
UNIT 18: INVENTORY MANAGEMENT

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18.0 OBJECTIVES

After studying this unit, you should be able to explain:

- The need for holding the inventories and cost-benefits associated with it.
- Economic order quantity as a tool to control inventory management costs.
- Re-order level, where the risk of non-availability of inventory for production needs is minimum.
- Quantify safety stocks and minimum stock levels to ensure continuous production.
- Tools of selective inventory controls such as ABC analysis applying the principles of the management by exception.

18.1 INTRODUCTION

The dilemma of the Chief Operating Officer (COO) of a firm in the present day world is to decide levels of different inventories to carry in order to ensure continuous and smooth production and in turn maximize the value of the firm. The average age of inventory along with average age of receivables will determine the days operating cycle (DOC) of a firm. Days operating cycle less average payment period to suppliers determine the days' working capital (DWC). Long DOC and short or negative DWC constitute high risk. DOC and DWC are the measures of the risk. The ratio of cash flow from operating activities to the sales is termed as cash conversion efficiency and is a measure of return. The COO has to make a trade-off between these two measures of risk and return while designing strategy for the working capital management. The working capital performance of corporate India in the diversified industry group for the year 2001 and the three-years' average is given in Table 18.1. The three-years average days working capital is 110 days and CCE is 15.64%.

Table 18.1 Working Capital Performance of Diversified Industry Group

	2001	3-Yr Avg.	2001	3-Yr	2001	3-Yr.
	CCE	CCE	DOC	Avg.	DWC	Avg.
			(days)	DOC	(days)	DWC
				(days)		(days)
Diversified Industry Group						
Century Textiles & Inds. Ltd.	15.93%	15.63%	157	178	102	128
E I D-Parry (India) Ltd.	7.64%	9.88%	151	143	75	75
Grasim Industries Ltd.	16.92%	18.15%	152	174	104	132
Hindustan Lever Ltd.	15.44%	13.63%	93	88	2	3
I C I India Ltd.	8.41%	10.17%	125	141	56	61
Indian Rayon & Inds. Ltd.	12.05%	14.63%	163	181	135	148
Kesoram Industries Ltd.	13.80%	19.17%	110	165	65	114
Larsen & Toubro Ltd.	8.59%	6.89%	233	210	162	142
Rallis India Ltd.	0.43%	3.94%	206	174	125	100
Raymond Ltd.	9.97%	17.50%	210	202	164	157
Reliance Industries Ltd.	19.30%	17.05%	58	64	4	-10
Tata Chemicals Ltd.	34.64%	40.97%	309	319	268	269
Industry Average	13.59%	15.64%	164	170	105	110

CCC = Cash conversion efficiency. It is the ratio of cash flows from operating activities to sales. It is a measure of return.

DOC = Days operating cycle. It is the sum of average age of inventory and average age of receivables. It is an average length of the operating cycle of the firm. It is a measure of risk.

DWC = Days working capital. It is DOC less average payment period to the vendors. It is also a measure of risk.

Anand and Gupta (2003) have found that the cash conversion efficiency ratio for the period 2000 -2001 is highest (62.01%) in case of Coal and Lignite Industry as against three-year (1998-99 to 2000 -2001) average of 47.57% in case of Telephone Services. The lowest CCE ratio for the period 2000 -2001 is -54.94% of Readymade Garments Industry as against three-year (1998-99 to 2000 -2001) average of -1.97% in case of Communication Equipment Industry.

For the period 2000 -2001, the highest DOC is of Computer Hardware Industry (2541 days) while it is of Telephone Services (3242 days) for three-year (1998-99 to 2000 -2001) average. The lowest DOC for the period 2000 -2001 is 45 days of Liquor Industry as against three-year (1998-99 to 2000 -2001) average of 41 days in case of Health Services.

The highest DWC for the year 2000-01 is of Computer Hardware Industry (2481days) while it is of Telephone Services (3155 days) for three-year (1998-99 to 2000 -2001) average. The lowest DWC for the period 2000-2001 is -234 days of Tourism Industry as against three-year (1998-99 to 2000 -2001) average of -272 days in same industry.

In this unit, you will learn as to how the COOs make trade off between risks and return while determining optimal levels of the different inventories of the firm.

18.2 NEED FOR HOLDING INVENTORIES

The firm holds inventory to ensure continuous production and to avoid a situation of stock-out. In the process, it incurs the carrying and handling costs. These are insurance, interest on funds blocked in the inventories, obsolescence, and handling & maintenance. The need for holding the inventories appears to be same as for the cash. The generally accepted arguments for holding inventories are transaction needs, precautionary needs, and speculative needs.

18.2.1 Transaction needs

The transaction need of holding inventories is dependent upon the manufacturing cycle & normal production level of the firm and policy of the management. The manufacturing cycle of the firm will vary from industry to

industry. It will be very large (months) in case engineering, procurement, & construction contractor and will be small in case of food processing, and detergent & soap manufacturer. The policy of the management such as aggressive, moderate, and conservative will also guide the inventory-holding period of the firm. An aggressive management will hold minimal inventories and conservative firm will hold high level of inventories.

18.2.2 Precautionary needs

The firm will like to hold some level of inventory for precautionary needs. The actual level of production may exceed the planned level and thus there is need for higher level of inventories. It may be in case of firm, which is in a seasonal industry or has just come out of a recession. The objective is not to have stock out but at the same time not to erode the profitability of the firm by maintaining excessive inventories.

18.2.3 Speculative needs

The management of the firm depending on its attitude may like to benefit from speculative activities by maintaining the higher level of inventories to benefit from the price fluctuations.

Maintaining inventories entails cost. Lack of inventories causes disruption in production, unsatisfied demand, and customer switching to the competitors. Thus, there is a need that firm should be able to quantify optimum level of inventories and hold it.

18.3 OBJECTIVES OF INVENTORY MANAGEMENT

The firm has to make a difficult choice between maintaining a large size of inventory to ensure continuous production and at the same time have minimum investment in the inventories to increase the profitability.

18.3.1 Return

The objective of firm should be to have optimal investment in the inventories, which yields maximum return on investment (ROA). The inventories constitute a major part of assets in case of retailer.

$$ROA = \frac{NOPAT}{Sales} \times \frac{Sales}{Assets}$$

Where:

NOPAT	=	Net operating profits after taxes or EBIT (1-T _c)
Assets	=	Investment in Fixed assets and current assets less non-interest bearing current liabilities
T _c	=	corporate income tax rate

18.3.2 Risk

The risk relating to the inventories faced by the management of the firm is the possibility of stock out. In case of manufacturing firm, the product may be held up due to non-availability of raw materials, stores, and thus lead to delay in delivery and loss of customer. The firm should have optimum investment in the inventory.

To quantify the optimum level of inventories will not be difficult if the firm is able to estimate the annual consumption levels and time required to replenish the stocks precisely. This is possible in a certain environment. However, the firms operate in an uncertain environment. Thus, the firm has to make most likely forecasts, optimum forecasts, and pessimistic forecasts to decide inventory levels. It may follow a conservative policy or aggressive policy. The firm with aggressive management style may carry minimum safety stock. The firm with conservative approach will carry higher level of inventories to avoid the possibility of stock out.

18.3.3 Risk & Return trade off

The CFO of the firm has to make a risk return trade off in the following context:

- To decide how much safety stock level to maintain in order to avoid the stock out situation. It involves the analysis of expected stock out cost and relevant carrying cost of safety stock.

The management situation on this dilemma will be discussed in the next section after the discussions on the various stock levels.

- To determine the inventory holding period vis-à-vis cash operating profits of the firm.

The Indian industry practice on the above dilemma is presented in section 18.6.

18.4 INVENTORY MANAGEMENT TECHNIQUES

18.4.1 Economic order quantity

The firm has to decide the inventory order quantity. If the order quantity is large, the firm economizes on the ordering cost, as the number of the orders will be less during the year. The ordering cost is the administrative cost associated with the placing of an order. For example, if the annual production level of a motorbike manufacturer is 100,000 units, the tyres and tubes required will be 200,000. If the firm places an order for 50,000 tyres and tubes at one time, it has to place just four orders during the year. However, the inventory carrying cost of 50,000 tyres and tubes will be very high. The inventory carrying cost includes the insurance, rental of stores, spoilage, obsolescence, and interest on investment in the inventories. Thus, the trade-off is between the ordering cost and the carrying cost.

The economic order quantity is that quantity where the total cost of inventory management is the minimum. The cost of inventory management includes the purchasing cost, carrying cost and the ordering cost.

The model for determination of the economic order quantity makes the following assumptions:

- The ordering cost per order and carrying cost per unit per annum are known a priori and are fixed.
- The material cost per unit is known a priori and is constant.
- The material consumption level during the year are known in advance
- No stock out occurs.

Let the annual material requirement in quantity be equal to A . The ordering cost per order be equal to O . Let the raw material cost per unit equal to C and carrying cost per annum be $i\%$. The order quantity be equal to Q .

Since the raw material cost per unit is assumed constant. Hence, the relevant costs of inventory management for the analysis are carrying cost and the ordering cost.

Carrying cost

= Average order quantity X cost per unit X carrying cost percentage p.a.

$$= Q/2 \times C \times i\%$$

The firm will be incurring carrying cost on the average inventory level.

Ordering Cost

= Number of orders placed during the year X Ordering cost per order

$$= A/Q \times O$$

The order size and the annual material requirement will determine the number of orders to be placed during the year.

Total Cost (TC) = Carrying cost + Ordering cost

$$TC = Q/2 \times C \times i\% + A/Q \times O$$

We have to determine at what level of Q, the total cost of inventory management is the minimum.

Let us differentiate (using the first principle of differentiation) both sides with respect to Q and equate it to zero.

$$dTC/dQ = Ci\%/2 \cdot d/dQ Q + AO \cdot d/dQ (1/Q)$$

$$\text{zero} = Ci\%/2 - AO/Q^2 \quad (d/dx x^n = nx^{n-1})$$

$$Q^2 = 2AO/Ci\%$$

$$\text{Therefore } Q = (2AO/Ci\%)^{1/2}$$

$$\text{EOQ} = [(2 \times \text{Annual material requirements quantity} \times \text{ordering cost per order}) / (\text{material cost per unit} \times \text{carrying cost percentage per annum})]^{0.5}$$

Illustration

Suppose a TV manufacturer plans to manufacture 25000 CTVs for the year 2005. It purchases colour picture tubes from other manufacturer. Its annual requirement of colour picture tube is 25000 units. The purchase cost is Rs. 3500 per colour picture tube. The ordering cost is Rs. 529.375 per order and carrying cost per annum is 10%. Determine the economic order quantity.

Solution:

A = 25000 units
 O = Rs. 529.375
 C = Rs. 3500
 i% = 10%

$$\begin{aligned}
 \text{EOQ} &= [(2 \times 25000 \times 529.375) / (3500 \times 10\%)]^{0.5} \\
 &= 275 \text{ units}
 \end{aligned}$$

The graphic presentation of the economic order quantity is as under:

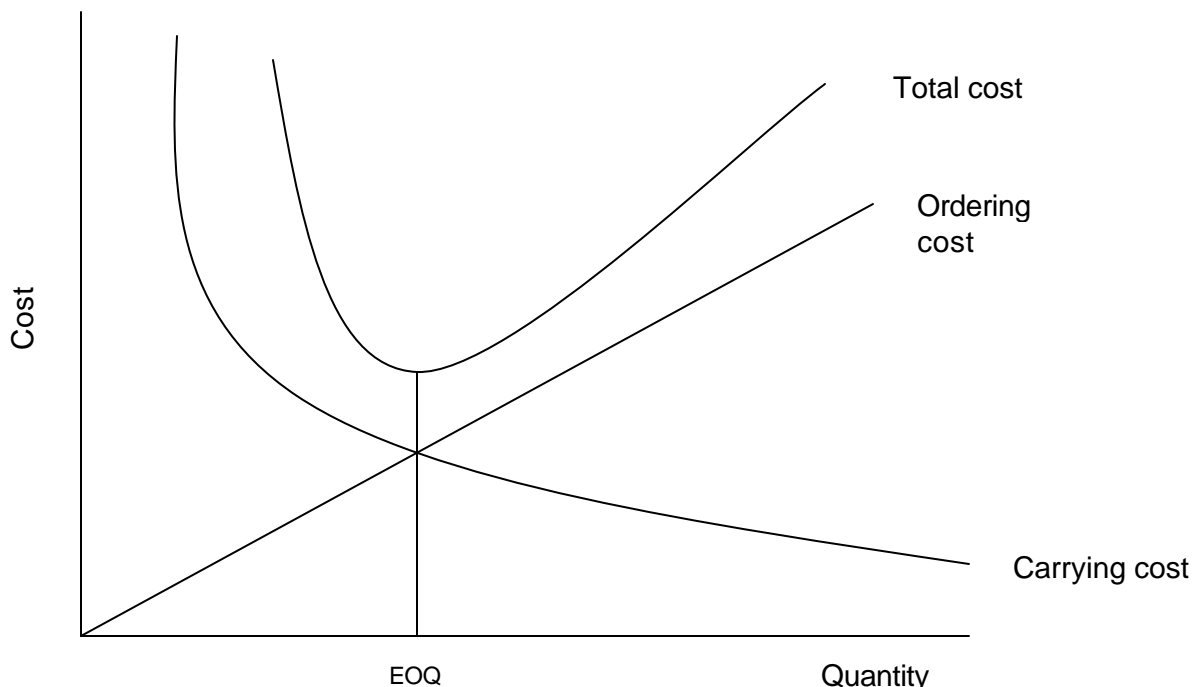


Fig.18.1 Economic Order Quantity

18.4.2 EOQ with quantity discount

The firm generally gets quantity discount, if it places an order for large quantity. Thus, quantity discount becomes relevant advantage in the economic order quantity analysis. Instead of using EOQ formula now tabular approach is suggested. The following illustration will substantiate this argument.

Illustration:

ABCM Limited has received the following quantity discount offer from its suppliers:

Price per ton (Rs)	Order quantity (tons)
2700	Less than 1000
2655	1000 but less than 2000
2610	2000 but less than 4000
2565	4000 but less than 6000
2520	6000 and above

The annual requirement of the material is 12000 units. The ordering cost is Rs. 5000 per order and inventory carrying cost is 25% of the material cost per annum.

Determine the EOQ.

Solution:

We will take minimum of the order size for availing quantity discount as quantity discount will be available and carrying cost will increase with the increase in order size.

As we increase the order size, the benefits are quantity discount and savings in the ordering cost. The cost associated with the increase in the order size is increase in the carrying cost. Thus, the cost benefit analysis will facilitate the determination of order size, where the total cost of inventory management is minimum.

Table 18.1: Computation of EOQ with quantity discount

Order Size (Q) (1)	Number of orders (A/Q) (2)	Purchase cost (A X C) (3)	Ordering cost (A/Q) X O (4)	Carrying cost (Q/2) X C X i% (5)	Total cost (3+4+5) (6)
500	=12000/500 = 24	=12000 X 2700 =3,24,00,000	= 24 X 5000 = Rs 120000	=(500X2700X 25%)/2 = Rs. 168750	Rs. 3,26,88,750
1000	= 12000/1000 = 12	=12000 X 2655 = 3,18,60,000	= 12 X 5000 = Rs. 60000	= (1000X2655X25%)/2 = Rs. 331875	Rs. 3,22,51,875
2000	=12000/2000 = 6	=12000 X 2610 = 3,13,20,000	= 6 X 5000 = Rs. 30,000	= (2000X2610X25%)/2 = Rs 652500	Rs. 3,20,02,500
4000	=12000/4000 = 3	=12000 X 2565 = 3,07,80,000	= 3X 5000 = Rs 15000	= (4000X2565X25%)/2 = Rs. 1282500	Rs. 3,20,77,500
6000	= 12000/6000 = 2	=12000 X 2520 =3,02,40,000	= 2 X 5000 = Rs 10000	= (6000X2520X25%)/2 = Rs. 1890000	Rs 3,21,40,000

Thus, the economic order quantity is 2000 units.

18.4.3 Re-order level

The re-order level is that stock level; on reaching the same, the firm places an order for the economic order quantity. The re-order level lies between the minimum stock level and the maximum stock level. The re-order level ensures that there is enough quantity available during the lead time to meet the normal production requirements and minimum stock level will meet the contingencies of either lead time reaching maximum or consumption during the lead time going to the maximum or both.

Re-order level = Minimum stock level + (Normal lead time X Normal level of raw material consumption per unit of time)

Re-order Level = Maximum lead time X Maximum level of raw material consumption per unit of time

Lead Time = Time taken to replenish the inventory levels.

The graphic presentation of the re-order level is as under:

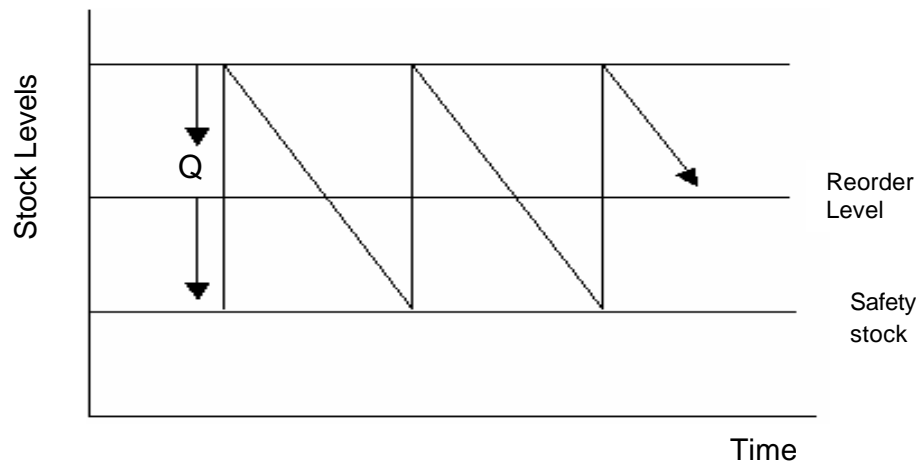


Fig. 18.2: Re-order level

The firm places an order for fixed order quantity i.e. economic order quantity, once the re-order level is reached.

18.4.4 Safety stock levels

The safety stock is the inventory held by the firm during all the times irrespective of the order size EOQ. The firm carries safety stock levels to meet the contingencies of lead-time going to the maximum and consumption levels also going to the maximum. It is a cushion to avoid stock out situation. It is also called minimum stock levels.

Safety stock level = Re-order level – (Normal Lead time X Normal level of material consumption per unit of time)

In such a situation the total cost of inventory management will include expected stock out cost besides carrying cost and ordering cost. The maintenance of safety stock has the benefit of avoiding loss of profits by meeting delivery schedules. The cost associated with it is the carrying cost. The safety stock is that stock level where the total cost of inventory management is the minimum.

18.4.5 Maximum stock levels

It is the maximum level of inventory maintained by the firm at any point of time. The firms with conservative approach will maintain the maximum stock levels. It is to be ensured that the firm has necessary storage space and funds to maintain this level.

Maximum Level of Inventory = Re-order Level + Re-order Quantity –
(Minimum consumption X Minimum lead-time)

18.5 SELECTIVE INVENTORY CONTROL

18.5.1 ABC Analysis

Always best control (ABC) analysis is a system of inventory control. It applies the principles of the management by exception to the inventory management. It argues that management should classify its inventories into three categories namely low-volume but high value; moderate volume and moderate value; high-volume but low-value items. Thus, the management should focus on low-volume but high value items as far as applications of inventory management tools are concerned to deliver value to the shareholders.

Table 18.2: ABC classification of inventories

Number of inventory items	% Of Inventory items	% Value of inventory holding (average)	Inventory Classification
595	12.53%	70%	A
1425	30%	20%	B
2730	57.47%	10%	C
4750	100%	100%	

The tools such as re-order level, economic order quantity and safety stock levels are applied to A-category items. The firm should order most of its requirements in respect of C-category items in one or two go to avail the benefits

of the quantity discount, since the associated carrying cost are going to be too small as they are low value items.

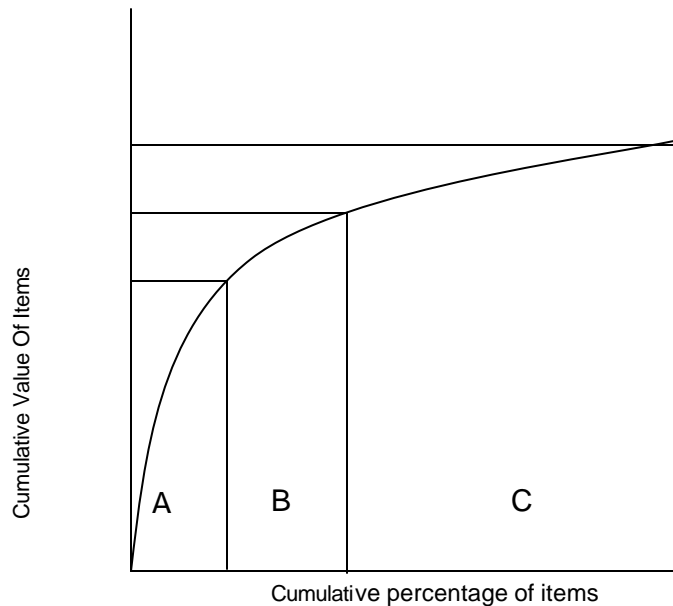


Fig. 18.3: ABC Classification of inventories

18.5.2 Just In Time Inventory Control (JIT)

Just-in-time inventory controls ask a basic question: does inventory create value? Just-in-time purchasing is the purchasing of materials and stores on time and having a situation of zero inventories.

Just-in-time inventory control approach requires developing the relationship with the suppliers and placing small size frequent orders. It is not that instead of having inventory in our factory and keeping it with the suppliers. It is a situation of not having inventories in the entire value chain and at the same time to ensure smooth production and meeting the delivery schedules. It is a win-win situation both for the manufacturers and the vendors. This kind of scenario is possible in information technology enabled communication networks and excellent road infrastructure. It calls for supply chain management initiatives. The Japanese firms have introduced the JIT concept initially and they have used it as a strategic tool to achieve competitive advantage.

The Indian firms such as Maruti Udyog Limited, Bajaj Auto Limited have managed their cost through a lot of supply chain cost management initiatives.

Needless to mention that buyer-supplier interface with the firm needs to be more efficient in order to manage cost across the value chain and thus create value. Few examples to bring improvements at the supplier end are: improve delivery performance; manage quality, smaller batch deliveries, and shorter lead times. On the other side of the value chain i.e. to bring improvements at the buyer end, the few examples are: reduce reliance on custom as opposed to standard products and reduce number of changes to the sales orders. The improvements at the firm level could be effected through total quality management and electronic data interchange with the supply chain and the distribution change.

18.5.3 Inventory Turnover Ratios

The firms also use inventory turnover ratios to manage inventories. These ratios are:

Finished Goods Inventory Turnover ratio
= Cost of goods sold / Average finished goods inventories at cost

Raw-material inventory turnover ratio
= Annual raw materials consumption / Average raw material inventory

Work-in-progress inventory turnover ratio
= Factory cost / Average work-in-progress inventory

Average Raw material purchases per day
= Annual raw material purchases / 360 days

Average raw material inventory holding period
= Average raw material inventory / Average Raw material purchases per day

Average Factory cost incurred per day
= Factory cost incurred during the year / 360

Average age of finished goods inventory
= Average Finished goods inventory / Average factory cost incurred per day

The firms can also classify their inventories into fast moving, slow moving and non-moving inventories for the purpose of control. This analysis is called as FSN analysis.

Most of the chief financial officer's (CFO) time and efforts are devoted to working capital management. Still, a large number of business failures have been attributed to inability of financial managers to plan and control properly the inventories of their respective firms. (Smith, 1973). Therefore, there is a need to develop sustainable inventory management practices.

- The objectives of holding inventories by the firms are to meet transaction needs, precautionary needs, and speculative needs.
- The holding of excessive inventories block the funds of the firm and reduces the profitability of the firm. Whereas holding inadequate inventories result in loss of production and in turn customer and profits. Therefore, the objective of the firm is to have optimum investment in the inventories to maximize the value of the firm.
- The costs associated with the inventory management are purchase cost, carrying cost, ordering cost and stock out cost. The objective of the inventory management is to reduce the total cost of inventory management.
- The inventory management tools provide the inputs on re-order level, re-order quantity, minimum stock level, and maximum stock level to the plant management for inventory control.
- The selective inventory control techniques such as ABC analysis suggests that sophisticated inventory control tools should be used in respect of high value items.
- The objective to reduce inventory levels to minimum lead the focus of the firms to the supply chain management.
- The analysis of working capital performance based on firm's financial statement will facilitate the monitoring of the average age of the inventories.

14.8 KEY WORDS

ABC analysis

The inventory control technique based on the principles of

		management by exception. It suggests application of sophisticated inventory management tool to high value inventory items termed as A category items.
Carrying cost		It is the storage, insurance, obsolescence and opportunity cost associated with the holding of the inventories.
Days Working Capital		$\text{Average age of inventory} + \text{Average age of receivables} - \text{Average age of payables}$
Economic order quantity		It is that order quantity where total cost of inventory management is the minimum.
Fill rate		The number of times the supplier has delivered on time.
FSN analysis		It is classification of inventories into fast moving, slow moving, and non-moving items and controlling accordingly.
JIT Inventory Management		Zero inventories in an IT-enabled environment with supply chain management initiatives.
Lead Time		Time taken to replenish the inventories. The time from placing of an order to vendors to the time actually material and stores received.
Minimum stock level		The safety stock level to meet the contingency of lead time and consumption level exceeding from normal level to maximum level.
Ordering cost		The administrative cost associated with the placing of an order.
Re-order level		The stock level, where fresh order is placed for economic order quantity.
Re-order quantity		See economic order quantity.
Safety stock		See minimum stock level.
Value chain analysis		Analysis of linkages and interdependencies between the suppliers, buyers, intermediaries and their end-users.

14.9.1 TERMINAL QUESTIONS / EXERCISES

1. What is purpose of holding the inventories? Why is the inventory management important?
2. Define the economic order quantity and discuss the process of its determination.
3. What are the inventory carrying cost and ordering cost and what are their roles in inventory management?
4. Write short notes on the following
 - a) Re-order level
 - b) Minimum stock level
 - c) Maximum stock level
5. Discuss the process of selective approach to inventory management.
6. Discuss the Indian Industry practices with respect to working capital management.

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