In the production-planning context, interpret the lead-time as the time required to produce the item.

A third significant source of uncertainty is the supply. The OPEC oil embargo of the late 1970's is an example of the chaos that can result when supply lines are threatened.

3. Speculation

If the value of an item or natural resource is expected to increase, it may be more economical to purchase large quantities at current price and store the items for future use than to pay the higher price at a future date. For example, silver is required for the production of photographic film. So by correctly anticipating a major price increase in silver, a major producer of photographic film, such as Kodak, could purchase store, large quantities of silver in advance of the increase and realize substantial savings.

4. Transportation

In-transit or pipeline inventories exist because transportation times are positive. When transportation times are long, as is the case when transporting Oil from the Middle East to the United States, the investment in pipeline inventories can be substantial. One of the disadvantages of producing Overseas is the increased transportation time, and hence the increase in pipeline inventories.

5. Smoothing

Change in the demand pattern for a product can be deterministic or random. Seasonality is an example of a deterministic variation. While unanticipated change in

economic conditions can result in random variations. Producing and storing inventory in anticipation of peak demand can help to alleviate the disruptions caused by changing production rates and work force levels.

6. Logistics

We use the term logistics to describe the reasons for holding inventory different from those outlined above. Certain constraints can arise in the purchasing, production, distribution of items that force the system to maintain inventory. One such case is an item that must be purchased in minimum quantities. Another is the logistic of manufacture; it is virtually impossible to reduce all inventories to zero and expect any continuity in a manufacturing process.

3.5 OBJECTIVES OF INVENTORY MANAGEMENT

Though inventory control /management may not be treated as an executive function but it is one of the most important function in an enterprise. The following are the main objective of inventory control.

- Minimize the investment in inventory.
- Minimize warehouse costs.
- Minimize losses from damage, obsolescence and perishability.
- Maintain enough inventories inorder to facilitate efficient and smooth production and sales operation.
- Maintain efficient transportation of inventories.
- Supply information on the volume of inventory to accounting.
- Make forecasts of inventory requirements.
- Establish an inventory system (policies and regulation that monitors inventories).

3.6 INTEREST OF THE FUNCTIONAL UNITS IN INVENTORIES

1. *Production Department*

The interest of the production unit is Overstocking, because under stocking usually leads to shut-down (disruption) of production, which may also result in high manufacturing cost.

2. *Purchasing Department*

This department is interested in buying large quantity to get quantity discount, so as to lower the cost of buying.

3. *Marketing Department*

This unit favors a stock of finished goods in order to provide efficient service to customers and to insure rapid distribution of the products to the final user.

4. *Financial Department*

The financial department favors low inventory level in an attempt to reduce the carrying cost and free-up the tied-up working capital.

Here the problem is the conflict of interest that arise between the different functional units. i.e. the conflict between (1-3) and N^o.4 because the three departments need high level of inventory but the 4th department needs low level of inventory. However, the above problem can be solved by the inventory management by deciding how much, when to buy, when to carry inventory ...etc.

3.7 NATURE OF DEMAND IN INVENTORIES

The demand for inventory may be dependent or independent.

■ **Dependent Demand Items:-** are those items where their demand is related to the demand for another item. This demand is also known as Derived Demand. For example, the demand of subassemblies or component part will depend upon the production schedule of other finished products.

■ **Independent Demand Items:-** are those items that are not influenced by production operation but by the market forces. For stocking decisions of independent demand item forecasting and EOQ model is required.

3.8 INVENTORY ANALYSIS (CLASSIFICATION)

Items that are in the inventory are not of equal importance in terms of the amount invested, profit potential, stock-out penalties...etc. Therefore, all items do not deserve the same degree of attention.

Which implies that selective inventory management approach has to be applied. From this we can conclude that a different control management effort has to be allocated to the various classes of inventoried items according to their relative importance.

Inventories can be classified into various groups on the basis of the selective inventory management approach as follows.

1. ABC Inventory Analysis (Always, Better, Control) Analysis.
2. VED Inventory Analysis (Vital, Essential, Desirable) Analysis.
3. SDE Inventory Analysis (Scarce, Difficulty, Easy) Analysis.
4. HML Inventory Analysis (High, Medium, Low) Analysis.
5. FNSD Inventory Analysis (Fast moving, Normal, Slow Dead) Analysis.
6. XYZ Inventory Analysis (High, Moderate & Low closing inventory items) Analysis.

From the above mentioned classification of inventory, we are going to look at the ABC inventory analysis in detail.

3.8.1 ABC Inventory Analysis

“ABC Analysis is based on Pareto principle i.e. vital few and trivial many” Vilfredo Pareto noted that many situations are dominated by a relative vital few elements. According to him 90% wealth of the nation is in the hands of 10% of the population.

The above principle also applies in inventory management, so a handful (vital few) items determine the success of the business. That is the highest investment is made on vital few items and the lesser investment on trivial many items. Modern inventory control system takes this into account by classifying items into ABC by value of usage. The high value items have lower safety stocks because the cost of production is so high. The low-value items carry much higher safety stocks.

Here there is no clear-cut principle to classify items into ABC for all organizations but the following are the general guidelines.

- 1- A items constitute about 5-10% of the total number of items purchased (in inventory) that would account for about 70–80% of the total dollar value (usage value).
- 2- B items constitute about 10-20% of the total number of items purchased (in inventory) that would account for about 10–15% of the total dollar value.
- 3- C items constitute about 65-80% of the total number of items purchased (in inventory) that would account for about 5 to 10% of the total dollar value.

ABC Analysis Procedure

The following procedure can be used for classifying items in to A, B and C categories.

1. List the items and compute the annual usage value for each of the items by multiplying the annual consumption or usage in to the unit cost.
2. Rank or arrange the items in descending order of annual usage value i.e. from the highest value to the lowest.
3. Determine the cumulative annual usage value and total number of items.
4. Convert the annual usage value and total number of items in to percentage.
5. Observe how your classification fits in to A, B, & C or categorize the items in to ABC on the basis of the given percentage.

Example

XYZ factory adopts the ABC –method for classifying items in inventory. Currently the factory has 14 items. The following is the data related to the items and assuming that you are the inventory control officer, classify the items in to the three classes with ‘A’ taking 70% , ‘B’ –20% and ‘C’ –10% of the total expenditure.

<u>Item No.</u>	<u>Annual Usage (Quantity)</u>	<u>Unit Cost (in Br.)</u>
1	2000	5
2	2500	3
3	1000	9.5
4	5500	20
5	4500	8
6	3000	9
7	400	5
8	150	10
9	5000	3
10	7000	20

11	8500	4
12	1300	2
13	2900	3
14	200	6

Solution:

Step –1 Calculate the annual consumption value.

<u>Item No.</u>	<u>Annual Usage</u>	<u>Unit Cost</u>	<u>Annual Consumption Value</u>	<u>Assign</u>
<u>Rank</u>				
1	2000	5	Birr. 10,000	(7)
2	2500	3	“ 7,500	(10)
3	1000	9.5	“ 9,500	(8)
4	5500	20	“ 110,000	(2)
5	4500	8	“ 36,000	(3)
6	3000	9	“ 27,000	(5)
7	400	5	“ 2,000	(13)
8	150	10	“ 1,500	(14)
9	5000	3	“ 15,000	(6)
10	7000	20	“ 140,000	(1)
11	8500	4	“ 34,000	(4)
12	1300	2	“ 2,600	
(12)				
13	2900	3	“ 8,700	(9)

(11)

Step – 2 Put the items in rank & Determine the Cumulative value & No. of items

Rank	Item No.	Annual Usage	Birr Usage	Cummulative % of items	Cummulative % of Birr Usage	Class
1	10	140,000	140,000	7	34	A
2	4	110,000	250,000	14	60.8	
3	5	36,000	286,000	21	69.6	
4	11	34,000	320,000	29	77.8	B
5	6	27,000	347,000	36	84.5	
6	9	15,000	362,000	43	88	
7	1	10,000	372,000	50	90.5	
8	3	9,500	381,500	57	92.7	C
9	13	8 700	390,200	64	95	
10	2	7,500	397,700	71	96.7	
11	14	7,200	404,900	79	98.5	
12	12	2,600	407,500	86	99	
13	7	2,000	409,500	93	99.6	
14	8	1,500	411,000	100	100	

Implementing ABC analysis

Factor	Item A	Item B	Item C
1-Degree of Control	High	Moderate	Low
2-Ordring procedure	High	Moderate	Low
3-Priority Treatment	High	Moderate	Low
4-Safety Stock	Low	Moderate	High
5- Price Discount	Low	Moderate	High

6-Physical Stock Taking	High	Moderate	Low
7-Value analysis	Heavy emphasis	Moderate	Less emphasis
8-Nature of purchasing	Centralized	Combined	Decentralized

3.8.2 VED (Vita, Essential, Desirable) Analysis

The analysis is based on the criticality of inventory.

- V-item- are items when go out of stock or when not readily available, completely bring the production to a halt. So they should be stored adequately to insure continuous production.
- E-item- are items with out which temporary losses of production or dislocation of production work occurs.
- D-item- are all other items which are necessary but do not cause any immediate effect on production.

VED analysis specially pertains to the classification of maintenance spare denoting the essentiality of stocking spares.

3.8.3 SDE (Scarce, Difficult, Easily) Analysis

This analysis is based on availability of items (raw materials).

- S-item - are items which are in small supply and are usually imported items.
- D-item - Stands for difficult items which are available in the market but not easily available. For example, items which have to come from far off cities.
- E-item - are easily available items; mostly local items.

3.8.4 HML (High, Medium, Low) Analysis

The cost per item (per price) is considered for this analysis, High cost item (H), Medium cost items (M) and Low cost items (L) help in bringing control over consumption at the department level.

3.8.5 FNSD (Fast, Normal, Slow Dead) Analysis

Here the quantity and rate of consumption is analyzed to be classified as fast moving, normal, slow and dead items. This classification helps in arranging stocks in the stores according to the frequency that the items are used or consumed.

3.8.6 XYZ Analysis

The analysis is based on the value of closing inventory

X-items	Items with high closing inventory
Y-items	Items with moderate closing inventory
Z-items	Items with low closing inventory

**** Which of these selective inventories control is the best one?**

There is no one best way of doing things; but the best analysis depends on the following factors –situation, need of the organization and nature of the items.

3.9 INVENTORY CONTROL

Inventory control may be defined as the planning, ordering and scheduling of materials used in the manufacturing process.

Buying the right quantity is one of the most important as well as the most complicated task of purchasing. A company's ability determines the right quantity and is influenced by basic managerial planning, organizing, coordination, and control. An effective inventory control system must be integrated with other company wide planning & control activities such as cash flow planning, capital budgeting, sales forecasting & production planning scheduling and control.

Type of Inventory control system

There are two basic systems controlling inventories;

1. Cyclical Ordering system and
- 2 . Fixed ordering system

1. Cyclical Ordering system

It is a time-based system which involves scheduled periodic reviews of the stock level of all inventory items. When the stock level of a given time is not sufficient to sustain the

production operation until the next scheduled review, an order is placed replenishing the supply. The frequency of reviews varies from company to company. Stock level can be monitored by physical inspection; by visual review of the perpetual inventory cards, or by automatic computer surveillance. In operations where a small quantity of material is involved, the simplest method is a periodic physical count of stock. In practice, the cyclical ordering system is well suited for materials whose purchases must be planned months in advance because of established and infrequent production schedules maintained by suppliers.

2. Fixed Order Quantity system

It is based on the order quantity factor rather than on the time factor. The design of this system recognizes that each item possesses its own unique optimum order quantity. The major advantage claimed by the systems are that (i.) each material can be procured in most economical quantity. (ii.) purchasing of items/materials is when required. (iii.) positive control can easily be exerted to maintain total inventory investment at the desired level simply by maintaining the planned maximum and minimum values. The system functions correctly only if each of the material exhibits reasonable usage and lead time. In fact, irrespective of the systems inventory policy for different group of items 'A', 'B', and 'C' there are two basic problems; what quantity of an item should be ordered each time; and when should an order be placed.

3.10 INVENTORY COSTS

Because we are interested in optimizing the inventory system, we must determine an appropriate optimization or performance criterion. Virtually all inventory models used cost minimization as the optimization criterion. An alternative performance criterion might be profit maximization. However, cost minimizations and profit maximizations are essentially equivalent criteria for most inventory control problems. Although different systems have different characteristics, virtually all inventory costs can be placed in to one of the three categories; holding cost, order cost, or penalty cost. Each will be discussed as follows:

1. Holding Costs

The holding cost, also known as the carrying cost or the inventory cost, is the sum of all costs that are proportional to the amount of inventory physically on hand at any point in time. The components of the holding cost include a variety of seemingly unrelated items. Some of these are:

- i. Cost of providing the physical space to store the items
- ii. Taxes and insurances
- iii. Breakage, spoilage, deterioration, and obsolescence
- iv. Opportunity cost of alternative investments
- v. The salaries and wages of storing, receiving and issue of material personnel.
- vi. Stationary and other consumables use by the stores.

The fourth item turns out to be the most significant in computing holding costs for most applications. Inventory and cash are in some sense equivalent capital must be invested to either purchase or produce inventory, and decreasing inventory levels results increased capital. This capital could be invested by the company either internally, in its own operation, or externally.

What is the interest rate that could be earned on this capital? You and I can place our money in a saving account with an interest rate of 3%, or possibly invest in a high-yield bond with a return of more than 3% per annum.

In general ,however, most companies must earn higher rates of return on their investment than do individuals in order to remain profitable. The value of the interest rate that corresponds to the opportunity cost of alternative investment is related to (but not the same as) a number of standard accounting measures, including the internal rate of return, the return on assets, and the hurdle rate (the minimum rate that would make an investment attractive to the firm). The value of the interest rate for the opportunity cost is usually estimated by the firms accounting department and it is an amalgam of the accounting measures listed above. For example, we will use the term cost of capital to refer to this component of the holding cost. Therefore, we may think of the holding cost, as an aggregated interest rate comprised of the four components listed above.

For example;

20% = cost of capital

2% = Taxes & Insurance

6% = Cost of Storage

2% = Breakage & Spoilage

30% = Total interest charge

This would be interpreted as follows: We would assess a charge of 30 cents for every birr that we have invested in inventory during a one-year period. However, as we generally measure inventory in unit rather than in birrs, it is convenient to express the holding cost in terms of birr per unit per year rather than birr per birr per year.

2. Order Costs

The holding cost includes all of those costs that are proportional to the amount of inventory on hand, whereas, the order cost depends on the amount of inventory that is ordered or produced. Placement of purchase order for a material is associated with certain obvious cost due to advertising, consumption of stationary and postage, telephone charges etc... In fact all the annual expenditure of the purchasing department of a company can be considered to be on the purchase order it places during the year.

The cost associated with ordering would, therefore, consist of;

- o Salaries of the staffs in the purchasing department.
- o Negotiating purchases, placing orders and follow up.
- o Rent for the space used by the purchasing department.
- o The postage, telegram, telephone bills.
- o The stationary and other consumables used by the purchasing department.
- o Entertainment charges for vendors.
- o Traveling expense.
- o Lawyers and court fees due to any legal matters arising out of purchase.
- o Inspecting shipment & moving goods to storage.

When more order placed in a period, the more would be the stationary and postage consumed, more staff and officers will be required for handling the work, the more will be the space required for accommodating them and soon. Thus the total expenditure on purchasing or

ordering would depend on the number of orders placed. It is assumed that the expenditure on ordering of material is directly proportional to the number of orders placed. The ordering cost is expressed as cost/order.

3. Penalty Costs

The penalty cost, also known as the shortage cost or the stock-out cost, is the cost of not having sufficient stock on hand to satisfy demand when it occurs. This cost has a different interpretation depending on whether excess demand is back-ordered (orders that cannot be filled immediately are held on the books until the next shipment arrives) or lost (known as lost sales). In the book-order case, the penalty cost includes whatever bookkeeping and /or delay costs might be involved. In the lost-sales case, it includes the lost profit that would have been made from sales. In either case, it would also include the “lost good-will” cost, which is a measure of customer satisfaction. Estimating the loss of goodwill component of the penalty cost can be very difficult in practice.

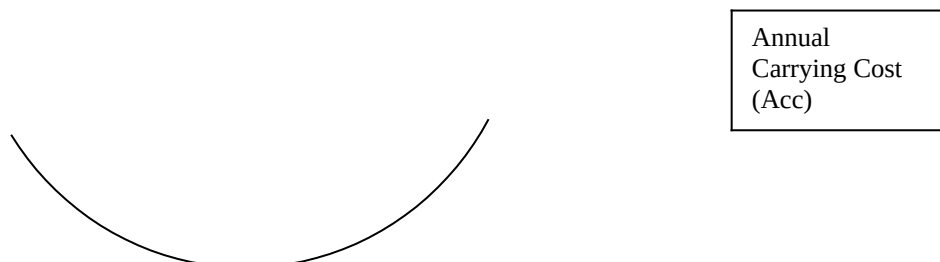
3.11 THE EOQ MODEL

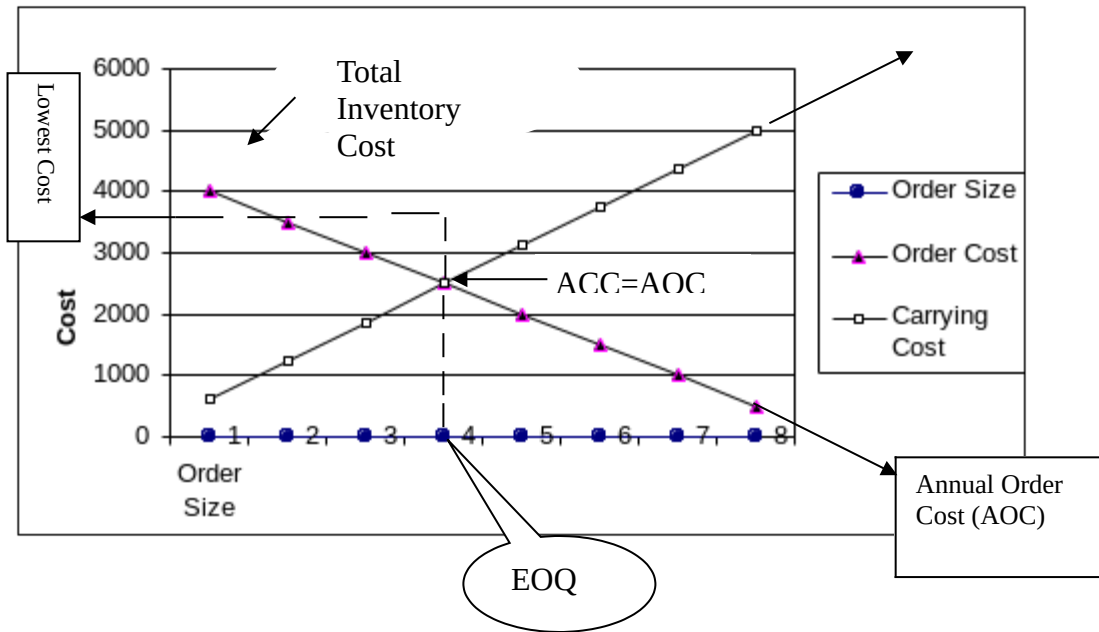
The EOQ (Economic Order Quantity) model is one method of determining the adequate (optimum) inventory level for independent demand materials.

This model is one of the mathematical model and it results in an inventory level which is not too large or too small. i.e. It is the economical level of inventory.

Here very large order size may result in few number of orders there by low ordering cost. However, the annual carrying cost may be high for large size of inventory. On the other hand, small order size involves many orders which decreases the annual carrying cost and increases the annual ordering cost of the item.

Therefore, the annual total inventory/increment at cost will be large due to both inadequate and more than adequate inventory level. At the point of EOQ, the total inventory cost will be kept at minimum level. (see the graph below based on assumptions data).





Note that the AOC line is not a straight line rather it is a curve.

Basic Assumptions of EOQ:

1. Annual demand is known - through forecast or actual order placed.
2. Items will be withdrawn from inventory at a uniform rate. i.e. usage is spread evenly through out the year.
3. Lead Time does not vary.
4. Each order is received in a single delivery. i.e. orders are received the movement inventory is deleted. We receive inventory immediately when our inventory level is reduced to zero.
 - 4.1 There is no stock – out situation
 - 4.2 There is no safety stock.

3.11.1 Economic Order Quantity Determination

EOQ is an order size that balances the annual carrying cost & annual ordering cost. At EOQ the annual carrying cost is equivalent to the annual ordering cost.

Now in order to calculate the annual carrying cost (ACC) let us look at the concept of average inventory. The concept of average inventory is based on the following assumption;

- o Purchase is made at the beginning.
- o Usage rate is constant and
- o The last item is used on the last date

Then the average inventory will be $Q/2$ where Q is the order quantity in units.

Consider the following illustration which considers the purchase of a product at the beginning of January & usage is constant at 833 units per month so average inventory will be 5000.

<u>Month</u>	<u>Stock</u>	
January 1	10,000	$\Rightarrow 10,000/2 = 5000$
February 1	9,167	
March 1	8,333	
April 1	7,500	
May 1	6,661	
June 1	5,833	
July 1	5,000	
August 1	4,167	
September 1	3,333	
October 1	2,500	
November 1	1,667	
December 1	833	
December 31	<u>- 0 -</u>	
	65,000 / 13	= 5,000 units.

□ On the average there will be 5,000 units in the inventory. Here the movement $Q = 0$, then we assume the replenishment order arrives

∴ The $ACC = Q/2 \times CC \quad \Rightarrow \quad \text{Where } CC = \text{unit carrying cost per year}$
 $Q = \text{Order quantity in unit}$

$\Rightarrow$ The annual ordering cost (AOC) is also calculated as follows;

$AOC = D/Q \times OC \quad \Rightarrow \quad \text{Where } D = \text{Annual Demand}$
 $OC = \text{Ordering Cost per order}$

Annual ordering cost is simply the product of number of orders & the ordering cost per order.

At EOQ $\Rightarrow$

ACC	$=$	AOC
$\downarrow$		$\downarrow$
$Q/2 \times CC$	$=$	$D/Q \times OC$

If we multiply both sides by Q, the result will be

$$\begin{aligned}\Rightarrow \frac{Q^2}{2} \times CC &= D \times OC \\ \Rightarrow \frac{Q^2}{2} &= \frac{D \times OC}{CC} \\ \Rightarrow Q^2 &= \frac{2 \times D \times OC}{CC} \\ \Rightarrow Q &= \sqrt{\frac{2 \times D \times OC}{CC}}\end{aligned}$$

Where $\Rightarrow$ Q = economic order quantity

D = Annual demand

OC = Ordering Cost/order

CC = Carrying Cost per unit per year.

The above analysis can be summarized as follow.

- Minimum Inventory Cost = ACC + AOC
- Minimum total Annual Cost = ACC + AOC + Purchase cost

Example

A local distributor for Addis tire company expects to approximately 9,600 steel belted tires of certain size next year. The annual carrying cost is 16.00 Birr per tier per year and the ordering cost are 75.00 Birr per order. The distributor operates 288 days a year.

Required:

1. Determine EOQ.
2. What is the Ordering Cost per year and annual carrying cost at EOQ?
3. What is the total incremental or total inventory cost at EOQ
4. If purchase price per tire is 80.00 Birr. What is the total cost at EOQ?
5. How many times per year does the store reorders.
6. Determine the length of an order cycle.

7. Compute Ordering, Carrying, Total Inventory costs & overall total costs. If order quantities are 100, 150, 200, 250, 300, 350 and 400 units. What do you infer from this exercise?

Solution:

Given: D = 9,600
 CC = 16.00 Birr
 OC = 75.00 Birr
 Working days per year 288

$$\begin{aligned}
 1. \quad Q_0 &= \sqrt{\frac{2 \times D \times OC}{CC}} \quad \text{Where } Q_0 \text{ is optimum Quantity.} \\
 &= \sqrt{\frac{2 \times 9600 \times 75}{16}} \\
 &= \underline{300} \text{ tires per order.}
 \end{aligned}$$

$$\begin{aligned}
 2. \quad ACC &= Q/2 \times CC & AOC &= D/2 \times OC \\
 &= 300/2 \times 16 & &= 9,600/300 \times 75 \\
 &= \underline{2,400} \text{ Birr} & &= \underline{2,400} \text{ Birr}
 \end{aligned}$$

$$\begin{aligned}
 3. \quad \text{Minimum Inventory Cost} &= 2,400 + 2,400 \\
 &= \underline{4,800} \text{ Birr}
 \end{aligned}$$

$$\begin{aligned}
 4. \quad \text{Total Cost} &= AOC + ACC + Pc \quad Pc = \text{is purchase cost} \\
 &= 2,400 + 2,400 + 80(9600) \\
 &= \underline{772,800} \text{ Birr}
 \end{aligned}$$

$$\begin{aligned}
 5. \quad \text{Number of Order per year} &= \frac{\text{Annual Demand}}{\text{Order Size}} \\
 &= \frac{9,600}{300} \\
 &= \underline{32} \text{ Order}
 \end{aligned}$$

$$6. \quad \text{Length of Order Cycle} = \text{Annual Working Days} \times \frac{Q_0}{D}$$

Or

$$= \frac{\text{Annual Working Days}}{\text{No. of orders per year}}$$

$$= \frac{288}{32} = 9 \text{ Working Days}$$

7. It means the optimum quantity will be used within working days

Order Quantity	ACC = (Q/2 x CC)	AOC = (D/Q x OC)	Annual Total Inventory Cost	Overall Total Cost
100	800	7200	8000	Birr 776,000
150	1200	4800	6000	774,000
200	1600	3600	5200	773,200
250	2000	2880	4880	772,880
300	2400	2400	4800	772,800
350	2800	2057	4857	772,857
400	3200	1800	5000	773,000
450	3600	1600	5200	773,200

From this we can infer that that at EOQ, total inventory or overall total cost will be minimum. When the order size is large, the ACC will be high & for small order sizes the AOC will be high.

3.11.2 EOQ with Quantity Discounts & Price Breaks

The optimum quantity when there is quantity discount is the one that makes the savings from the purchase cost equal to the total inventory cost. EOQ model is not the best method to determine the optimum level when there is quantity discount.

Example:

A factory required 1,500 units of an item per month, each costing 27.00 Birr. The cost per order is 150.00 Birr & inventory carrying charge is 20% of price.

Required:

1. Find the EOQ & the total material cost.
2. Would you accept a 2% discount on a minimum supply of quantity of 1,200 units?

Solution:

Given - Monthly demand = 1,500 unit so the annual demand will be $1,500 \times 12 = 18000$

Price = 27.00 Birr

CC = 0.2(P) $\Rightarrow$ 0.2(27) = 5.4 Birr /year /unit

OC = 150/Order

$$1. \quad \text{EOQ} = \sqrt{\frac{2 \times 1,800 \times 150}{5.4}} = \underline{1000} \text{ units}$$

The total cost without discount is

$$\begin{aligned} \text{TOC} &= D/Q \times \text{OC} \\ &= 18000/1000 \times 150 = \underline{2,700} \text{ Birr} \end{aligned}$$

$$\begin{aligned} \text{TCC} &= Q/2 \times \text{CC} \\ &= 18000/2 \times 5.4 = \underline{2,700} \text{ Birr} \end{aligned}$$

$$\text{Total Purchasing Cost} = \leftarrow 27 \times 18000 = \leftarrow \underline{486,000} \text{ Birr}$$

$$\begin{aligned} \text{Total Material Cost} &= 2491,400 \\ &= \underline{491,400} \text{ birr} \end{aligned}$$

2. The minimum supply is 1,200 units.

The unit cost will be decreased by 2% . i.e.

$$= 27 - (0.02(27)) = \underline{26.46} \text{ Birr}$$

The total material cost with quantity discount f 2% can be obtained as follows

(N.B. – Q is 1,200 unit)

$$\text{TOC} = 18000/1200 \times 150 = \underline{2,250} \text{ Birr}$$

$$\text{TCC} = 1,200/2 \times (26.46 \times 0.2) = \underline{3,175.20} \text{ Birr}$$

(CC is 20% of Price)

$$\text{TPC} = 18000 \times 26.46 = \underline{476,280} \text{ Birr}$$

∴ Total material cost is 481,705.20 Birr with a discount of 2% for an order size of 1,200 units.

Illustration on Price Breaks

Determine the order quantity that will minimize total annual inventory cost for the price schedule below. Annual demand is 1200 units, ordering cost is 41 br., and holding cost is birr 2 per unit per year.

<u>Quantity in Unit</u>	<u>Unit price (birr)</u>
1 to 199	27
200 to 299	26
300 to 399	25
400 or more	24

Solution:

The first step is to calculate EOQ, then to identify the price break that it falls.

$$EOQ = \sqrt{\frac{2 \times D \times OC}{CC}}$$

$$EOQ = \sqrt{\frac{2 \times 1,200 \times 41}{2}} = \underline{\underline{222}} \text{ units}$$

The EOQ is in the range of 200 to 299 which is not optimal because of the price breaks.

The second step is to calculate the total cost at EOQ and the price breaks of 300 to 399 and 400 or more. The calculation is as follow:

$$\begin{aligned} TC &= AIC + AOC + \text{Purchase Cost} \\ TC_{222} &= 222/2 \times (\text{br.}2) + 1200/222(\text{br.}41) + 1200(\text{br.}26) = \text{Birr } \underline{\underline{31,644}} \\ TC_{300} &= 300/2 \times (\text{br.}2) + 1200/300(\text{br.}41) + 1200(\text{br.}25) = \text{Birr } \underline{\underline{30,464}} \\ TC_{400} &= 400/2 \times (\text{br.}2) + 1200/400(\text{br.}41) + 1200(\text{br.}24) = \text{Birr } \underline{\underline{29,323}} \end{aligned}$$

Therefore, the fourth range's value is optimal because it has the lowest total cost.

Optimum Cost Determination when the carrying cost is given as a percentage of purchase prices.

The procedures are:

1. Compute the EOQ for each price break beginning with the highest price until a valid EOQ is found.
2. If it is not on the lowest cost curve then that quantity is not optimal.
3. If it is a higher cost curve compare its total cost and the total cost of all lower price breaks. The one with the lowest total cost is the optimal for the quantity.

Illustration:

A Computer department expects to use 4,500 reams of papers during the coming 12 months. Annual carrying costs per unit is 30% of unit price. Ordering cost is Br. 24.00. The price list below applies, what order quantity will minimize total inventory cost for the year.

<u>Quantity</u>	<u>Unit Price</u>
1 to 150	Birr 8.30
151 to 499	Birr 8.00
500 or more	Birr 7.50

Solution:

Let us now calculate the EOQ at different price breaks.

$$EOQ_{p=8.30} = \sqrt{\frac{2 \times 4,500 \times 24}{8.30(0.3)}} = \underline{294.50} \text{ units}$$

This is not feasible because this order size (294.50 units) is not in the range specified for the price 8.30 Birr.

$$EOQ_{p=8.00} = \sqrt{\frac{2 \times 4,500 \times 24}{8.30(0.3)}} = \underline{300} \text{ units}$$

This order size is valid (feasible), but it is not optimal since it is not on the lowest cost curve. Here this order size should be compared with the lower limit of the next class on the basis of their total cost,

$$\begin{aligned}
 TC &= ACC + AOC + PC \\
 TC_{300} &= \frac{300}{2} (\text{Br.} 8.00 (0.3)) + \frac{4500}{300} (\text{Br.} 24) + 4500 (\text{Br.} 8.00) = \text{Birr } \underline{\underline{36,720}} \\
 TC_{500} &= \frac{500}{2} (\text{Br.} 7.50 (0.3)) + \frac{4500}{500} (\text{Br.} 24) + 4500 (\text{Br.} 7.50) = \text{Birr } \underline{\underline{34,529}}
 \end{aligned}$$

Therefore, ordering 500 units is optimal.

3.11.3 EOQ with Gradual supply of orders from external supplier

This one is the case where the supply of orders is not instantaneous. i.e. there is no immediate supply of items from the suppliers'. In order to grasp the idea of gradual supply let's look at the concepts of lead-time and safety stock.

A. Lead Time

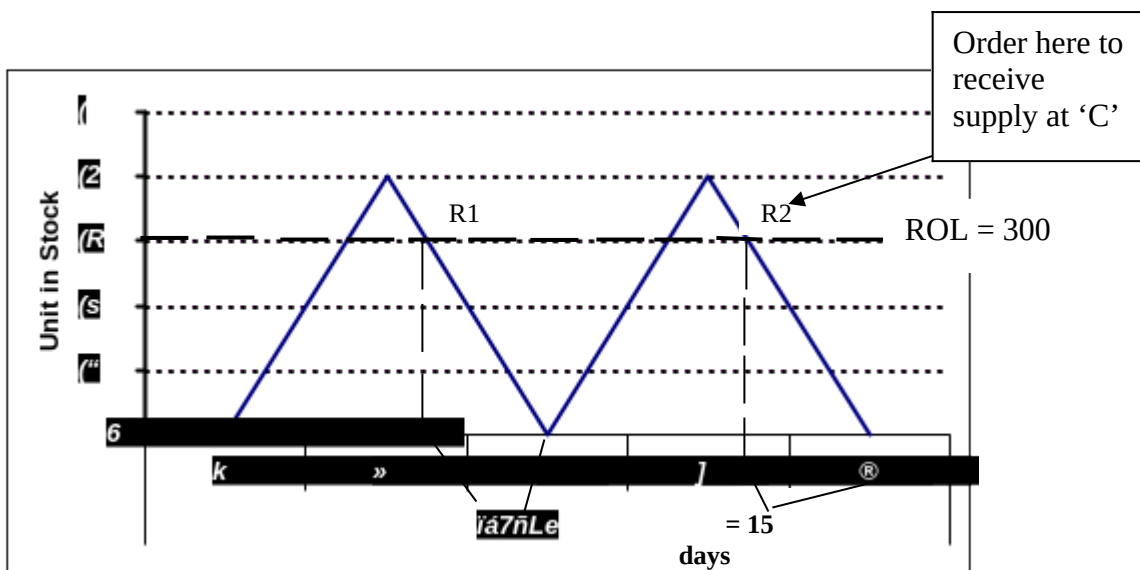
In the previous part of the EOQ model, the supplies of materials were assumed to be immediate in order but in practice this is not so. From the time the requisition for an item is raised, it may take several weeks or months before the supplies are received, inspected and taken in to the stock. This time is called Lead-Time and involves the time for the completion of all or some of the following activities.

- a. Raising purchase requisition.
- b. Inquires, quotations and approval, (import license procedure for imported items).
- c. Placement of an order on supplier(s).
- d. Suppliers time to make the goods ready.
- e. Transportation or clearing.
- f. Receipt of goods at the company.

- g. Inspection of received items.
- h. Taking the items in to the store.

Obviously, in order to receive supplies before the stock reaches zero level, it is necessary to order the materials much in advance. i.e. when the stock available is sufficient to last during the lead time. This is shown graphically in figure (3.1) given below.

Suppose an item has lead time of 15 days and the monthly consumption (assuming 30 days per month) of the item is 600 units, then the reorder must be placed when the stock available is sufficient to last 15 days is 300 units.



NC= MB= 15 days is lead time Re-order level (ROL).

ROL = Stock sufficient to last during the lead time is 300 units.

Here the Re-order point is lead- time multiplied by daily demand.

B. Safety Stock (Buffer or Reserve)

It is well known that neither the consumption rate of a material is constant through the year nor the lead-time. Hence in the earlier example though reorder is place at a stock level of 300 units. The consumption rate may rise subsequently and the stocks may well be exhausted in 7 days instead of 15 days or it may be that the supplier fails to supply after 15 days as expected. In either case a stock out would be experienced resulting into hampering of production to

guard mainly against these uncertainties in consumption rate and lead time, an extra stock is maintained all along this is called as buffer stock or safety stock.

This stock also come in use when:

- 1) Any excess in process rejections.
- 2) Rejections at the time of receipt of goods due to damages or subsequent quality.

Since safety stock is part of inventory, it should be maintained just sufficient to guard against the uncertainties and not –too –excessive (especially for ‘A’ items).

In order to decide on the level of the safety stock, we should analyze the following aspects:

1. Is the variation in consumption more predominant in lead-time?
2. If the variation in consumption more predominant, can it be forecasted in Advance?
3. If the variation in lead-time is more predominant, is it restricted to a particular period (say a season) or spread allover the year?

In most cases it is found that the variations in consumptions can be predicted fairly in advance accurately by good production and maintenance planning and does not present much a problem. However, the lead-time variation is more erratic and unpredictable.

Determining Safety Stock

One simple method of determining safety stock in such cases is to approximately estimate the maximum lead-time and the normal lead time for an item in consultation with the purchasing personnel and from the past records. The safety stock then be sufficient to last the periodic difference between maximum and minimum lead-time period.

Suppose for an item monthly consumption is 100 units, the normal lead-time is 15 days and maximum lead-time is estimated as one month. The safety stock will be;

(Maximum lead-time in a month – Normal lead-time in a month) x Monthly consumption

= (1-1/2) x 100

= 50 or say 50 to be on safe side.

It should be well understood that safety stock is meant only to provide for above normal lead-time and above normal consumption rate. The normal lead-time and consumption rate is already taken care of in setting Re-Order Level (ROL). If normal lead-time consumption is 300 units and safety stock is 100 units, the reorder level is set at 400 units.

3.12 ECONOMIC PRODUCTION QUANTITY (EPQ)

We have seen the application of the EOQ model in determining the optimum order quantity of items purchased/ordered from external suppliers. But when the company is the producer and user of its items, the run size is the economic production quantity (EPQ). In other words the company is the supplier for itself.

In the determination of the EPQ the carrying cost remains the same but the ordering cost is replaced by set-up-cost which is the cost of preparing production for operations.

Let us now derive the formula of EPQ;

Let d = Daily demand rate for the products.
 P = Daily production rate for the product
 T = Number of days for a production run (Inorder to produce the Specified quantity).

When $p > d$;

- Daily rate of inventory build-up = $p-d$
- Level of inventory by the end of t-day = $(p-d) \times t \Rightarrow$ Maximum inventory.

Run size $\Rightarrow Q = pt$

Run time = $\frac{Q}{p}$ $\Rightarrow$ Stated as days.

The maximum inventory is given above as $= (p-d) \times t$

Since t is $= \frac{Q}{p}$ it can also be stated as $= (p-d) \times Q/p$

$$= (1 - d/p) \times Q$$

$$\text{And the average inventory will be} = \frac{\text{Maximum inventory}}{2}$$

$$= Q/2 (1 - d/p)$$

$$\text{Consequently, the annual carrying cost is} = Q/2 (1 - d/p) \times CC$$

The annual set-up cost (ASC) can be obtained as follows:

$$\text{ASC} = (\text{No. of production run /year}) \times (\text{set -up cost /year})$$

$$= \left(\frac{D}{Q_0} \right) \times Sc$$

Where :

$$Q_0 = \text{run Size} \Rightarrow \text{EPQ}$$

$$Sc = \text{Set-up cost/year.}$$

$$\therefore \text{The Total Annual} = \frac{Q}{2} \left(1 - \frac{d}{p} \right) \times CC + \left(\frac{D}{Q_0} \right) \times Sc$$

The Optimum production size will also be determined as follows;

$$\text{EPQ} \Rightarrow Q_0 = \sqrt{\frac{2 \times D \times Sc}{(1 - d/p) \times CC}}$$

$$\text{Where } D = \text{Annual demand}$$

$$Sc = \text{Set-up cost /run}$$

$$CC = \text{Annual carrying cost/unit}$$

$$d/p = \text{Part of production that is not inventoried}$$

$$1 - d/p = \text{Part of production that is carried in inventory}$$

Example 1

A merchandising business enterprise has a forecasted demand of 10,000 units per year. Holding costs are Br. 0.4 per unit per year. Acquisition cost is Br. 5.5/order. Daily demand is 40 units. The enterprise agreed with a supplier for a gradual delivery of 120 units/day.

Based on the above information;

A) Determine the optimum order quantity and annual inventory costs.

B) What will be the effect of using this policy?

Solution:

$$\begin{aligned}
 \text{A) The optimum quantity} = Q_0 &= \sqrt{\frac{2 \times D \times Sc}{(1 - d/p) \times cc}} \\
 &= \sqrt{\frac{2 \times 10,000 \times 5.5}{(1 - 40/120) \times 0.4}} \\
 &= \underline{642} \text{ units}
 \end{aligned}$$

- The total number of orders will be approximately $16 = D/Q = 10000/642 \cong 16$
- The number of deliveries are $= 642/120 = 5.35$ deliveries.
- Number of days of one delivery $= 120/40 = 3$ days

$$\begin{aligned}
 \text{Finally the total inventory cost is} &= ACC + AOC \\
 &= 642/2(1-40/120) \times 0.40 + (10000/642) \times 5.5 \\
 &= \underline{171.20} \text{ Birr}
 \end{aligned}$$

B.) In order to learn the effect of the policy lets consider the EOQ with instancous Supply (receipt) of orders.

Optimum quantity

$$\begin{aligned}
 Q_0 &= \sqrt{\frac{2 \times D \times OC}{CC}} \\
 &= \sqrt{\frac{2 \times 10,000 \times 5.5}{0.40}} = \underline{524.40} \text{ units}
 \end{aligned}$$

$$\text{Total Inventory Cost} = (524/2) \times 0.40 + (10,000/524) \times 5.5 = \underline{209.60} \text{ Birr}$$

Decision:

Since the total cost in non-instancous supply (under A) is less than the instancous receipt (under B), the enterprise should use the gradual delivery system.

Example 2

A toy manufacturer uses 48,000 rubber wheels per year for its popular dump- truck series. The firm makes its own wheel, which it can produce at a rate of 800 per day. The toy trucks are assembled uniformly over the entire year. Carrying cost is Br 1.00 per wheel a year. Set

up cost for a production and change over from the previous production is Br. 45.00. The firm operates 240 days per year. Determine each of the following.

- A) The optimum Size (EPQ)
- B) The minimum total inventory cost.
- C) The cycle time for the optimal size.
- D) The run time.
- E) The number of production runs in a year.
- F) Maximum level of inventory.
- G) Depict the above situations graphically.

Solution:

Given: D = 48,000
 P = 800/day
 CC = Br. 1/unit /year
 Sc = Br. 45/production
 Run

Working Days = 240 days

Daily demand = $\frac{48000}{240} = 200/\text{day}$

A) The optimum Size

$$= \text{EOQ} = \sqrt{\frac{2 \times D \times Sc}{(1 - d/p) \times CC}}$$

$$= \sqrt{\frac{2 \times 48,000 \times 45}{(1 - 200/800) \times 1}} = \underline{\underline{2400}} \text{ Wheels}$$

Here one run will last for 3 days = $\frac{2400}{800}$ and form this quantity level 600

wheels will be consumed (3 x 200) and the remaining 1,800 units will be kept in the store.

B) The minimum Total inventory cost is = ASC + ACC

$$\therefore \text{ The Total Annual } = \left(\frac{D}{Q_0} \right) \times Sc \frac{Q}{2} \left(1 - \frac{d}{p} \right) \times CC$$

$$\begin{aligned}
&= \left(\frac{48,000}{2,400} \right) \times 45 + \frac{2,400}{2} \left(1 - \frac{200}{800} \right) \times 1 \\
&= 900 + 900 \\
&= \text{Birr } \underline{1,800}
\end{aligned}$$

C) The cycle time for the optimal run size:

$$\frac{\text{Optimum Quantity}}{\text{Daily Demand}} = \frac{2,400}{200} = 12 \text{ Working days}$$

The optimal run size covers 12 working days.

i.e. 3 days for production & usage time & 9 days will be idle time.

D) The Run time:

$$t = \frac{Q_0}{p} = \frac{2,400}{800} = 3 \text{ days}$$

E) The number of production runs in a year:

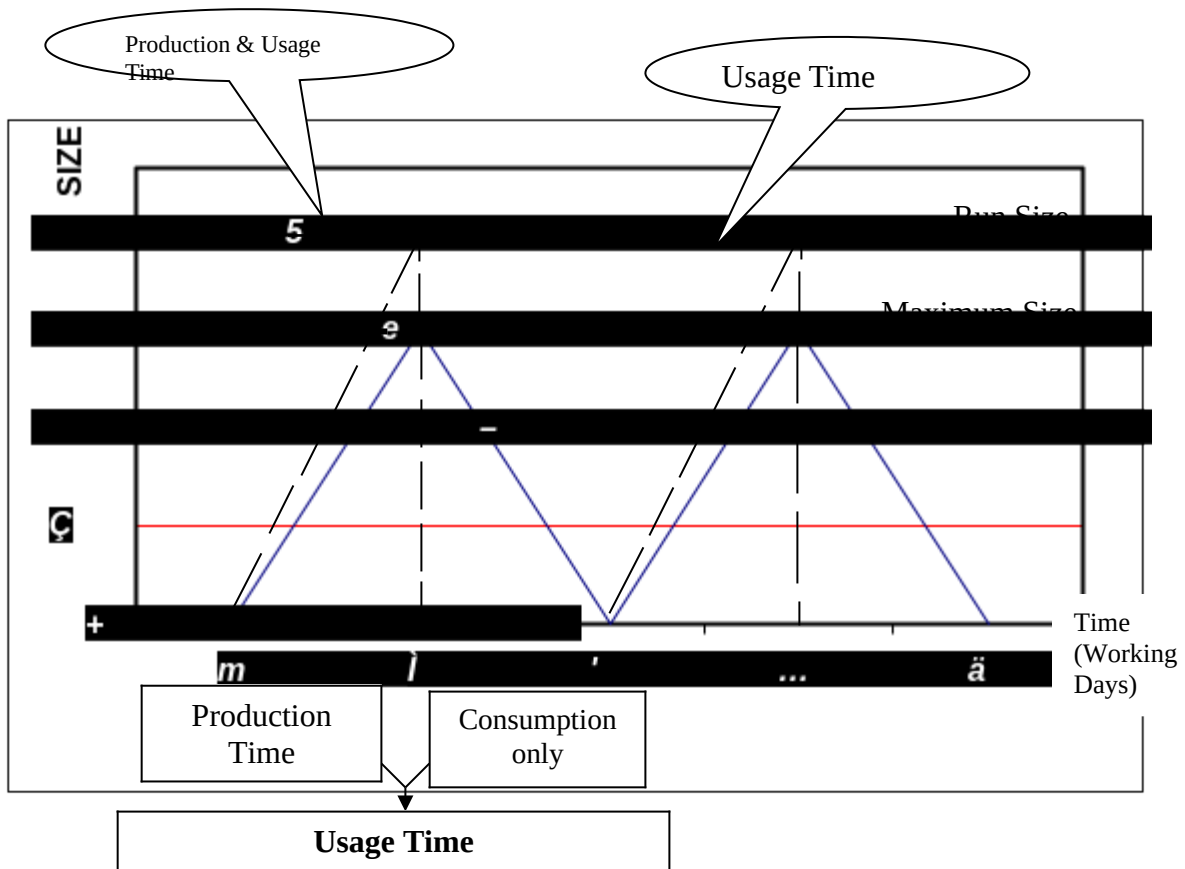
$$= \frac{\text{Annual demand}}{\text{Optimal Quantity}} = \frac{4,800}{2,400} = 20 \text{ runs.}$$

The 20 runs cover 60 production days. i.e. $20 \times 3 = 60$ days and in this period there is production and consumption simultaneously. The remaining 180 days are idle time between runs & during these periods there is only consumption.

F) Maximum inventory level:

$$\begin{aligned}
&= Q_0 \times (1 - d/p) \\
&= 2,400(1 - 200/800) = \underline{1800}
\end{aligned}$$

G) Graphically representation of EPQ with non- instancous replenishment.



Check Your Progress Question

1. What are the motivation for holding inventory?

.....

.....

2. What is/are the basis for the classification of items to ABC?

-
-
3. Perform on ABC Analysis for the following inventory items based on their annual usage or dollar value if A, B & C account for 70%, 25% and 5% of the total annual value/expenditure respectively. Support your analysis with a diagram.

<u>Item</u>	<u>Annual Quantity Usage</u>	<u>Unit Price</u>
E-10	40,000	0.07
E-20	195,000	0.11
E-30	4,000	0.10
E-45	100,000	0.05
E-50	2,000	0.14
E-60	240,000	0.07
E-70	16,000	0.08
E-80	80,000	0.06
E-90	10,000	0.07
E-100	5,000	0.09

4. Identify the different components of the three inventory cost
-
-
5. Philips manufacturing assembles TV sets. It purchases 3,600 black and white picture tubes a year at Birr 65.00 each. Ordering costs are Birr 31.00 and annual carrying costs are 20% of the purchase price. Compute:
- The optimum order quantity
 - The total annual cost of ordering, annual carrying cost and total inventory costs.
 - Total annual costs. Approximate the decimal points in your calculation.
6. Wongi sugar factory is both a producer and user of sugar. The factory operates 220 days a year and uses the sugar at a steady rate of 50 quintals per day. Sugar can be

produced at rate of 200 quintals per day. Annual storage costs are Birr 2.00 per quintal and machine set up costs are Birr 35.00 per run.

Required:

1. Determine the economic run size (EPQ).
2. What is the total inventory cost?
3. Approximately how many production runs per year will there be?
4. Determine the production time (length of run), the length of one run cycle.
5. Compute the maximum inventory level.
6. Represent the entire situation with a graph.

3.13 SUMMARY

The pressure for operating capital has made business an increasingly aware of inventory as a form of earning investment. Inventory is any idle resource that possesses economic value. Inventories are usually in the form of raw materials, supplies, component parts, work in progress, finished goods etc. Service organizations are often unable to inventory their final products, however, they manage materials and supplies. The target behind inventory control is to have the right quantity materials in the business. Here inadequate inventory can result in cost due to production delay and inefficiency. On the other hand more than adequate inventory is also a cost. The excess lead to excessive expenditure and inefficient utilization of materials and ultimately it leads to the death of the organization. For independent demand items the Economic Order Quantity (EOQ) model is used to determine the optimum (right) quantity of materials. Finally the ABC analysis is also part of inventory control i.e. it gives different emphasis for different items based on the total annual expenditures of the items.

3.14 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

1. Refer section 3.4
2. Refer section 3.8
3. Refer section 3.8
4. Refer section 3.10
5. a) $Q = 131$ picture tube

- b) $AOC = 852 = ACC$
- i. $TIC = 1704 \text{ Birr}$
- c) Br. 235,704.
- 6. 1) $EPQ = 716.47 \text{ quintals}$
- 2) Br. 1074
- 3) approximately 16
- 4) 3,58 days.
- 5) Refer 3.12

UNIT 4: MATERIAL REQUIREMENT PLANNING (MRP)

Content

- 4.0 Aims and Objectivities
- 4.1 Introduction
- 4.2 Dependent Demand
- 4.3 MRP Inputs
- 4.4 MRP processing
- 4.5 Requirements and Benefits of MRP
- 4.6 Other Issues in MRP
- 4.7 Summary
- 4.8 Answers to Check Your Progress

4.0 AIMS AND OBJECTIVES

In this unit we will examine one philosophy for finding rules to move products with in the production facility. As we will see, the method developed in unit three is not always appropriate for production planning purposes, and a different perspective is required. Demand can no longer be thought of as independent and the approach we consider here is materials requirement planning. For dependent demand items.

By the time you finished this unit, you should be able to:

- ✎ define dependent demand.
- ✎ identity the inputs for MRP.
- ✎ discuss Benefits of MRP

4.1 INTRODUCTION

In a manufacturing environment, the items carried in inventory generally consist of raw materials, part, sub assemblies, and assemblies that will be used in the manufacture or assembly of end items such as automobiles, appliances, and a host of other products. What sets inventories of these items apart from inventories of retail items or finished goods is that demand for finished goods can be characterized as independent demand, where as demand for items that becomes a part of another product can be characterized as *derived*, or *dependent*, demand. Material requirement planning (MRP) has been developed to handle the ordering and scheduling of dependent type inventories.

4.2 DEPENDENT DEMAND

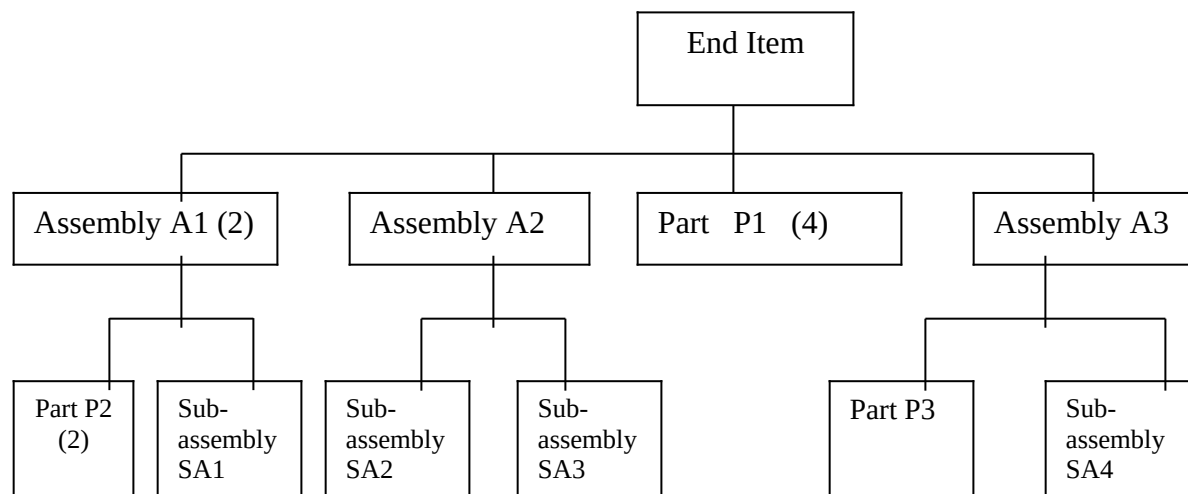
When a producer of automobiles, for example, makes a decision on how many automobiles to produce during a given month, this automatically fixes the quantities of the materials and parts that go in to making the autos. Thus, if 700 cars will be produced, and each is to have a compact square fire, then exactly 700 compact spare fire will be required. Similarly, each car will need 4 wheels; hence, the 700 cars will require exactly 2,800 wheels. The same can be said for all the nuts and bolts, screw, bumpers, rear windows, and so on. Thus, the demand (requirements) for each different part or material is derived form knowledge of the components of each car and the number of cars to be produced. Therefore, it is possible to determine almost exactly how much of each component will be required (defective parts and damaged items may require ordering a slightly larger amounts).

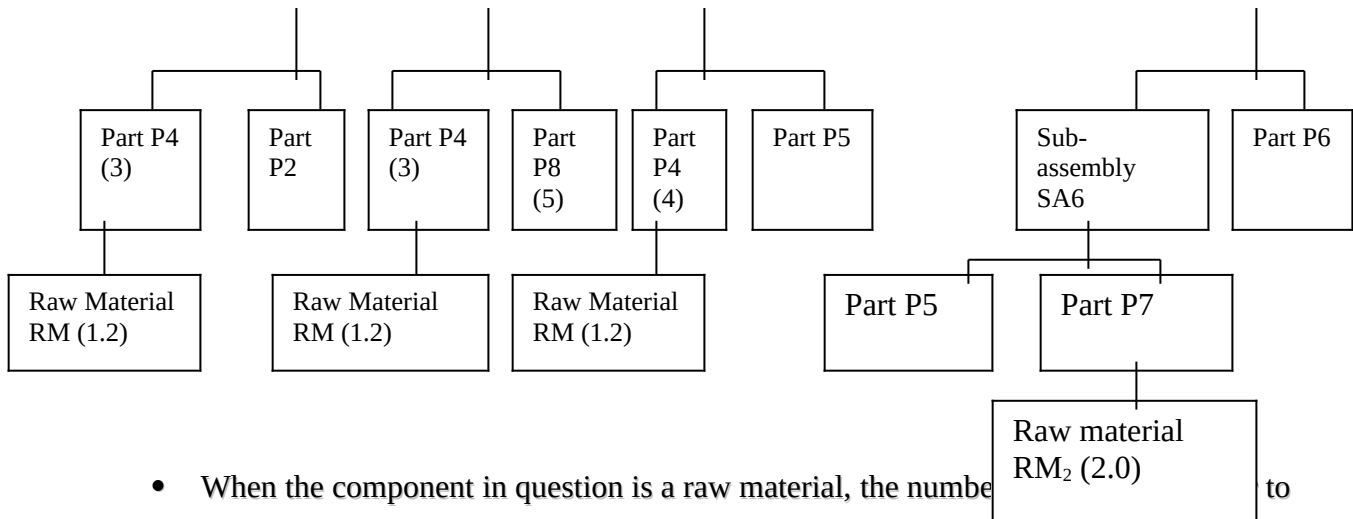
This dependent nature of derived demand is one of the two major differences between dependent and independent demand. With independent demand, which generally applies to end items or finished goods, there is an element of randomness that is absent with dependent demand. When randomness is present, demand cannot be predicted exactly, consequently, where as independent demand necessitates *safety stocks* to reduce the threat of stock-outs

because of random variability in demand, dependent demand items have much less need for safety stock, and often no safety stock is required. Independent demand tends to be fairly stable over time, where as dependent demand tends to be “lumpy” because usage (demand) tends to occur over relatively narrow time intervals with periods of no intervening usage. This is because in many kinds of assembly operations, assembly occurs in stages or cycles rather than on a continuous basis. As noted in the preceding unit, two basic questions in inventory management are when to order and how much to order. In comparing how these questions are dealt with in dependent demand and independent demand, consider that with dependent demand, managers can determine very closely how much is needed and when in contrast, independent demands variability makes the timing of orders more difficult, although order size is generally based on economic order quantity.

You can get some idea of the inter relationship that exist in assembled products by considering the product tree shown below. Product tree show, in hierarchical form what an end product is composed of (i.e. the quantity of each component need to make one unit of the end item). Reading the tree from the top to down, we can see that the hypothetical end item in this case is composed of three assemblies (**A₁**, **A₂** and **A₃**) and part **P₁**, which probably is a connector. The number in parentheses indicates the quantity of each component needed to make one of the next higher components on that same rank. When no number appear in the parentheses, this means that only one unit of the component is required for the next higher component (its “parent”). Thus in the figure below the end item requires 2 of assembly **A₁**, 1 each of assemblies **A₂** and **A₃** and 4 of **P₁**.

Hypothetical Product Tree





- When the component in question is a raw material, the number represents the weight or volume of raw material needed to make one unit of the immediate parent. For example, part P4 requires 1.2 Pounds of raw material 1. Three units of part P4, required $3 \times 1.2 = 3.6$ pounds of Raw material 1.

4.3 MRP INPUTS

Basically, MRP is a computerized system for ordering and scheduling dependent demand inventories. There are three primary inputs to MRP:

1. A master Schedule
2. A Bill of materials
3. Inventory records

A master schedule indicates the desired quantity and timing of an end item (e.g. a finished product, such as a refrigerator or a micro wave oven). The next figure illustrates how a master schedule for End item P might appear. It shows that 200 units of P will be needed at the start of the Week 6 and that another 100 units of P will be needed at the start of Week 8.

Figure 2:

A master schedule for End item P

Item: P	1	2	3	4	5	6	7	8	9
Quantity						200		100	

The quantities in the master schedule combine actual customer orders with forecasts and any orders from warehouses.

The bill of material (BOM) file contains a list of all the components (sub assemblies, parts etc..) a needed to assemble one unit of the end item. Thus, each end item will have a separate bill of materials file. The bill materials in visual form is a product tree. The inventory record file contains information on the status of each component on a period by period basis. This includes quantity on hand, quantity on order, changes due to cancelled orders, the lead time, and the lot size.

4.4 MRP PROCESSING

The essence of MRP is determining the quantity and timing necessary for each component inorder to achieve the quantity and timing of end items in the master schedule. The process, then begins with the master schedule. Then, each end item is “exploded” into its component parts using the bill of materials file, indicating the assemblies, sub-assemblies, parts, and raw materials that will be needed. Conceptually, this is the same as identifying an end items product tree. Next, the actual amounts (net requirements) of each component are determined, level-by-level, beginning at the top of the tree and working down. This is the heart of MRP; it involves determining the quantity of each item called for (gross requirements) and, then, subtracting out inventory available, which consists of any inventory on hand from previous period plus orders scheduled to be available (scheduled receipts).

Net requirements are deemed planned order receipts until the order are actually executed, at which time they become scheduled receipts. Inorder to meet the quantity and timing of net requirement, orders are planned for execution (planned order release) prior to planned order receipt according to the lead-time needed. The computation of net requirements of each component is based on this formula.

$$\text{Net Requirement} = \text{Gross Requirement} - \text{Available}$$

Now inorder to process the material requirement of a dependent demand item we can use the following format of a material requirement plan and the product tree for the end item as follows:

	1	2	3	4	5	6	7
Gross Requirement							
Schedule receipts							

Available							
Net Requirement							
Planned order Receipts							
Planned order Release							

Product Tree for end item

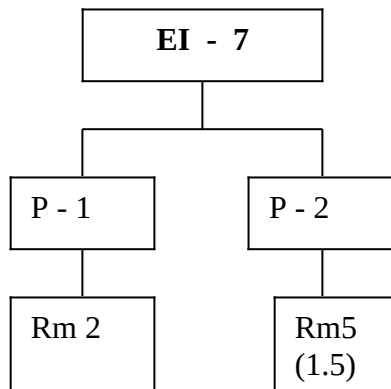
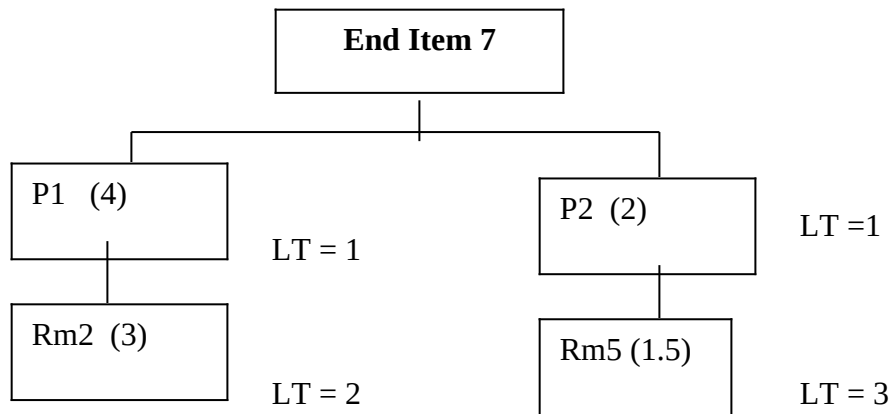


Illustration on MRP

Based on the following general information develop the MRP for End Item 7.

- o 100 units of End item 7 will be needed at the start of Week 5.
- o The lead- time for the end item is one Week.
- o Each end item will use 4 of part. P1 and P1 has a scheduled receipt of 150 units in Week 2.
- o Each part P1 require 3 units of Raw material Rm2 and 100 units of Raw material Rm2 are available on hand
- o Each end item will also requires 2 units of part P2 and 40 units of are available on hand.
- o Each part P2 requires 1.5 units of raw material Rms. and the scheduled receipt of 40 pounds in Week 3 and on hand inventory of 200 units.
- o Finally the lead-time for P1, P2, Rm2 and Rm5 is given as 1Week, 1Week, 2Weeks and 3Weeks respectively.

Now in order to process let us first draw the product tree then the process will follow:



Schedule Models

Master Schedule: End Item 7

Week	1	2	3	4	5	6
Quantity					100	

End Item 7 LT = 1	1	2	3	4	5	6
Gross Requirement					100	
Schedule receipts					---	
Available					---	
Net Requirement					100	
Planned order Receipts					100	
Planned order Release				100		

Part P1 (4) LT = 1	1	2	3	4	5	6
Gross Requirement				400		
Schedule receipts		150				
Available		150	150			
Net Requirement				250		
Planned order Receipts				250		
Planned order Release			250			

x 3
↓

Raw Material RM2 (3) LT = 2	1	2	3	4	5	6
Gross Requirement			750			
Schedule receipts			--			
Available		100				
Net Requirement			650			
Planned order Receipts			650			
Planned order Release	650					

Part P2 (2) LT = 1	1	2	3	4	5	6
Gross Requirement				200		
Schedule receipts						
Available	40	40	40			
Net Requirement				160		
Planned order Receipts				160		
Planned order Release			160			

Raw Material RM5 (1.5) LT = 3	1	2	3	4	5	6
Gross Requirement			240			
Schedule receipts			40			
Available	200	200				
Net Requirement						
Planned order Receipts			0			
Planned order Release						

The plan with the master schedule. We can see that 100 units are needed at the start of Week 5. This means that gross requirements for End Item 7 also are 100 units at the start of Week 5. Then, because there are no scheduled receipts or available inventory of End Item 7, the net requirements are 100 units in Week 5. Hence, there is a planned receipt of 100 units in Week 5. Then, because lead time (for assembly) of the end item is 1 Week, there is a planned order release of 100 units one Week ahead of this (i.e. in Week 4).

Each end item will use 4 of part P1. Therefore, the planned order release of 100 units of End Item 7 in Week 4 will create a requirement of $4 \times 100 = 400$ of Part P1, also in Week 4. But Part P1 has a scheduled receipt of 150 units in Week 2, making 150 units available in Weeks 2 and 3. So, net requirement become $400 - 150 = 250$ units in Week 4. Thus there is a planned order receipt of 250 units of Part P1 in Week 4. Because lead time is one week there is a planned order release of 250 units (i.e. fabricate 250 of part P1) one week earlier (i.e. Week 3).

Because each part P1 will require 3 units (pound) of Raw Material RM2, the 250 units will require $3 \times 250 = 750$ units of Raw Material RM2. There are no scheduled receipts, but 100

units of Raw Material RM2 available (i.e. are now on hand). Hence, net requirement will be 650 units, in Week 3. Because lead-time is two weeks, the planned order release is for 650 units in Week 1.

Gross requirements for Part P2 are derived from the quantity of the end item needed(i.e., 100 in this case). Because two of Part P2 are needed for each unit of the end item, a total of $2 \times 100 = 200$ units will be needed. There are no scheduled receipts, but 40 units will be available, so net requirement become 160 units. Thus, a planned order receipt of 160 units in Week 4 is needed and a planned order release of the same amount in week 3 is needed because lead - time is, again, one week.

The 160 units of Part P2 will require $1.5 \times 100 = 240$ pounds of Raw Material RM5 in Week 3. There is a scheduled receipt of 40 pounds in Week 3. Added to the previously available quantity of 200 pounds 240 pounds will be available in Week 3. Because that just equals gross requirements of Raw Materials RM5, no additional ordering will be needed. (Note that lead - time is 3 week for Raw Material RM5. In order to received the 40 units in Week 3, an order must be placed one week earlier, say in week 0. Once an order is placed, it is no longer a planned order; rather the quantity becomes a scheduled receipt.).

4.5 REQUIREMENTS AND BENEFITS OF MRP

Among the benefits of material requirement planning are the following:

1. Relative low holding cost.
2. The ability to keep track of material requirements.
3. The ability to determine capacity requirements related to given master schedule.

In order for MRP to be truly effective, it is necessary to have a computerized processing system. This includes the appropriate software. In addition, it is necessary to have accurate and timely mater schedules, bills of materials, and inventory records.

In some instances, companies have attempted to install MRP systems with out carefully checking on the accuracy of their bills of material and inventory records. This has led to serious difficulties in adopting MRP because of the need to correct record, substantial amount

of time and human resources had to be invested. Also, employees sometimes resist new methods, leading to additional difficulties.

Even without these problems, MRP has not been panacea may had hoped it would be. I part, this has caused manufacturers and consultants to take a more comprehensive view of resource planning.

4.6 OTHER ISSUES IN MRP

Management of dependent demand inventory is an important concern for manufacturing and assembly operations. Much has been written about the subject. Unfortunately, space limitations do not permit an in-depth coverage of it. Nonetheless, there are a few additional issues that must at least be mentioned:

1. Safety stock
2. Lot sizing.
3. Capacity planning

Let's briefly examine each of these issues.

Safety Stock

Under independent demand, safety stocks are held to offset variabilities in demand and/or lead-time. Under dependent demand, demand quantities tend to be less variable, although lead times may vary. Consequently, under those circumstance it may make more sense to include some **Safety time** in ordering; that is, when lead times tend to vary, order a bit earlier to allow for this rather than hold additional stock. In some case, safety stock may be held; this usually occurs at the lowest level of product structure (e.g. raw materials) or for purchased part that are used in several products (e.g. engines for several different lawnmower model) safety stocks may represent a reasonable approach to variation in lead time. In practical terms, however, safety stocks should be viewed as exceptions rather than the general rule for dependent demand situations.

Lot Sizing

Selecting order (or production) quantities is referred to as **Lot sizing**. In general, the primary goal in choosing a lot size is to minimize the sum of ordering (or set up) costs and inventory

carrying costs. When demand tends to be lumpy, as it often does with dependent-demand items, the task of identifying an appropriate lot size is more difficult than when demand tends to be uniformly distributed over time. A variety of difficult approaches are used in practice, none of which is necessarily better than the others. Judgment and experience often are factors in choosing a particular approach.

Economic Order Quantity (EOQ) models (covered in the preceding chapter) sometimes are employed. The closer demand is to being uniformly distributed, the better such model work. EOQ models seem to work best either for components at lower level of product tree or for purchased parts that are used in multiple products, for which demand tends to be the most uniform. For other components and for end items, demand tends to be lumpy to use an EOQ approach to ordering. When demand is lumpy and/or uneven, the average inventory is less likely to equal one-half the order quantity, and the EOQ logic breaks down.

Lot –for-lot ordering often is used. It involves using an order size that is equal to demand. This method was illustrated in the preceding example. It is by far the simplest approach; no computations are needed. It has the advantage of holding inventory only for short period, unlike the EOQ approach, which would result in carrying inventories on a continual basis. One disadvantage is the inability to take advantage of economic related to a fixed order size, such as standard container sizes.

Fixed period ordering involves ordering enough inventory for a number of periods (e.g., one-month supply). The number of periods may be arbitrary or it may reflect an effort to incorporate knowledge of demand patterns, such as cycles of demand.

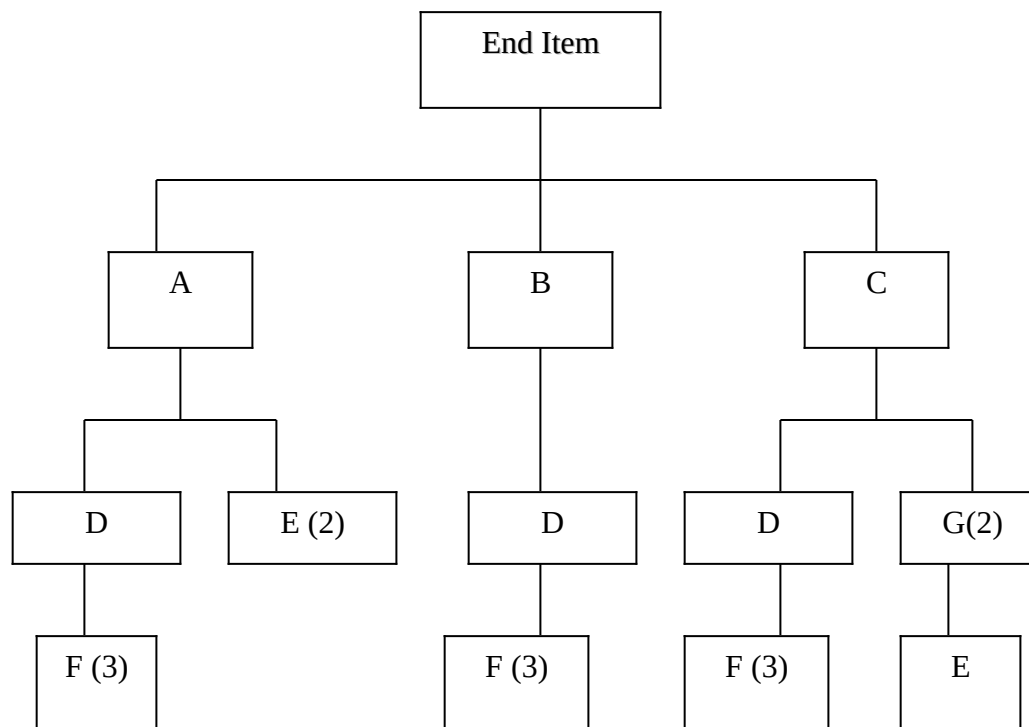
A fairly sophisticated approach, the *Wagner-Within algorithm*, uses dynamic programming to try to minimize the sum of ordering and carrying costs. It involves identifying and examining a small number of strategies and, then choosing the one that minimizes total costs. The complexity of the technique limits the willingness of many managers to adopt it.

Capacity Requirement Planning

When a master schedule is being developed, usually it is in terms of what will be needed and when it will be needed, not what is possible. It is not until those needs have been exploded and compared to available amounts of inventories and production capabilities that the

feasibility of requirements plans can be determined. Consequently, it may be necessary to go through a number of iterations of revising the master schedule until a schedule that does not exceed capacity limitation is obtained.

Check Your Progress Questions



Given the above product structure tree and the following additional information

Answer the following questions.

- 300 units of the end item are needed in period 6
- On hand inventory consists of; 60 units of the end item 100 units of compounded C, 100 units of components E.
- Scheduled receipts are 40 units of components A in period 3.
- Lead times are two periods for the end item and for component 4 and , one period for all other component.
- Lot for lot ordering is used, except for component E, which has order sizes that are multiples of 400 units.

Required:

- Q1. The net requirement for End item in period 6 will be;
A) 300 B) 247 C) 600 D) 240 E) None
- Q2. There will be a planned order release of 200 units of component A in Period.
A) 1 B) 2 C) 3 D) 4 E) None
- Q3. Gross requirement for component E in period 2 will be
A) 200 B) 300 C) 400 D) 700 E) None
- Q4. How much unit of component E must be ordered in period 1?
A) 800 B) 600 C) 400 D) 350 E) None

4.7 SUMMARY

Materials requirements planning (MRP) is a set of procedures for converting forecast demand for a manufactured product into a requirements schedule for the components, subassemblies, and raw materials comprising that product. A closely related concept is that of the master production schedule (Mps), which a specification of the projected one needs of the end product by time period. Information contained in the product structure diagram is the production lead times needed to produce the specific component to the time required to obtain the item from external sources.

Many MRP systems are based on a lot-for-lot production schedule. That is, the number of units of a component produced in a period is the same as the requirements for that component in that period. However, if setup and holding costs can be estimated accurately, it is possible to find other lot-sizing rules that are more economical.

4.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

1. D

2. C

3. A

4. C