

# Inventory Control

A MANAGEMENT GUIDE

8



NATIONAL PRODUCTIVITY COUNCIL

# ABOUT NPC

The National Productivity Council is an autonomous organization registered as a Society. It is tripartite in its constitution and representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organizations interested in the Productivity Drive. Besides its headquarters at New Delhi, NPC operates through eight Regional Directorates. In addition, there are 49 Local Productivity Councils.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide service with a view to maximizing the utilization of available resources of men, machines, materials and power ; to wage war against waste ; and to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organizations, it organizes and conducts training programmes for various levels of Management in the subjects of productivity. It has also organized an advisory service for industries to facilitate the introduction of productivity techniques.

Recognizing that for a more intensive productivity effort, the training and other activities of NPC, designed to acquaint management with productivity techniques, should be supported by demonstration of their validity and value in application, NPC offers a Productivity Survey and Implementation Service (PSIS) to industry. The demand for this service has been rapidly growing. This service is intended to assist industry adopt techniques of higher management and operational efficiency consistent with the economic and social aspirations of the community. PSIS is a highly competent consultancy service concerned with the investigation of management and operational practices and problems, and recommendation of measures of improvement and their implementation. NPC has established a special Fuel Efficiency Service. It has set up cells for servicing small scale industries. It has introduced a National Scheme of Supervisory Development under which an examination is held and certificates awarded to successful candidates. NPC also conducts a two-year practice-oriented programme for training in Industrial Engineering for first class graduates in Engineering disciplines.

NPC publications include pamphlets, manuals, and Reports of Productivity Teams. NPC utilizes audio-visual media of films, radio and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and create an appropriate climate for increasing national productivity.

**Management Guide 8**

# **INVENTORY CONTROL**

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# PREFACE

Practically the world over, there has been increasing recognition that the development of supervisory skills can significantly contribute to the improvement of productivity of an enterprise. From its inception in 1958, the National Productivity Council has laid stress on supervisory development in its programmes, but since it needed a more concerted drive, it introduced during the Asian Productivity Year—1970 a nation-wide scheme to prepare candidates through self-study and class-room or enterprise-level guidance for a professional qualifying examination leading to the award of the National Certificate in Supervision.

We are happy that the response to the NPC Scheme has been quite good. Management of all forward-looking enterprises have evinced considerable interest, and over four thousand candidates in all have appeared for the Examination during the last three years. In implementing the NPC's Supervisory Development Scheme, some of the Local Productivity Councils have extended their cooperation and support. The success of any self-study scheme ultimately depends on making available adequate study material prepared by competent experts, and written in a lucid and simple style. NPC has brought out as many as 27 *Management Guides* so far which attempt to give a basic understanding of the various topics included in the syllabus.

This Guide, *Inventory Control* has been prepared by Mr. B. D. Khare, NPC consultant. It has to be stressed that the NPC *Management Guides* are not intended as a substitute for enterprise-level assistance for supervisory development by way of training, demonstration, seminars, etc., but mainly as complementary to these activities.

These Guides are also designed to be of help to managerial personnel as well as students of management who wish to have some basic understanding of the science and practice of management.



G. R. DALVI  
Executive Director  
National Productivity Council

# I - INTRODUCTION TO INVENTORY CONTROL

## INVENTORY & ITS FUNCTIONS:

Inventory in a wider sense is defined as any idle resource of an enterprise. However, it is commonly used to indicate materials raw, in process, finished, packaging, spares and others—stocked in order to meet an expected demand or distribution in the future. Even though inventory of materials is an idle resource in the sense it is not meant for the most immediate use, it is almost a necessity to maintain some inventories for the smooth functioning of an organisation.

The benefits of inventories can be best understood, if one imagines of an organisation working on no inventories at all. This organisation, on receiving a sales order, would have to order out the quantity of materials required for completing this order, wait till these arrive and then start production. One can well think of the various disadvantages of this way of functioning. The customer would invariably have to wait too long for the delivery. The materials, may have to be bought at very high prices because of piece-meal buying. The production costs would also be high because of failure to take advantages of batching. In case there is excessive rejection at either receipt or at any of the manufacturing stages, long waiting would be inevitable to get fresh supplies. The load on the manufacturing shops would vary from period to period depending upon the orders on hand. In short, such a company would not be able to provide a satisfactory customer service and would fail to take advantage of economies in bulk-procurement, and batch manufacture and thus would not stand long in competition both in the matter of price and customer service.

To summarise inventories are essential:

- (1) for adequate customer service,
- (2) to take advantage of price discounts by bulk purchasing,
- (3) to make possible economies in transportation and clearing and forwarding charges,
- (4) for batching in the manufacture, to take advantages of longer production runs,
- (5) to serve as a buffer in cases of shop rejections and delayed deliveries of materials,
- (6) for providing flexibility to allow changes in production plans due to changes in demands or any other reasons, and

(7) to even out the work loads on the shops in the face fluctuating demands.

#### EVILS OF EXCESS INVENTORY:

Essential though they are, inventories also mean lock-up capital of an enterprise, which could be invested in certain more profitable operations. Besides, maintenance of inventories also costs money by way of expenses on stores i.e., stores space, equipment and personnel, insurance, taxes, pilferage, etc. Obviously more the inventories, more would be the money locked-up in them and higher would be the expenses on maintaining them. Excess inventories are hence undesirable.

#### INVENTORY CONTROL & ITS ADVANTAGES:

Introduction of a proper inventory control system helps in keeping the investment in the inventories as low as feasible, and yet (i) ensures availability of materials by providing adequate protection against uncertainties of supplies and consumption of materials and (ii) allows full advantage of economies of bulk purchases and transportation. Such a system in an organisation reduces considerably the chances of going out-of-stock and at the same time leads to reduction in the inventory levels and release of capital. The latter has a direct effect on the profitability of an enterprise.

To illustrate, consider a company with a total investment of Rs. 12 lakhs and average borrowings to the tune of Rs. 2 lakhs. The financial statement of the company indicates:

<i>Fixed assets</i>	<i>Inventories</i>	<i>Cash and Credits</i>	<i>Borrowings</i>	<i>Total annual Sales</i>
Rs. 5 lakhs	Rs. 8 lakhs	Rs. 11 lakhs	Rs. 2 lakhs	Rs. 16 lakhs
<i>Profit before interest and taxes</i>	<i>Interest on borrowings at 9 per cent</i>		<i>Profit before taxation</i>	
Rs. 2 lakhs	Rs. 18,000		Rs. 1,82,000	
<i>Rate of Return on Investment</i>				
15.17 per cent.				

If the company had introduced inventory control and reduced some of its excess inventories and brought down the investment on inventories to Rs. 6 lakhs, the picture would have been thus:

<i>Fixed assets</i>	<i>Inventories</i>	<i>Cash &amp; Credits</i>	<i>Borrowings</i>	<i>Sales</i>	<i>Profit</i>
Rs. 5 lakhs	Rs. 6 lakhs	1 lakh	Nil.	Rs. 16 lakhs	Rs. 2 lakhs
<i>Interest on borrowings</i>		<i>Rate of Return</i>			
Nil		16.67 per cent			



Thus, the return on the investment would have increased from 15.17 per cent to 16.67 per cent i.e. about 10 per cent.

There would also be another possibility in case the inventories could have been reduced further say to Rs. 4 lakhs. The new picture would be:

<i>Fixed assets</i>	<i>Inventories</i>	<i>Cash &amp; Credit</i>	<i>Total investment</i>
Rs. 5 lakhs	Rs. 4 lakhs	Rs. 1 lakh	Rs. 10 lakhs
<i>Annual Sales</i>	<i>Profit</i>	<i>Return on investment</i>	<i>Capital available for investment elsewhere</i>
Rs. 16 lakhs	Rs. 2 lakhs	20 per cent	Rs. 2 lakhs

In this case, a capital of Rs. 2 lakhs would be released for investment elsewhere while the remaining investment of Rs. 10 lakhs would earn a higher return of 20 per cent.

## II - TECHNIQUES OF INVENTORY CONTROL (SELECTIVE CONTROL)

Any average medium-size organisation consumes a few thousand items of stores. A high degree of control on inventories of each item would, therefore, neither be practical considering the work involved, nor worthwhile since not all items are of equal importance. Hence, it is desirable to classify or group the items depending upon their importance and subject each class or group of items to controls, commensurate with importance. This is the principle of selective control as applied to inventories and the technique of grouping is termed as A B C Analysis or classification.

### A B C CLASSIFICATION:

If the annual consumption in an organisation of the various items is worked out in terms of rupee value it is noticed that only a small percentage of items account for a major portion of the total consumption in Rupees. Obviously these are the items, that are most important from the point of view of inventory control and call for a higher degree of control. Hence these are classified as A-items. As against A-items, there are items which are large in numbers but account for only a very small portion of the total consumption in terms of value. These are termed as C-items and they do not call for strict controls. In between A and C lie B-items of medium importance. These are typically a percentage of items which accounts for equal percentage of consumption value or near about. Based on A B C Analysis an average pattern of percentages of items and percentages of their respective Rupee Values may work out as follows:

	<i>Percentage of items</i>	<i>Percentage of Rupee Value</i>
A=items	10 per cent	70 per cent
B=items	20 per cent	20 per cent
C=items	70 per cent	10 per cent

However, this is only a very rough guide and individual organisations may present patterns widely varying from this. Before we get ready for the actual method of classification following aspects need to be clarified:

- (1) Two or more items which can be completely substituted for each other should be treated as one item for A B C Analysis. For example, Shell Tellus 29 and an equivalent oil supplied by ESSO should be treated together as one item

6' x 3' Aluminium sheet imported from Canada and 2 meter by 1 meter purchased locally both intended for the same use should be treated as one item. However, cotton of long staple variety and cotton of short staple variety would be two different items since they cannot replace each others in blending.

- (2) All items that the company consumes must be considered together when classifying into A B C classes. Separate classification of raw materials spares and consumables etc. is not really meaningful.
- (3) While classifying as A B C items, what counts is the consumption in Rupees and not the unit price of an item or its consumption in terms of units. Thus of the three items given below the last one is most important since its Annual consumption in terms of value is more than the other two.

<i>Item</i>	<i>Price/Unit Rupees</i>	<i>Annual consumption in Units</i>	<i>Annual consumption in Rupees</i>
X	20,000	2	40,000
Y	0.02	1,00,00,000	20,000
Z	1,000	500	5,00,000

- (4) Even though, so far we have referred to annual consumption, it is not at all necessary that the consumption figures should be taken only for one year. It can be for 6 months or even 3 months. But the period should be so selected that the consumption figures would be representative. However, Annual figures are more convenient and are universally followed.
- (5) Though classification into 3 groups A B and C is normally adequate enough, if there is sufficient justification, items may as well be categorised into any convenient number of groups, for instance, some may find 5 groups A B C D and E convenient or some may find the necessity of sub-dividing group A into A1, A2 & A3.

#### METHOD OF CLASSIFICATION:

To be able to classify the items in three classes A B & C, we need to know two limiting consumption values  $V_a/b$  and  $V_b/c$  so that:

- (1) An item with consumption above  $V_a/b$  would be considered as high value item and would be classified as A item.
- (2) An item with consumption below  $V_b/c$  would be considered as low value item and would be classified as C item.

- (3) An item with consumption between Va/b and Vb/c would be considered as medium value item and would be classified as B item.

With the above explanation, the method of classification is described with the help of an example.

First some values for Va/b and Vb/c are assumed (say Va/b = 5000 and Vb/c = 500) and going through the list of items, all items with consumptions above Rs. 5000 are classified as A, those between Rs. 500 to Rs. 5000 as B and those below Rs. 500 as C. The percentages of the items so classified and the percentages of Rupee values of A B & C items are then calculated and examined. If found satisfactory the classification is complete. If found to be unsatisfactory the limits Va/b and Vb/c are revised and a fresh classification is made, the process being repeated till satisfactory results are obtained. The work involved is considerably reduced by classifying and finalising A items first (by assuming Va/b only and revising if necessary) and then going to B items.

In practice not more than 3 to 4 trials may be necessary and the work involved can be reduced further by following certain thumb rules for choosing values Va/b and Vb/c. A part-example worked out below will clarify the procedure. For the sake of brevity only 6 items have been taken from the total 3000 items actually to be classified:

STEP I (Ref: Exhib. 1) :

Make a list of all the items with their annual consumptions shown against each. Total up the number of items and the consumptions. Leave 5—6 columns blank on the right hand side for trials.

<i>S. No.</i>	<i>Item Code</i>	<i>Annual consp. in Rs.</i>
106	1605	5,050
107	1127	4,900
108	1205	6,500
109	1169	3,900
110	2761	650
111	5672	4,150
Total 3,000		60,00,000

Exhibit-1

			<i>Step II</i> <i>Va/b</i> 5000	<i>Step III</i> <i>Va/b</i> 6000	<i>Step IV</i> <i>Vb/c</i> 500	<i>Step V</i> <i>Vb/c</i> 600
106	1,605	5,050	A		B	B
107	1,127	4,900			B	B
108	1,205	6,500	A	A		
109	1,169	3,900			B	B
110	2,761	550			B	
111	5,642	450				

*Exhibit-2*

STEP II (Ref: Exhibit 2):

Select a value for  $Va/b$ . A good thumb rule for this is

$$Va/b = \frac{\text{Total Consumption in Rs.}}{\text{Total number of items}} \times 2.5$$

$$\text{here } Va/b = \frac{6000000}{3000} \times 2.5 = \text{Rs. } 5,000$$

Enter this at the top of the first blank column and make an 'A' mark in this column against items for which the consumption is above Rs. 5000 as shown. Also count the number of items so marked and total up their annual consumptions and compare this with guide-lines for A item.

*Guide lines for A items*

*Results*

Less than 10 per cent items

No. of items marked A = 450 i.e. 15 per cent.

More than 70 per cent Rupee Value total of consp. = Rs. 51,30,000 or 85.5 per cent

STEP III:

Comparing the results with guide lines we notice that the items classified as A are 15 per cent and a reduction in this is desirable. To drop some of the items from A class, we would have to revise  $Va/b$  upwards; say to Rs. 6,000. Enter this at the top of second column and reclassify A items.

(Note: here that only the items marked A in the first column will have to be re-examined since  $Va/b$  has been revised upwards)

*Results:*

No. of items marked A = 291 i.e. 9.7% and total of consp. = Rs. 43,20,000 i.e. 72 per cent.



#### STEP IV:

Results of Step III are satisfactory hence no further revision of Va/b is necessary and we can proceed to classify B Items.

Select now a value for Vb/c. The thumb rule is :

$$Vb/c = \frac{\text{Total consumption in Rs.}}{\text{Total number of items}} \times 0.25$$

$$\text{here } Vb/c = \frac{6000000}{3000} \times 0.25 = \text{Rs. } 500$$

Enter this at the top of the third column and classify B items as those for which consumption is above Rs. 500 but below Rs. 6000.

#### *Guide lines for B items*

(1) A+B items together should be less than 30 per cent and value together should be over 90 per cent.

#### *Results*

No. of items = 1000 i.e. 33.3 per cent.  
Total of consump.=Rs. 1380000 i.e. 23 per cent.

#### STEP V:

Comparing the results with the guide lines for B items given above i.e. we find that the number of items classified as B is a little too large.

Hence, revise Vb/c upwards to Rs. 600 enter at the top of fourth column and reclassify B items in the fourth column as shown.

#### *Results:*

No. of B items = 579 i.e. 19.3 per cent.

Total of consumption = 1149000 i.e. 19.5 per cent.

Since these results are satisfactory the analysis is complete at this stage. A items appear in column 2 and B in column 4 and the remaining are all C items.

Sometimes one comes across organisations wherein just a dozen or so of the items account for over 90 per cent of the total consumption value. In such cases, A items can be classified just from memory and the trials may be necessary only for B items. To give a few examples: a few varieties of cotton make up for over 70 per cent of the Rupee value of materials consumption in a textile mill, similarly in case of a fertiliser unit Naphtha, Rockphosphate, Sulphur, and jute bags would account for over 90 per cent of the consumption value. In these cases the guide line for B items of equal percentages of items and value does not hold.

#### CONTROLS FOR A, B & C ITEMS:

We are now ready to discuss the purchasing and stocking policies recommended for the different classes of items A, B & C. All these emanate from two basic requirements, viz. (1) to keep the capital tied-up in the inventories as low as is practicable

and (2) to make sure that all the materials would be available when required for consumption.

*Policies for A Items* : (Less than 10 per cent items more than 70 per cent value)

- (1) Since these items account for over 70 per cent of the value, they should be ordered more frequently to reduce the capital locked up at a time in inventories.
- (2) There would be many A items for which the consumption varies considerably from time to time during a year. For such items the expected future consumption should be estimated in advance and they should then be procured on a planned basis, so that, only the required quantities arrive a little before they are required for consumption. Of course, a small extra stock (buffer) would be carried throughout to meet any eventualities.

It may be pointed out here that the advance estimation of future consumption can be made with the help of periodic production schedules and master schedules. In the absence of proper production schedules there is no reliable way of estimating what quantities would be required when and a planned procurement would be rather difficult. Thus, it may be emphasized that a proper inventory control basically calls for a good production planning system.

- (3) Annual or 6-monthly contracts with scheduled deliveries or deliveries within a specified period of order are welcome for A items.
- (4) Develop and revise more often ordering quantities, reorder points and safety stocks for items not covered by long term contracts mentioned in (3) (this will be clear from the subsequent chapter on ordering systems).
- (5) Since these items are to be stocked as less as possible, purchasing department should make maximum efforts to expedite the delivery of these items.
- (6) As far as possible, two or more suppliers should be sought for each item so that the dependency on one supplier is avoided. Due to strike, fire, accidents, or any other eventualities if one supplier fails to supply, the other suppliers can be approached.
- (7) Purchase of A items should be looked into by the top executives in the purchasing department to ensure prompt service from suppliers.
- (8) Stock and issue records should be meticulously maintained in the inventory control or in the stores as the case may be to be able to get the up-to-date position of stocks at any time.

- (9) The stock reports of A items should be sent more frequently to the top management. There can be no set rule, though once a month is good enough.

*Policies for B Items:* (Less than 20 per cent items about equal percentage value)

- (1) The policies for B items in general are intermediate between those for A and C items.
- (2) Order quantities, reorder points and safety stocks should be fixed for B items and barring exceptions revisions once a year is adequate.
- (3) Annual or 6-monthly contracts with scheduled deliveries can be used to a advantage for B items.
- (4) Stock and issue records are necessary to be maintained.
- (5) Should be ordered less frequently than A items; about 3 to 6 orders per year is the range of frequency.

*Policies for C Items:* ( Over 70 per cent items less than 10 per cent value)

Since the items are too many and the value is less the policies are to be aimed at reducing the ordering and stock keeping work to the extent possible and ensuring the availability at all times by stocking liberal quantities.

- (1) Liberal quantities (stocks to last 6 months to over one year) can be kept in stock since in case of C items it does not involve much capital tie-up.
- (2) Annual or 6 monthly orders, should be placed to reduce paper work in the purchasing department and also to take advantage of quantity discounts for bulk purchases.
- (3) Items should be grouped like all electricals, all hardwares, all paints, etc., and one group of items should be ordered all at once preferably from one or two vendors. This saves ordering work and also transportation costs. In addition, because of the inclusion of several items in one order, each order becomes sizable enough for the vendors to make concessions and give discounts.
- (4) For the ordering of those items a combination of review period system and two-bin system is suggested. In this system, for a group of items as particular review period is fixed. At the time of review, the stock of all the items coming under this group is checked and orders are placed to replenish the stocks to last a certain period (actually one review period + one delivery period). When the materials are received each item is stored in two bins, one main and one reserve. Issues are made from the stock in the main bin which is normally sufficient to last till the next review period. However,

for an odd item due to heavy consumption the main bin does get empty before the next review. In such a case a reorder is immediately placed for this item and the issues are continued from the reserve bin till the fresh supplies are received. Obviously the reserve bin stock should be a quantity sufficient to last one lead time. In normal case the main bin would not be empty before the next review but the two-bin system safeguards against any stockout because of excess consumption.

In practice there is no necessity of 2 separate bins, only some method of indicating the reserve stock from the main stock is all that is necessary. (In a stock of glass sheets, a small red mark on some would suffice to indicate that they are from the reserve stock). An example given below would clarify the system.

**Example:**

<i>Item</i>	<i>Group</i>	<i>Review period</i>	<i>Review date</i>	<i>Annual consumption</i>
M.S. Washer, 16 gauge, 1/2" ID	Hardware	6 months	1st Feb. & 1st Aug.	(from past figures) 1200 washers.

**Delivery period**

1 month.

Stock to last 1 review and 1 order period = (Review period in months + delivery period in months) monthly consumption

$$= (6 \times 1) \times \frac{1200}{12}$$

$$= 700 \text{ washers.}$$

In order to be on safer side we will enhance this by another 50

hence replenishment level = 700 + 50 = 750 washers.

Theoretical reserve stock = Stock to last during the delivery period (1 month)  
= 100 We would keep 10 more for safety.

∴ Reserve Stock 110 washers.

Hence 110 washers would be kept in the reserve bin and the rest in the main bin.

Now suppose at the review date (for hardware) the stock is 160 (110 in reserve bin + 50 in main bin) an order would be placed for 590 washers. (750 - 160 = 590). By the time these are received after a month another 100 washers would be consumed leaving 60 in stock. At the delivery time the total stock would then be (60 + 590 = 650)

550 with 5 months to go till next review. Of these 650 washers, 110 would be kept in the reserve bin and 540 in the main bin. If now the consumption suddenly rises and after 3½ months the issue clerk finds the main bin is empty he would immediately raise an indent for 640 more washers (750—110 Reserve) and make further issues from the reserve bin.

- (5) Authority for the purchase of C items could be delegated to the Junior Executives in the purchasing department or even to the storekeeper so as not to bother the personnel at higher levels with work on these low-value sundry items.
- (6) Stock and issue records can be minimised to the extent the rules of the organisation allow. In some companies for most of the C items only records of receipts are kept. In others, one consolidated issue entry each month for an item is recorded. However, in quite a few cases no records are maintained at all for C items barring some pilferable, and short-life items.



### III- TECHNIQUES OF INVENTORY CONTROL (ORDERING SYSTEM - PRELIMINARY CONSIDERATIONS)

#### COST FACTORS:

With the discussion on general inventory policies for the different group of items A, B & C, we now pass on to the analysis of two basic problems of inventory control:

- (1) What quantity of an item should be ordered each time?
- (2) When should an order be placed?

There are three cost factors in the picture, when we try to seek a solution to these two problems. These are:

- (a) The cost of the materials itself.
- (b) The costs associated with keeping the materials in stock (inventory carrying charges).
- (c) The costs associated with the placement of a purchase order (ordering costs).

The price of the materials is by far the most important and for items with frequent unexpected price variations (speculative items) 1 and 2 above are totally dictated by price and no set rules are possible. However, most of the items have more or less steady prices over substantial periods of time and for these item the price has less influence on the how much and when to order.

The latter are essentially the types of items considered here and hence, the cost of the material itself is not necessary to be dealt with here. (Even for items with steady prices, the price discounts do have an influence on how much to order—(Refer Q. 15 in Model Questions).

#### THE INVENTORY CARRYING CHARGES:

These arise out of the following factors:

- (1) The loss of interest (or profits) on the money invested in the stocks of materials.
- (2) The salaries and wages of the stores personnel employed to receive, store and issue the materials.
- (3) The rent for the stores.

- (4) The depreciation and repairs cost for the stores facilities and handling equipment.
- (5) Any loss of materials through pilferage and deterioration.
- (6) Materials rendered obsolete because of design changes or other factors.
- (7) Taxes on inventories.
- (8) Stores insurance charges.
- (9) Stationery and other consumables used by the stores etc.

For every 100 rupees worth of materials stored for a length of one year, these charges total up to about Rs. 20. However, this can vary from Rs. 15 to Rs. 30 from company to company depending upon, the kind of materials stored, the personnel employed in stores, the equipments used, etc.

It is easy to realise that the annual inventory carrying charges should increase as the value of the materials stored increases due to increased expenditure on handling, interest, space, etc. At this stage, we may therefore, assume that the inventory carrying charges are proportional to the value of inventory.

In practice to calculate the inventory charges for a rupee worth of material stored per year (as it is expressed usually) for a company the steps involved are as follows:

- (a) Take the total inventory holdings (in rupees) for each month and average them i.e.  $\frac{\text{Inventory on 31st Jan.} + \text{28th Feb.} + \dots + \text{31st Dec.}}{12}$
- (b) Now work out the costs incurred under the seven heads 2 to 8 given above as accurately as possible.
- (c) Add to this costs due to loss of interest on capital invested in inventories at a suitable rate i.e.  $\frac{\text{Average inventories as in (a)} \times \text{rate of interest}}{100}$
- (d) and divide all the costs by average inventories:

$$\text{i.e. } \frac{(b) + (c)}{(a)}$$

This cost is expressed as a decimal fraction i.e. 0.20 or 0.30 as the case may be.

#### ORDERING COSTS:

Placement of a purchase order for a material is, associated with certain obvious costs due to advertising, consumption of stationery and postage, telephone charges, telegrams, etc. In fact all the annual expenditure of the purchasing department of a

company can be considered to be on the purchase orders it places during a year. The costs associated with ordering would, therefore, consist of :

- (1) Rent for the space used by the purchasing department.
- (2) The salaries and wages of officers and staff in the purchasing department.
- (3) The depreciation on the equipment and furniture used by the department.
- (4) The postage, telegram and telephone bills.
- (5) The stationery and other consumables required by the purchasing department.
- (6) The entertainment charges incurred on receiving vendors.
- (7) Any travelling expenditure incurred.
- (8) Lawyers and court fees due to any legal matters arising out of purchases.

Obviously, the more the number of orders placed in a period, the more would be the stationery and postage consumed, more staff and officers would be required for handling the work, the more would be the space required for accommodating them and so on. Thus the total expenditure on purchasing or ordering would depend on the number of orders placed. Let us assume for the time being that the expenditure on ordering of materials is directly proportional to the number of orders placed.

The ordering cost is expressed as the cost per order and is calculated by dividing the total ordering costs (head 1 to 8) during a year (or a period) by the number of orders placed during the year (or the period). These work out from between about Rs. 15 to Rs. 40 depending upon the purchasing practices of each company. It may be pointed out here that the ordering costs have no relation with the value of order. Whether an order is worth Rs. 5,000/- or worth Rs. 10,000/- the work and hence the cost involved is the same.

#### PROCUREMENT AND CONSUMPTION CYCLE:

Consider now an over simplified procurement and consumption cycle for an item having a steady consumption all through the year and which is available immediately on placing an order (without fail).

In such a case the item would have the procurement and consumption cycle as graphically shown in Fig. No. 1. (see next page).

At time A the stock is zero and hence an order would be placed and (the delivery being immediate) the stocks would be brought up to a level say Q. These would be steadily issued out upto time B and another order would be placed at B to bring up the stocks to Q and so on.

The inventory at the beginning of period A—B would be Q and at the end of the period zero or the average inventory would be  $Q/2$  and orders would have to be placed of A, B, C, etc.

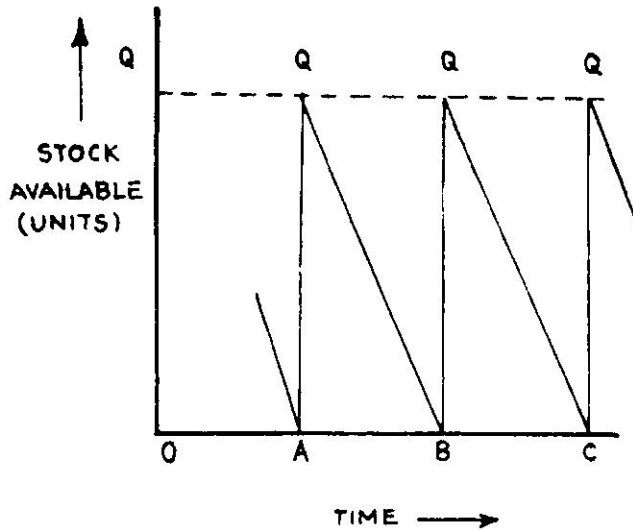


Fig. No. 1.

We can now discuss what should be the quantity  $Q$  ordered each time to keep down both the inventory costs and the ordering costs in this consumption and procurement cycle.

**ECONOMIC ORDERING QUANTITY:**

Consider now the procurement of the entire annual requirement of an item. As discussed earlier under the "Procurement and Consumption Cycle", average inventory equal *quantity per order*. Hence, for keeping the inventories and inventory costs low it would be better to procure the item in as small consignments as possible. But this would mean larger number of orders and more ordering costs. This has been shown graphically in Fig. No. 2.

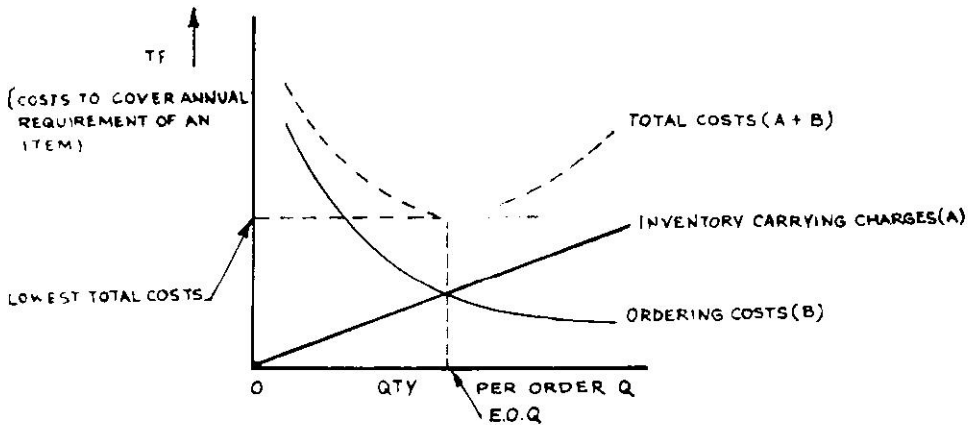


Fig. No. 2.

The requirements are thus conflicting and there is a particular quantity at which the sum of both the ordering and inventory costs are the least and this quantity is called as the "Economic Ordering Quantity" (E.O.Q.).

We can now proceed to derive what is E.O.Q. ?

A = Annual requirement of an item in terms of *Rupees*

S = Cost per placement of an order in *Rupees*

i = Inventory carrying charges per Rupee per year expressed as a decimal

Q = Quantity per order in *Rupees*

Total procurement and inventory costs per item (TF) = Procurement costs + Inventory costs

$$\therefore TF = \text{No. of orders} \times S + \text{Average inventory in Rupees} \times i$$

If Q is the quantity per order the number of orders to cover entire quantity A would be  $\frac{A}{Q}$

$$\therefore = \frac{A}{Q} \times S + \frac{Q}{2} \times i$$

For the total costs to be minimum we differentiate TF with respect to Q and equate to zero.

$$\therefore \frac{dTF}{dQ} = \frac{-AS}{Q^2} + \frac{i}{2} = 0$$

$$\therefore \frac{i}{2} = \frac{AS}{Q^2}$$

$$\therefore Q = \sqrt{\frac{2AS}{i}} \dots \dots \dots \text{E.O.Q.}$$

It can also be proved that at Q = E.O.Q. the ordering costs and inventory carrying charges are equal:

$$Q = \sqrt{\frac{2AS}{i}} \therefore Q^2 = \frac{2AS}{i} \text{ or } \frac{Q \times i}{2} = \frac{AS}{Q} \text{ i. e. inventory costs} \\ = \text{ordering costs.}$$

It may be noted here that the shape of the total cost curve is fairly flat near about the Q = E.O.Q. or in other words if you order a little more or a little less than the E.O.Q. the total costs increase only slightly. In practice, 25% less or more than E.O.Q. makes very little difference in the total costs. Also the formula is quite general and A need not necessarily be annual consumption. A could very well be 6-month consumption. However, in that case 'i' should be taken as inventory carrying charges per Rupee for 6 months.



**EXAMPLE :**

An oil engine manufacturer purchases Lubricators at Rs. 42/- per piece from a vendor. The requirement of these lubricators is 1800 per year. What should be the order quantity per order (S=Rs. 16 & i= 0.2) ?

$$\begin{aligned} \text{Annual requirement in Rupees} &= 1800 \times 42 \\ &= \text{Rs. } 75,600 \quad S = \text{Rs. } 16 \\ & \quad \quad \quad i = 0.2 \end{aligned}$$

$$\text{E.O.Q.} = \sqrt{\frac{2 AS}{i}}$$

$$\begin{aligned} \text{Substituting E.O.Q.} &= \sqrt{\frac{2 \times 75600}{0.2} \times 16} \\ &= \text{Rs. } 34,776 \end{aligned}$$

$$\begin{aligned} \text{at price Rs. } 42/\text{- the quantity} &= \frac{34776}{42} \text{ lubricators} \\ &= 82.8 \text{ or } 83 \text{ since .8 lubricators cannot be supplied.} \end{aligned}$$

**EXERCISE :**

- (a) Calculate the total costs at order quantity of 83 lubricators per order.
- (b) Calculate the total costs at order quantity of 100 lubricators per order and compare the costs a and b.

**MODIFICATION OF E.O.Q.**

Now we can go back to our assumptions of stores cost and ordering costs. In both the cases it will be noticed that a substantial portion of costs is fixed and the rest variable. If you reduce the quantities of stocks by 25% do you pay a rent of 25% less? Can you reduce a few clerks in stores? Similarly, if you place 25% less orders can you reduce the salaries of purchase officers by 25%? Or can you lay off 25% of purchase personnel? Since such is not the case, it is more proper to consider only the variable portion of the ordering costs and the variable portion of inventory carrying costs. The E.O.Q. formula will still hold good except that S will be variable costs per order and i=variable portion of carrying costs.

Variable ordering costs would be the costs under heads:

- (1) Postage, Telegraph and telephone bills
- (2) Stationery and other consumables required
- (3) The entertainment charges
- (4) Travelling expenditure

(5) Lawyers and court fees due to legal matters and variable inventory carrying charges would be:

- (i) Interests
- (ii) Loss through deterioration and obsolescence
- (iii) Materials rendered obsolete
- (iv) Taxes
- (v) Insurance

**EXERCISE :**

Calculate E.O.Q. for the lubricator example given above

(S variable=Rs.6 & i Variable=.1 )

Hint : Use formula  $Q = \sqrt{\frac{2A S_v}{i_v}}$  where  $S_v$  &  $i_v$  represent the variable portions of respective costs.

**LEAD TIME:**

Referring to the over-simplified "Procurement and Consumption Cycle" described earlier two more elements viz. lead time and safety stock can now be introduced to make the cycle more practical.

In the earlier cycle the supplies of materials were assumed to be immediate on 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 stock*. This time is called as "Lead Time" and involves the time for the completion of all or some of the following activities:

1. Raising of a purchase requisition
2. Inquiries, quotations, scrutiny and approval (Import license procedure for imported items)
3. Placement of order on a supplier/suppliers
4. Suppliers time to make the goods ready (may have to be manufactured or supplied ex-stock)
5. Transportation and clearing
6. Receipt of goods at the company
7. Receiving inspection
8. Taking into stock

Obviously, in order to receive supplies before the stock reaches a 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 No. 3.

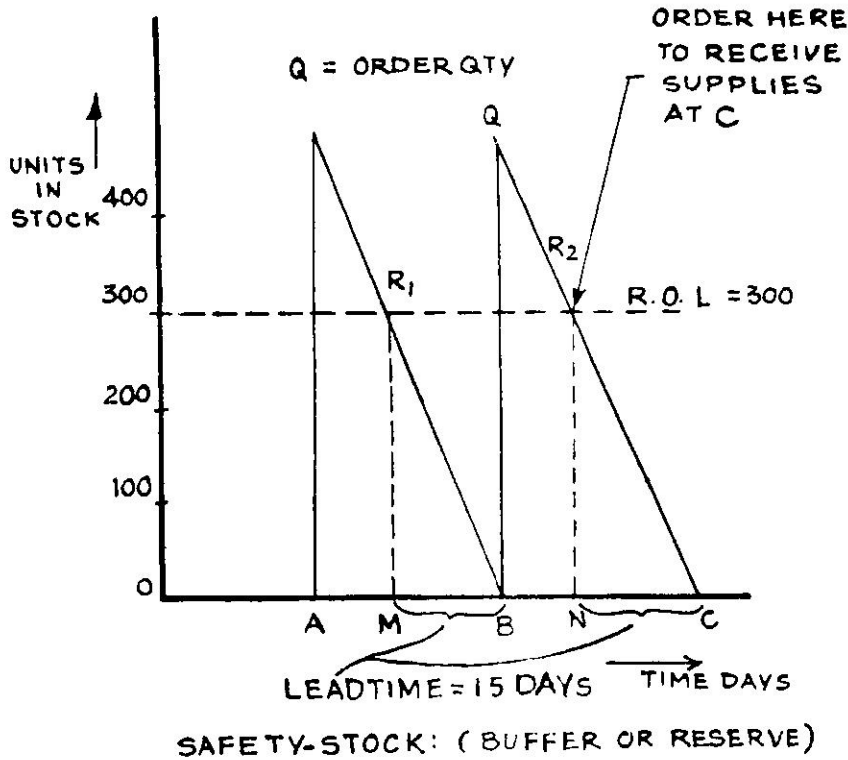


Fig. 3

Suppose an item has a lead time of 15 days and the monthly consumption of the item is 600 units, then a re-order must be placed when the stock available is sufficient to last for 15 days i.e. 300 units.

In the graph  $Q = \text{order quantity}$   $MB = NC = 15 \text{ days}$  i.e. lead time  $\text{Re-order level (R.O.L.)} = \text{stock sufficient to last during the lead time of 15 days} = 300 \text{ units}$ .

(SAFETY-STOCK) (BUFFER OR RESERVE):

It is well known from experience that neither the consumption rate of a material is constant throughout the year nor is the lead time. Hence in the earlier example, though we placed a re-order 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 stockout 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 and this is called as "Buffer Stock or Safety Stock

or Reserve". This stock also comes handy in case of (1) any excessive in-process rejections (2) rejections at the time of receipt of goods due to damages or substandard quality, etc.

Since Safety Stock is a part of inventory, it should be maintained just sufficient to guard against the uncertainties and not too excessive (especially for A items).

As the uncertainties are unpredictable there is no accurate method of determining what should be the most economic safety stock; though there are certain methods based on statistics and simulation for calculating Safety Stock.

Before deciding on how much the Safety Stock should be, analysis of the following aspects is most essential :

1. Is the variation in consumption more predominant or that in the lead time ?
2. If the variation in consumption is more predominant why is it so ? and can it be forecast in advance ?
3. If the variation in lead time is more predominant, is it restricted to a particular period (say Monsoons) or spread all over the year ?

In most cases it is found that the variations in consumptions can be predicted fairly accurately in advance by good production and maintenance planning and does not present much of a problem. But in the present Indian conditions, it is the lead time variation that 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 should then be sufficient to last the period difference between maximum and normal lead time.

Suppose for an item the monthly consumption is 100 units, the normal lead time is 15 days and the maximum lead time is estimated as one month. The Safety Stock would be (Maximum lead time in a month—Normal lead time in a month) × monthly consumption :

$$= (1-1/2) \times 100$$

$$= 50 \text{ or say } 60 \text{ to be on the safer side.}$$

Or for an imported item with a normal lead time of 1 year and maximum estimated lead time 15 months, the Safety Stock would be = Stock to last (15—12)=3 months or say 4 months for additional Safety.

*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. If normal lead time consumption is 300 and Safety Stock is 100, the re-order level is set at 400 units (i.e. Safety Stock + lead time consumption = R.O L.).*

In quite a few cases it is noticed that the lead time increases in monsoons or in a particular period or periods of year. In such cases Safety Stock should be sufficiently raised only near about these periods and not all through the year.

### OPTIMUM SAFETY STOCK:

If the safety stock maintained is inadequately low the inventory carrying charges (on the safety stock) would be low but stock-outs will be frequently experienced and the stock-out costs would be very high. As against this, if the safety stock maintained is rather large, stock-outs would be rather rare resulting into low stock-out costs but the inventory costs would be high. Hence, it is necessary to strike a balance between stock-out costs and inventory costs to arrive at an optimum safety stock.

Stock-outs may give rise to the following losses:

1. Customer dissatisfaction or customer loss.
2. Loss of production.
3. Idling of machines or men.
4. Emergency purchases at high prices.
5. Extra transportation charges for speedier modes of transportation.

We will now consider with the help of an example the calculation of optimum safety stock.

#### **Example :**

A small camera maker sells imported electronic flash gun with his camera as an optional accessory. Last 3 years records indicate that the average demand for the flash guns was about 100 units per month, the actual demand varying generally between 70 to 140 units per month. Only thrice had the demand exceeded 140 and was 150, 160 and 180 units per month. The camera maker, by an agreement with a reliable overseas supplier, receives 100 guns each month. Calculate the most economic safety stock the supplier should hold. Assume inventory carrying charges of 20%; the landed cost of gun = Rs. 200 per unit. In case of excess demand the camera maker purchases extra units from other importers at a premium of Rs. 50 per unit.

In this case there are two variable costs (1) Inventory carrying charges and (2) stock-out costs. (The ordering costs are also there but are independent of Safety

Stocks). If the safety stock held is say 75 then the consumption cycle would be as graphically shown in Fig. No. 4.

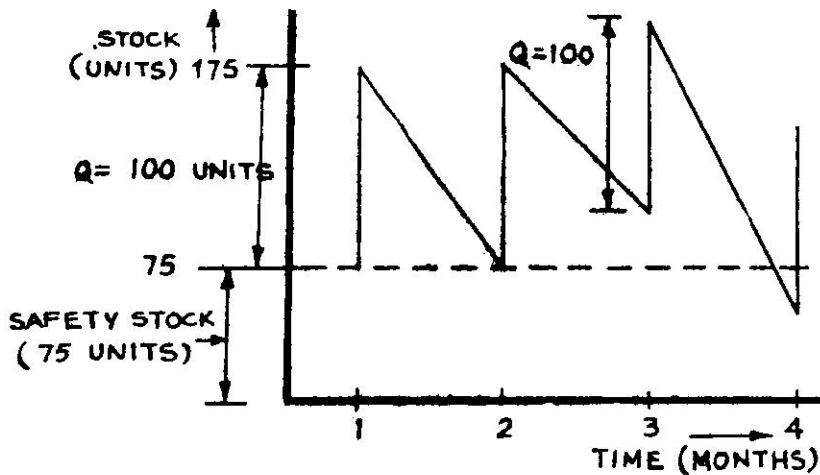


Fig. 4

$$\begin{aligned} \text{Average inventory} &= \left( \text{Safety stock} + \frac{Q}{2} \right) \\ &= \left( 75 + \frac{100}{2} \right) \\ &= 125 \text{ units} \end{aligned}$$

$$\begin{aligned} \text{\& Inventory carrying charges for 3 years (Simple Interest)} \\ &= (125 \times 200 \times 0.20) \times 3 \\ &= \text{Rs. } 15,000 \end{aligned}$$

With a starting stock of  $(75 + 100) 175$ , only once in 3 years would there be a stock-out of 5 units (when consumption rate is 180) and the same will be purchased at Rs. 50 premium each.

$$\begin{aligned} \text{Therefore stock out costs} &= 5 \times 50 \\ &= \text{Rs. } 250 \end{aligned}$$

$$\begin{aligned} \text{Therefore total costs} &= 15000 + \text{Rs. } 250 \\ &= 15250 \text{ at safety stock of } 75 \text{ units.} \end{aligned}$$

Similarly, the costs with various other safety stocks are calculated and given in next page in a table form.

<i>Safety Stock Units</i>	<i>Maximum stock = (Safety Stock + Q)</i>	<i>Inventory costs (3 years)</i>	<i>Stockout costs (3 years)</i>	<i>Total costs (3 years)</i>
85	185	16200	0	16200
80	180	15600	0	15600
75	175	15000	250	15250
70	170	14400	500	14900
65	165	13800	750	14550
60	160	13200	1000	14200
55	155	12600	1250 + 250	14100
50	150	12000	1500 + 500	14000-Min. costs
45	145	11400	1750 + 750 + 250	14150

This indicates that the most economic safety stock is around 50 units (total costs Rs. 14000 for 3 years) and that it is more economical to go out of stock occasionally than to try to provide for all possible demands.

These considerations should be specially applied for perishable items, short-shelf life items, and for non-critical items (i.e. the ones that do not have a very significant effect even if they are out of stock for some time. Example: Worker's uniforms, paper weights in an office, etc.). Elsewhere, these considerations should be applied with caution, since stockouts can have serious side effects, like:

1. Loss of customer.
2. Loss of goodwill.
3. Loss of employee morale due to lack of work.
4. Loss of face for sales personnel.
5. Interdepartmental conflicts and tensions.

Also, the availability at even premium prices may be difficult and quality of such goods may not be very reliable.

## IV - TECHNIQUES OF INVENTORY CONTROL (ORDERING SYSTEM)

Having discussed all the basic elements of a procurement and consumption cycle we can now pass on to various ordering systems:

### FIXED ORDER QUANTITY SYSTEM, OR E.O.Q. SYSTEM OF ORDERING:

In this system of ordering, each time a fixed quantity equal to E.O.Q. is ordered. The Safety Stock and lead time consumption is calculated as mentioned earlier and reorder level is set at (Safety Stock + Lead time consumption). The procurement and consumption cycle is as shown graphically in fig. No. 5. At A a supply equal to

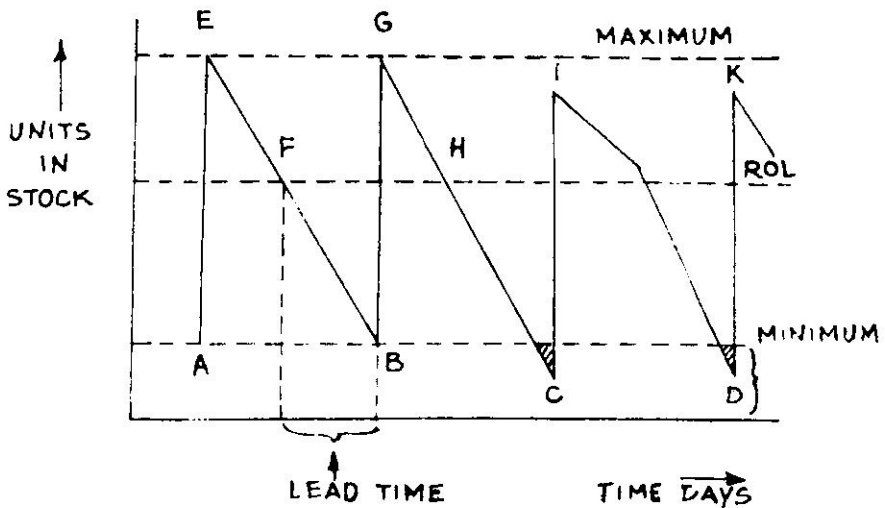


Fig. 5

E.O.Q. is received and the quantity in stock reaches a point E. The materials are then issued and at time F when the stock reaches the re-order level an order is placed for quantity  $Q = \text{E.O.Q.}$  and the issues continued. At B the supplies of order placed at F are received and the stock reaches G. In the further part of cycle it should be noted that at C there is a delay in receiving the supplies and we cut into the Safety Stock. Similarly at D due to heavy consumption we cut again into the Safety Stock. Three elements are to be decided for an item to be placed on this system of ordering:

1. E. O. Q. =  $\sqrt{\frac{2 AS}{i}}$  Price ( to convert Rs. into quantity).



2. Minimum = Safety Stock = (Max. lead time — Normal lead time)  
 × consumption rate + a little extra stock  
 (This is in case lead time variation is predominant)
3. R.O.L. = Safety Stock + lead time consumption.

**Example :**

Find out the various Parameters for setting up the fixed order quantity system for an item with following data:

Annual consumption 10000 units price = Re. 1/unit

S = Rs. 12

i = 0.24 (consumption more or less constant throughout the year)

Past lead times: 15 days, 25 days, 13 days, 14 days, 30 days, 17 days.

$$\begin{aligned} \text{E.O.Q.} &= \sqrt{\frac{2 AS}{i}} \\ &= \sqrt{\frac{2 \times 10000 \times 12}{0.24}} \\ &= \text{Rs. } 1,000 \end{aligned}$$

E.O.Q. (units) = 1000 units i.e. order quantity.

Excluding the high lead times of 25 days and 30 days the lead time varies from 14 to 19 days. Thus normal lead time is around 15 days (one may decide this by average also).

$$\begin{aligned} \text{Safety Stock} &= (\text{Max. lead time} - \text{normal lead time}) \times \text{monthly consumption} \\ &= \frac{(30-15)}{(30)} \times \frac{10000}{12} \\ &= 416.66 \text{ rounded off to } 450 \text{ units for more safety.} \end{aligned}$$

Normal lead time consumption = normal lead time in months × monthly consumption:

$$= \frac{15}{30} \times \frac{10000}{12}$$

= 416.66 rounded off to 417 units

Hence re-order level = Safety Stock + normal lead time consumption  
 = 450 + 417  
 = 867 units or 870 units.

The inventory would fluctuate from a maximum of 1450 to a minimum of 450:

$$\text{Hence average inventory} = \frac{1450 + 450}{2}$$

=950 units

(In practice average inventory would be lower, since during certain periods you would cut into safety stock because of uncertainties and during these periods your average stocks would also come down).

The fixed order quantity system lowers the inventory and ordering costs and is recommended for A & B items with.

1. More or less uniform rates of consumption i.e.

$$\frac{(\text{Max. monthly consumption} - \text{Min. monthly consumption})}{\text{Average monthly consumption}}$$

upto about 30 per cent (if this is more the system still works but the economies are reduced)

and

2. Steady marked prices.

There are certain disadvantages of this system which should be understood before deciding about ordering an item by this system.

1. The orders are raised at irregular intervals which may not be convenient to the suppliers.
2. In case the lead time is very high, say 3 months, and the ordering quantity happens to be materials supplies for one month, there would be 2 or 3 pending orders with the supplier each time and there is every likelihood that he may supply all orders at one time.
3. The items cannot be grouped and ordered at one time since the reorder points occur irregularly. It is quite likely with this system that you order 4 items each month from the same supplier but at 4 different dates which would increase the purchasing work as also the transportation and clearing costs.
4. E.O.Q. may give you an order quantity which is much below the supplier's minimum (For a good discount).
5. There is always a chance that the ordering level for an item has reached but someone has failed to take note of it in which case a stock-out may occur.

#### FIXED PERIOD ORDER SYSTEM, PERIODIC REVIEW SYSTEM, REPLENISHMENT SYSTEM:

In this system the stock of an item is checked at a certain fixed interval and a re-order is placed for a quantity by which the stock level has fallen down from a pre-determined level (also called as replenishment level). From the cycle shown in Fig. No. 6 it can be explained how the replenishment level is determined.

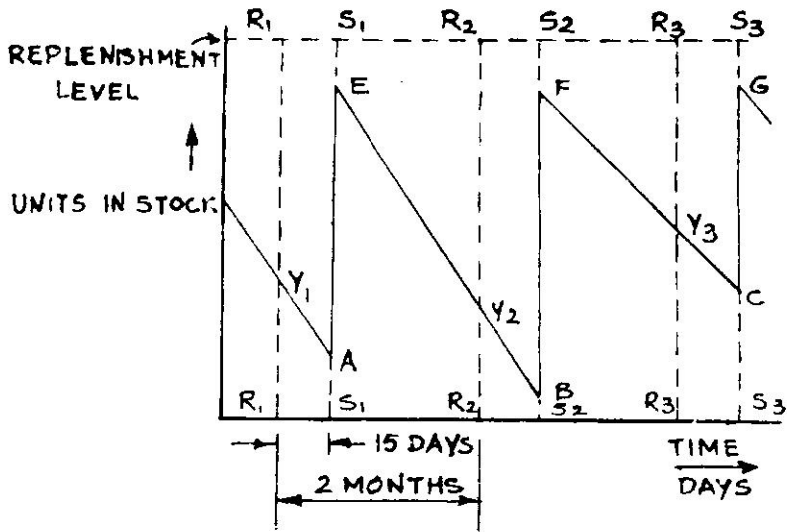


Fig. 6

Suppose we fix the review period for an item as 2 months and the lead time for the item is 15 days. Then the order would be placed every 2 months, i.e. at ordinates  $R_1, R_2, R_3$  etc. and the respective supplies would be received at ordinates  $S_1, S_2, S_3$  etc. (i.e. 15 days after  $R_1, R_2, R_3$  etc.).

At  $R_1$  let us assume the stock available to be  $Y_1$  then this stock together with the quantity ordered at  $R_1$  (Supplies received at  $S_1$ ) should be sufficient to last till the next supplies are received at  $S_2$  i.e. to last for a total period of 2-1/2 months (1 Review + 1 lead time).

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

$$\begin{aligned} \text{Hence replenishment level} &= \text{Stock to last (Review period + lead time + Safety stock)} \\ &= \text{Average monthly consumption (Review period in months + lead time in months) + Safety stock.} \end{aligned}$$

$$\text{and order quantity} = \text{Replenishment level} - \text{stock available.}$$

#### REVIEW PERIOD:

For determining what should be the review period for an item the major considerations are :

- (a) The minimum quantity on which a supplier would give good service (Price, delivery etc.).
- (b) The average consumption rate.

If an item is consumed at a rate of 1000 units per month (Price Rs. 10/unit) but the supplier's minimum quantity is 5000 units per consignment it may be proper to fix the review period as over 5 months (say 6 months). But in case this factor is not significant and the supplier supplies any quantity; the review period can be fixed on the basis of E.O.Q. If the E.O.Q. for the item happens to be a quantity equivalent to 2 months consumption; the review period can be fixed at 2 months so that in effect each time the order quantity would be near about E.O.Q.

It must be remembered, however, that the economies of review system with review period based on E.O.Q. are not the same as E.O.Q. system itself, because of the differences in safety stocks that have to be maintained in the two systems.

In the review period system once an order is placed at  $R_1$  you get a chance of placing another order only at  $R_2$  and the supplies from this order would be in hand at  $S_2$ . Thus the safety stock should be sufficient to meet any increased consumption from  $R_1$  to  $S_2$  and also to take care of any delay in supplies.

For putting an item on review system 3 elements would have to be determined:

- (i) Review period
- (ii) Safety stock
- (iii) Replenishment level.

For the items to be put on this system, a review schedule is made which gives the dates of review and against each date a list of all the items to be reviewed on that date are mentioned.

**Example :**

Put the item with following data on review period system  
 Annual consumption=14000 units — price Rs. 10 per unit  
 Supplier's minimum quantity=1000 units  
 Normal lead time 10 days. Maximum lead time=15 days.  
 Maximum consumption=1.20 (average consumption)

Since the suppliers minimum quantity is 1000 units, maximum number of orders to cover the annual requirement would be:

$$\frac{14000}{1000} = 14 \text{ orders. The review period should therefore be } \frac{1}{14} \text{th of an year or } 26 \text{ days.}$$

It may be more convenient to have a review after a month than after 26 days.

∴ Review period = 1 month

$$\begin{aligned}
 \text{Safety stock} &= \text{Maximum consumption rate (1 review period +} \\
 &\quad \text{1 maximum lead time)} \\
 &= \text{Normal consumption rate (1 review period +} \\
 &\quad \text{1 normal lead time)} \\
 &= 1.20 \times \frac{14000}{12} \left(1 + \frac{15}{30}\right) - \frac{14000}{12} \left(1 + \frac{10}{30}\right) \\
 &= 1400 \times 1.5 - \frac{14000}{12} \times \frac{4}{3} \\
 &= 2100 - 1555 \\
 &= 545 \text{ units say } 550 \text{ units.}
 \end{aligned}$$

Replenishment level = Average rate of consumption (1 review period +  
1 normal lead time) +  
Safety stock

$$\begin{aligned}
 &= \frac{14000}{12} \left(1 + \frac{10}{30}\right) + 550 \\
 &= 1555 + 550 \\
 &= 2105 \text{ units.}
 \end{aligned}$$

The maximum inventory when the supplies are received would be:

$$\begin{aligned}
 &= 550 + \text{order quantity} \\
 &= 550 + \frac{14000}{12} \\
 &= 1710 \text{ units and the minimum inventory would be } 550 \text{ units}
 \end{aligned}$$

$$\begin{aligned}
 \text{So average inventory} &= \frac{1710 + 550}{2} \\
 &= 1130 \text{ units.}
 \end{aligned}$$

Sometimes the consumption of an item is not very steady but it can be estimated from time to time in such a case the following formula can be used:

$$\text{Quantity ordered } Q = (C + L + R) - V$$

Where C = Consumption expected till the next review date

L = Average lead time consumption

R = Safety stock (Reserve)

& V = Stock available (on hand or on order, or both on hand +  
on order, as the case may be)

Review period system can be applied to A & B items. It can also be applied to C items in combination with two bin system. Its main advantages are, group purchases and convenience in operation. It appears to be less economic compared with E.O.Q. system in terms of ordering costs and inventory carrying charges, but may in some cases prove to be otherwise; if the overall economics and convenience is considered.

## SINGLE ORDER & SCHEDULED PART-DELIVERIES SYSTEM:

(Annual or 6 monthly contract).

In this system the total requirements of an item for a particular period (usually 6 months or 1 year) are covered in a single order or contract with instructions, however, to supply a number of part-deliveries at specified times.

A typical order may contain the total requirements and supply schedule such as:

<i>Item/ Code</i>	<i>Quantity</i>	<i>Price in Rs.</i>	<i>Date of delay</i>	<i>Quantity</i>
1095 Ball bearings S.K.F. 6062	6,000	Rs. 6.50 per pc.	1-4-70	500
			15-4-70	500
			2-5-70	500
			30-5-70	500
			30-6-70	500
			30-7-70	500
			15-8-70	500
			21-8-70	1000
			1-9-70	1000
15-9-70	500			

or the supply schedule may be specified in another case as:

Supply 500 units each fortnight with the 1st delivery on 1-4-70.

In this system both ordering costs and inventory carrying charges are reduced, since only one order is placed for, may be, an entire years' requirement of an item but the actual procurement is broken into a number of small scheduled deliveries thus keeping low average inventory on hand at any time.

Since the ordering cost cannot (only one order is placed) be reduced further attention should be on inventory costs, which can be reduced by reducing the quantity per delivery to the extent possible (of course taking into account the transportation costs, follow-up costs, etc.).

This system has many advantages over the other systems of ordering. The ordering and inventory costs are low. The ordering work is considerably reduced

though follow-up work for each delivery may be necessary. The suppliers also give better price discounts, since the sale is guaranteed. The service i.e. keeping to delivery schedule, is better since the supplier knows your requirements in advance and can plan for it.

The only disadvantages of the system are :

- (1) In case the item becomes redundant subsequently or its requirement is reduced considerably, penalties may have to be paid to discontinue the contract or reduce the quantity of contract.
- (2) In case the market price of the item reduces after entering into contract it becomes difficult to revise the price of the contract.
- (3) In case the market price of the item increases substantially after the contract, there is a chance of the suppliers service becoming bad (since he would prefer selling in market at higher prices to supplying on contract at lower prices). This can, however, be corrected by paying high rates to the supplier (These would still be below market prices).

However, in practice due to the advantages of the system suppliers in most cases they agree to compromise and the burden to the buyer is reduced. This system is recommended for all A, B, and also C items.

## V - INVENTORY CONTROL IN OPERATION

Having dealt with the various techniques of inventory control in the earlier chapters, we would discuss in this chapter the operation of an inventory control system.

In order to understand the operation of an inventory control system better, it is necessary first to discuss a basic inventory control form called as inventory card, stock card or inventory record.

### INVENTORY RECORDS:

An inventory record or stock record has two main functions to fulfil in inventory control. First it should provide in a convenient form the information, such as consumption pattern, lead times, cumulative consumption etc. which is necessary for framing the inventory policies. Secondly, it should also give the various stock transactions, the balance on hand, order levels, order quantities or review periods and replenishment levels etc. for day-to-day action such as placement of orders, emergency follow-up and so on.

Minimum information a stock record usually gives for each item is (1) Identification and Name of an item (2) A record of stock transactions (such as receipts, issues etc.) and (3) Balance on hand. This information alone would suffice only for an elementary type of inventory control and in practice, most inventory control systems described earlier would call for more information such as:

- (a) A more descriptive item reference.
- (b) The principle use/uses of the item (Assy No./Code etc.).
- (c) The number and date of documents from which the posted figures of stock transactions (issues, receipt, etc.) are taken.
- (d) Allocation (i.e. reservation of stock against a future order) and available balance.
- (e) Order quantities, R.O.L., safety stocks (Minimum) or review periods, and review dates and minimum order quantities, if any.
- (f) Cumulative figures of consumption.
- (g) Money value of stocks and transactions.
- (h) Purchase requisition numbers, dates and quantities, due dates of deliveries.
- (i) Reference to production schedules; and may be some more.

However, not all the above mentioned information may be necessary for one single item and the requirement would differ from item to item.



Earlier, bound-stock-registers were very popular as stock records. One or more sheets used to be allotted for each item and the stock transaction entered in appropriate columns. These registers were primarily meant for stock accounting purposes and used to contain information suitable only for an elementary control. The registers present certain clerical inconveniences. Since only one clerk can handle one register at a time; division of work is not possible, unless of course there are a number of registers. Then again the registers are bulky to handle and locating the page for an item, takes more time. The major drawback with conventional registers, however, is that they do not allow a rapid examination of the items to separate only those that call for action (such as placing a reorder, or emergency follow-up etc.).

The registers are fast getting obsolete these days and many companies today have switched over to loose card records and visible index filing systems. In visible index systems, one card is allocated for each item and these cards are inserted into a series of pockets in a file tray or placed in other gadgets, so that they overlap each other leaving only a small margin at the bottom or on side of each card visible. This margin carries the identification of the item and may carry coloured signals indicating the stock level of the item, the month in which the last order was placed or the date on which the card was checked last, and any other information of particular interest in inventory control. Loose card records, do not have these features, but they allow division of work.

The design of the cards is made by each organisation to suit its own requirements. A fundamental error one is likely to commit in this respect is to have one type of card for all the items and to record information on this to the same degree of detail irrespective of the importance of the various items. This defeats the very purpose of selective control and also increases the recording work unnecessarily. To give any set rules is rather difficult though information under the exhibits given on the adjoining pages would be quite helpful in the design of cards.

### EXHIBIT-3

Visible inventory cards housed in cabinet trays, with travelling requisition card in the upper position and inventory—status signalling devices at lower visible edge.

#### NOTE:

1. The "Travelling requisition" serves as a purchase requisition. Every time an order is required to be placed a row under the column "Requisitioned" is filled up and the card is sent to Purchasing for placement of an order. Several requisitions can be raised on one card and each time, it is not necessary to write the name of the item, specification, etc.

2. Travelling Requisition contains dates of Requisition and dates of receipt thus giving the lead times for analysis. It also contains monthly usage, data for the analysis of consumption pattern.
3. The stock card (lower form) gives information about Receipts, Issues, Balances and in addition cumulative monthly issues.
4. Note the signals at the lower edges of the cards. The small vertical signals on the left indicates the month in which the last order was placed. The right hand tip of the long horizontal signal indicates the stock position (usually in terms of weeks-stock). Note also that the dark vertical lines at right indicate the stock position in terms of overstock, order level and follow-up. Thus at a glance it is possible to single out from a tray of many items only those calling for action.
5. This type of card is suitable for A & B items placed on E.O.Q system as can also be adopted for items placed on review period system.

#### EXHIBIT-4

Example of a stock card with provision for advance Reservation of materials for issues (i.e. Allocation, Booking or Apportioning).

**NOTE:** In case of Apportioning; the requisitions are sent in advance to the inventory control and the appropriate quantities of materials are apportioned against each requisition. The total quantity so apportioned—but still not issued—appears under column "Apportioned Balance". Quantity available over and above this appears under "Available Balance". "Quantity Proof" is the sum of these two columns.

Total due on order appears under column "on order Balance" and quantity actually in stock appears under column "Quantity Balance" and the next column "Quantity proof" is the sum of these two columns. This "Quantity proof" and the "Quantity Proof" mentioned in earlier paragraph should always be equal.

This kind of card gives not only the present status of stock but also the future requirements.

Note also the last three columns, which give the value of stock on hand. Entries in these three columns are made only for receipts and issues and not for apportioning or ordering since the latter are not actual stock transactions.

These type of cards are suitable for important direct materials of A types (sometimes may be even applied for B items).

## EXHIBIT-5

Vertical visible index cards.

**NOTE:** These cards are filed vertically and singled to the left of adjacent cards so that the reference margin of each card is visible (i.e. CHK—date of last check and Number).

### INVENTORY CONTROL SYSTEM (INFORMATION FLOW)

The operation of an inventory control system takes place through a channelised flow of information, connected with inventory control, among the various departments of an organisation.

One such information flow is given below and explained with the help of a block diagram to give an idea of the working of a typical inventory control system. In practice the information flow takes place through different forms and paperwork procedures; which differ widely from company to company and, therefore, these are not discussed here.

#### EXPLANATION OF EXHIBIT 6:

1. Sales forecasts are made by Sales Department and passed on to Production Planning Department.
2. Production Planning converts the forecasts into long-term production schedules and sends these to Inventory control.
3. Bills of Materials are sent by Design department to Inventory control.
4. Maintenance department and other operational departments are also send their periodic requirements of materials to the Inventory control.
5. Purchasing department supplies the data regarding lead time for various group of items to Inventory control.
6. Inventory control draws up from (a) Production schedules (b) Bills of materials (c) Periodic materials requirements of other departments (d) lead times and (e) Past records; the inventory control policies.
7. Production Planning sends short-term periodic schedules from time to time to Inventory control and the inventory policies are suitably revised (Mainly the order quantities for items put on scheduled deliveries and review period systems are revised).

8. From the periodic schedules the Production Planning prepares work orders and materials requisitions. A few days before issuing these to the Production shops, Planning sends the materials requisitions to inventory control for checking the availability of materials and also for reservation of materials for the concerned work orders.
9. Inventory control checks the availability of materials from the records and reserves the materials for these orders. (Mainly direct materials and of A & B classes only).
10. These are now okayed for materials and sent back to Production Planning.
11. Production Planning issues the work orders and materials requisitions to the Production Department.
12. Production Department presents the materials requisitions to the stores as and
13. & when necessary and draws the materials.
14. The materials requisitions are sent by stores to the Inventory Control, where
15. & the issues are posted on Inventory records.
16. Whenever any item reaches reorder level or the review date for an item occurs the inventory control raises a purchase requisition and sends it to purchasing.
17. After inquiry from vendors, the due date is informed by purchasing to inventory
18. & control and orders are placed with vendors.
19. When the delivery is effected the Stores/Receiving section receives the goods
20. & and the goods receipts are passed on to the inventory control for posting receipts. The information flow described above is particularly applicable for batch type of production.

#### ORGANISATIONAL ASPECTS:

It would also be quite appropriate here to discuss the organisational aspects of inventory control.

Function of inventory control traditionally used to be associated with Stores and Purchasing but the trend is slowly shifting towards associating it with Production Planning, since the latter arrangement has certain definite advantages. Through their long term and short term schedules, Production Planning has the first hand information of what materials are required; in what quantities and when; which is

exactly the information required by Inventory control. Planning is also at an advantage with the associating of inventory function, since this allows them to ensure before issuing the work orders to shops that the necessary materials are available.

Inventory control and production planning are thus complementary functions and grouping them together is of mutual advantage.

However, for items with fluctuating prices or rather uncertain delivery periods association of Inventory Control with Purchasing will be more advantageous. Even otherwise, there will have to be always a close coordination amongst Production Planning, Inventory Control and Purchasing, because the lead times, consumption patterns and production schedules are all liable to change and are never static and so would be the inventory control policies. *It may also be stressed here in this context that any inventory control system is not- "Once-set, goes-automatic" type; but needs to be reset from time to time as the conditions such as lead time, consumption patterns etc. change.*

## QUESTIONS

1. Define inventory?
2. What are the benefits of having inventories?
3. What are the disadvantages of having excess inventories?
4. What are the objectives of inventory control?
5. Classify the 100 items given below into A, B and C classes:

<i>Sr. No.</i>	<i>Item</i>	<i>Annual Consumption (Rs)</i>	<i>Sr. No.</i>	<i>Item</i>	<i>Annual Consumption (Rs)</i>
1.	609 F	1,00,000	18.	197 W	4,500
2.	283 A	55,200	19.	204 G	165
3.	192 C	2,60,000	20.	197 P	1,320
4.	54 W	15,750	21.	890 G	32
5.	671 P	66,000	22.	641 K	23 60
6.	891 A	6,250	23.	182 A	134 40
7.	672 N	13,125	24.	237 C	4,550
8.	124 G	7,200	25.	918 W	4,700
9.	126 G	1,890	26.	50 G	830
10.	81 P	35,000	27.	556 F	7 20
11.	94 P	120	28.	45 F	72
12.	96 A	1,88,200	29.	56 F	252
13.	127 R	88,100	30.	568 A	446
14.	617 F	3,067	31.	35 F	380
15.	127 F	39,350	32.	202 A	609
16.	32 G	79,250	33.	642 B	4,950
17.	83 B	57,000	34.	763 E	249

<i>Sr. No.</i>	<i>Item</i>	<i>Annual Consumption (Rs)</i>	<i>Sr. No.</i>	<i>Item</i>	<i>Annual Consumption (Rs)</i>
35.	194 C	1,84,200	61.	290 A	4,500
36.	33 T	1,60,000	62.	818 E	1,750
37.	332 A	750	63.	819 T	364
38.	124 O	13,800	64.	351 A	17,000
39.	802 I	1,500	65.	167 O	810
40.	407 N	360	66.	839 T	3,645
41.	57 S	1,000	67.	35 N	512
42.	84 H	6,000	68.	202 S	7,500
43.	979 R	7,65,000	69.	642 H	3,600
44.	469 D	1,900	70.	763 R	21,600
45.	211 L	16,500	71.	33 D	73.60
46.	199 U	1,40,600	72.	332 L	1,680
47.	381 E	2,390	73.	90 U	5
48.	961 T	7,390	74.	124 P	400
49.	948 A	40	75.	80 U	4,400
50.	702 O	500	76.	407 T	1,647
51.	703 I	125	77.	578 H	1,550
52.	812 N	1,600	78.	669 T	850
53.	649 S	7,125	79.	899 N	3,500
54.	84 P	1,48,400	80.	211 G	20,000
55.	329 U	5,000	81.	381 H	600
56.	631 T	225	82.	522 E	9,260
57.	122 H	87	83.	961 S	55
58.	648 T	6,250	84.	948 T	4
59.	143 S	1,750	85.	631 A	36
60.	156 T	300	86.	122 U	1,120

<i>Sr. No.</i>	<i>Item</i>	<i>Annual Consumption (Rs)</i>	<i>Sr. No.</i>	<i>Item</i>	<i>Annual Consumption (Rs)</i>
87.	68 P	1,28,000	94.	73 A	6,750
88.	14 R	56,000	95.	570	6,790
89.	156 U	1,839	96.	491 R	3,275
90.	290 T	8,046	97.	167 S	350
91.	258 H	12	98.	703 T	5,700
92.	16 E	1,280	99.	231 U	8,300
93.	186 T	250	100.	839 V	1,614

6.
  - a) Rank the items in example 5 based on their consumption values (i.e. the item with highest value being ranked as 1 & so on).
  - b) Arrange them rankwise (1 in the beginning, 2 below that and so on).
  - c) Enter the cumulative consumption value against each item by adding to its own consumption value the consumption values of all items preceding it. (To reduce the quantity of work involved, you may proceed item by item only for A & B items and take every 10th C item).
  - d) Plot on a graph now the item ranks and the corresponding cumulative consumption values. (With item ranks 0 to 100 represented on x-axis and value in Rupees on the y = axis). Join the points so obtained by a smooth curve.
  - e) This is the well known "A-B-C curve" except that in ABC curve the x = axis represents the percentage of items and the y = axis represents the percentage of value.
  - f) A typical A-B-C curve (i) soars up rapidly in the beginning (A items) (ii) the rate of rise dropping off appreciably in the second phase (B items) and (iii) tends to flatten out in the third phase (C items).
  - (g) From this curve segregate the A-B-C items and see if that concurs with your classification in 5.
7. Discuss the inventory policies for A & C items.
8. Discuss the inventory policies for A, B and C items.



9. What are inventory carrying charges? How are they calculated?
10. What are ordering costs? How are they calculated?
11. From the data given below calculate:
- (a) Inventory carrying charges per Rupee per year.
- (b) Ordering costs in Rupees per order.
- (c) Variable portion of inventory carrying charges per Rupee per year.
- (d) Variable portion of ordering costs in Rupees per order.

**DATA :** (i) *Inventory holdings for year 1969-70 each month.*

Month	Rs.	Month	Rs.	Month	Rs.	Month	Rs.
April	12,00,000	July	15,00,000	October	13,20,000	Jan.	15,00,000
May	17,00,000	Aug.	15,00,000	Nov.	12,10,000	Feb.	12,90,000
June	17,90,000	Sept.	13,40,000	Dec.	14,50,000	March	10,00,000

(ii) *Stores and allied expenses :*

	Rs.
Salaries & wage bills for stores personnel	44,400
Taxes on inventories	30,000
Insurances	35,000
Expenses on consumables & stationery	4,000
Rent for stores space	24,000
Depreciation on equipment and repairs & running charges	5,000
Losses due to deterioration & loss of materials	6,000
Value of materials rendered obsolete, less scrap value recovered	1,600
Assume rate of interest on borrowed capital at 10%.	

(iii) No. of orders placed in 1969—70—2800

(iv) Purchasing and allied expenses:

Salaries & wages of purchasing personnel	61,200
Rent of space used by purchasing including electricity bill	6,000
Advertising, Postage/Telegrams & Telephone Bills, Stationery, travelling & entertainment charges	37,000

Lawyer's and court fees	5,200
Depreciation on equipment	600

12. Derive the formula for the Economic Order Quantity.
13. Assume ordering costs and inventory carrying charges as obtained from question 10 and calculate the E.O.Q. for an item with annual consumption of Rs. 5,60,000 both by taking variable costs and otherwise.
14. A company has  $i = 0.20$  and ordering cost = Rs. 40 per order. Calculate E.O.Qs for items with following annual consumption:

A Rs.	E.O.Q. (Rs.)	A Rs.	E.O.Q. (Rs)
40,00,000		10,000	
10,00,000		4,900	
4,90,000		2,500	
2,50,000		400	
1,60,000		100	
90,000			
40,000			

Plot now a graph of A vs. E.O.Q. and by interpolation find out E.O.Qs for  $A = \text{Rs. } 26000, \text{ Rs. } 110000$  and  $\text{Rs. } 5000$ .

15. A Pharmaceuticals company consumes 864 Kgs. of a chemical called Niacinamide every year. The prevailing market rates of the chemical are:
- Rs. 100/Kg. from 1 to 9 Kgs./per order.
- Rs. 96/Kg. from 10 to 99 Kgs./per order.
- Rs. 94/Kg. from 100 to 249 Kgs./per order.
- Rs. 93/Kg. from 250 to 1000 Kgs./per order.

Calculate the most economic quantity per order if  $i=0.20$  and  $s = \text{Rs. } 40$ .

*Hint :* In this case there are three variable costs in the picture (1) ordering costs (2) inventory costs & (3) the materials costs. In one price range, however, EOQ calculated as usual would give the lowest total costs in that price range.

*Proceed as follows :*

- a. Calculate EOQs for different prices by formula.

$$Q (\text{Units}) = \sqrt{\frac{2 AS}{iP}}$$

A being annual consumption in units & P being price per unit.

- b. Discard any fictitious values i.e. the price of one range giving an EOQ quantity not falling in that range.
- c. If there are more than one realistic solutions, select the highest EOQ.
- d. Calculate now the total annual costs at this EOQ (including materials costs also). Also calculate the total costs; at all those higher quantities where further rebates start (taking them as order quantities) and compare all these.
- e. The one giving lowest total cost is the most economic ordering quantity.

*Answer = 100 Tonnes per order.* The proof is left for the reader to find.

- 16. What is lead time? What are the various activities occurring during the lead time?
- 17. How much is the average lead time in your company for imported items? How is this time distributed on various activities?
- 18. Why are safety stocks necessary?
- 19. The average monthly consumption for an item is 200 units and the normal lead time is one month. If the maximum consumption has been upto 250 units per month and maximum lead time = 1 1/2 months, what should be the safety stock for the item if the item is controlled by EOQ system?  
(Answer about 175 units.)
- 20. Calculate the various parameters for the item in examples (19) for putting it on EOQ system of inventory control if  $S_v = \text{Rs. } 6$ ,  $I_v = 12$  and cost per unit = Rs. 1.50.

(Answer EOQ = 400 units. Safety Stock = 175 units & ROL = 375).

- 21. Calculate the various parameters for putting an item with following data on EOQ system.

Annual consumption = 12000 units (uniform consumption) price = Rs. 7/50 per unit  $S_v = \text{Rs. } 6$  and  $i = .12$ . Normal lead time = 15 days, maximum lead time = 20 days. (Answer EOQ = 400 units (i.e. 12 days supply) safety stock = about 200 units, ROL = 700 units).

(Note: Here, safety stock + EOQ which is the maximum stock on hand, is less than ROL. In such cases *quantity on pending orders* + stock on hand should be taken *together* to decide if ROL has been reached).

- 22. Discuss the disadvantages of Fixed Order quantity system.
- 23. Calculate the parameters for placing an item with following data on a review period system. Is it possible to put this item on EOQ system?

Average monthly consumption = 300 units, price = Rs. 4/units,  $S_v = \text{Rs. } 6$ , and  $I_v = 0.12$ . Supplier takes orders of minimum 500 units per consignment. Normal lead time  $x = 1$  month. Maximum lead time = 1 1/2 months. Maximum consumption = 500 units/month. (Answer Review Period = 2 months, safety stock over 500 units, Replenishment level = 1400 units, EOQ = 300 units which is not acceptable to supplier and hence EOQ system is unsuitable).

24. If in example (23)  $S_v$  was Rs. 24 and  $I_v = 0.12$  examine if item can be placed on EOQ system. If so calculate the safety stock.  
(Answer : 300 units. Note this is much less than safety stock for equivalent Review Period System).
25. Discuss advantages of a review period system. Point out also its drawbacks.
26. Discuss advantages and disadvantages of single order scheduled-part-delivery system.
27. Draw a block diagram and explain the inventory control, information flow as it exists in your organisation. What modification would you suggest to improve the same?
-

## SUGGESTED READING

<i>S.No.</i>	<i>Title of Book</i>	<i>Author</i>	<i>Publisher</i>
1.	Scientific Inventory Management	J. Buchan & E. Koenigsberg	Prentice-Hall of India Pvt. Ltd., New Delhi.
2.	Inventory Management In India	R. S. Chhadda	Asia Publishing House.
3.	Production & Inventory Control	W. E. Ritchie	American Technical So- ciety, U.S.A.
4.	Production Planning & Inventory Control	J. F. Magee	Mc-Graw Hill, New York
5.	Materials Management	N. K. Nair	Asia Publishing House, New York.
6.	Materials Management & O. R. in India	P. G. Manon	M. M. J. Publication, New Delhi-3.
7.	Industrial Engineering	H. B. Maynard	Mc-Graw Hill, New York.

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