Operations Management

Chapter 12 – Inventory Management




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PowerPoint presentation to accompany
Heizer/Render
Principles of Operations Management, 7e
Operations Management, 9e

Inventory

- ☑ *One of the most expensive assets of many companies representing as much as 50% of total invested capital*
- ☑ *Operations managers must balance inventory investment and customer service*

Inventory Cost

- *Price or Variable Production Cost*
- *Ordering cost*
- *Receiving and inspections cost*
- *Inventory holding cost*
- *Out of stock/shortage cost*
- *Other costs*

Ordering Cost

- *It is the cost of ordering the item and securing its supply.*
- *It includes:*
  - *Expenses from raising the indent*
  - *Purchase requisition by user department till the execution of order*
  - *Receipt and inspection of material*

Inventory holding cost

- *Cost incurred for holding the volume of inventory and measured as a percentage of unit cost of an item.*
- *They include:*
  - *Capital cost*
  - *Obsolescence cost*
  - *Deterioration cost*
  - *Taxes on inventory*
  - *Insurance cost*
  - *Storage & handling cost*

Out-of-Stock cost

- *It is the loss that occurs (or may occur) due to non availability of material.*
- *It includes:*
  - *Break down/delay in production*
  - *Back ordering*
  - *Lost sales*
  - *Loss of service to customers, loss of goodwill, loss due to lagging behind the competitors, etc.*

Other costs

- *Capacity Costs*
  - *Over-time payments*
  - *Lay-offs & idle time*
- *Set-up Costs*
  - *Machine set-up*
  - *Start-up scrap generated from getting a production run started*
- *Over-stocking Costs*

Functions of Inventory*

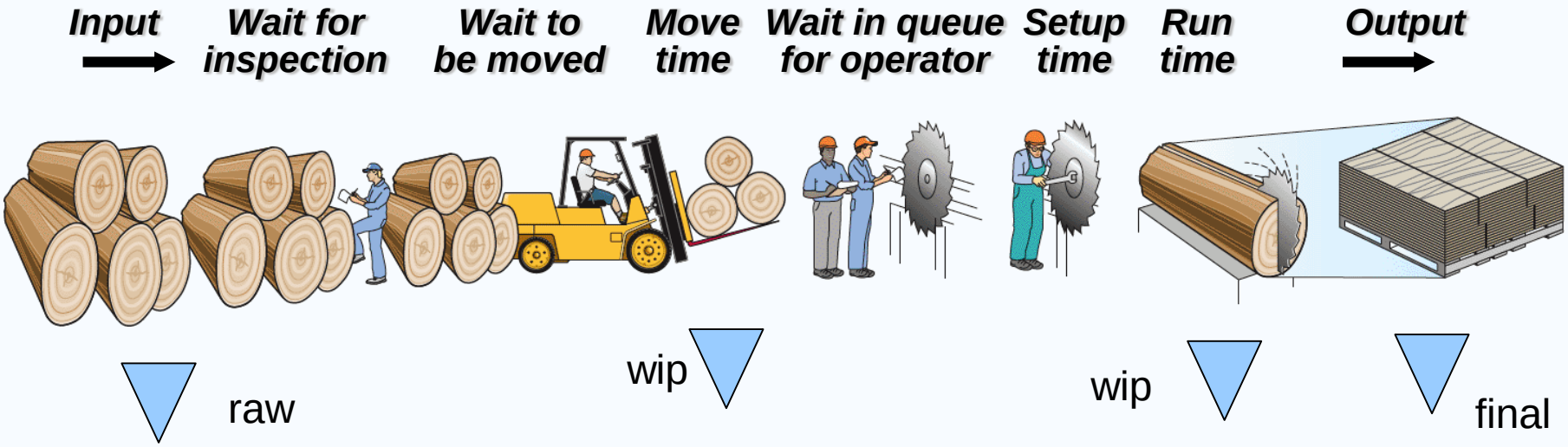
1. To separate various parts of the production process
2. To decouple the firm from fluctuations in demand
3. To take advantage of quantity discounts
4. To hedge against inflation

Types of Inventory*

- ☑ *Raw material*
  - ☑ *Purchased but not processed*
- ☑ *Work-in-process*
  - ☑ *Undergone some change but not completed*
- ☑ *Maintenance/repair/operating (MRO)*
  - ☑ *Necessary to keep machinery and processes productive*
- ☑ *Finished goods*
  - ☑ *Completed product awaiting shipment*

The Material Flow Cycle

Figure 12.1



Inventory Management

- ☑ Companies can have thousands of products to manage
- ☑ Must focus energy on important items.
  - ☑ Example: ABC analysis
- ☑ Must have accurate inventory records to manage properly

ABC Analysis*

- ***Divides inventory into three classes based on specific criteria***

  Example: annual monetary volume

  - Class A - **high** annual monetary volume
    - About 15% of items but 75% of value
  - Class B - **medium** annual monetary volume
    - About 30% of items but 20% of value
  - Class C - **low** annual monetary volume
    - About 55% of items but 5% of value

- ***Used to establish policies that focus on the few critical parts and not the many simple ones***

Example: ABC Analysis

Item Stock Number	Percent of Number of Items Stocked	Annual Volume (units)	x	Unit Cost	=	Annual Dollar Volume	Percent of Annual Dollar Volume		Class
#10286	20%	1,000		$ 90.00		$ 90,000	38.8%		A
#11526		500		154.00		77,000	33.2%	72%	A
#12760		1,550		17.00		26,350	11.3%		B
#10867	30%	350		42.86		15,001	6.4%	23%	B
#10500		1,000		12.50		12,500	5.4%		B

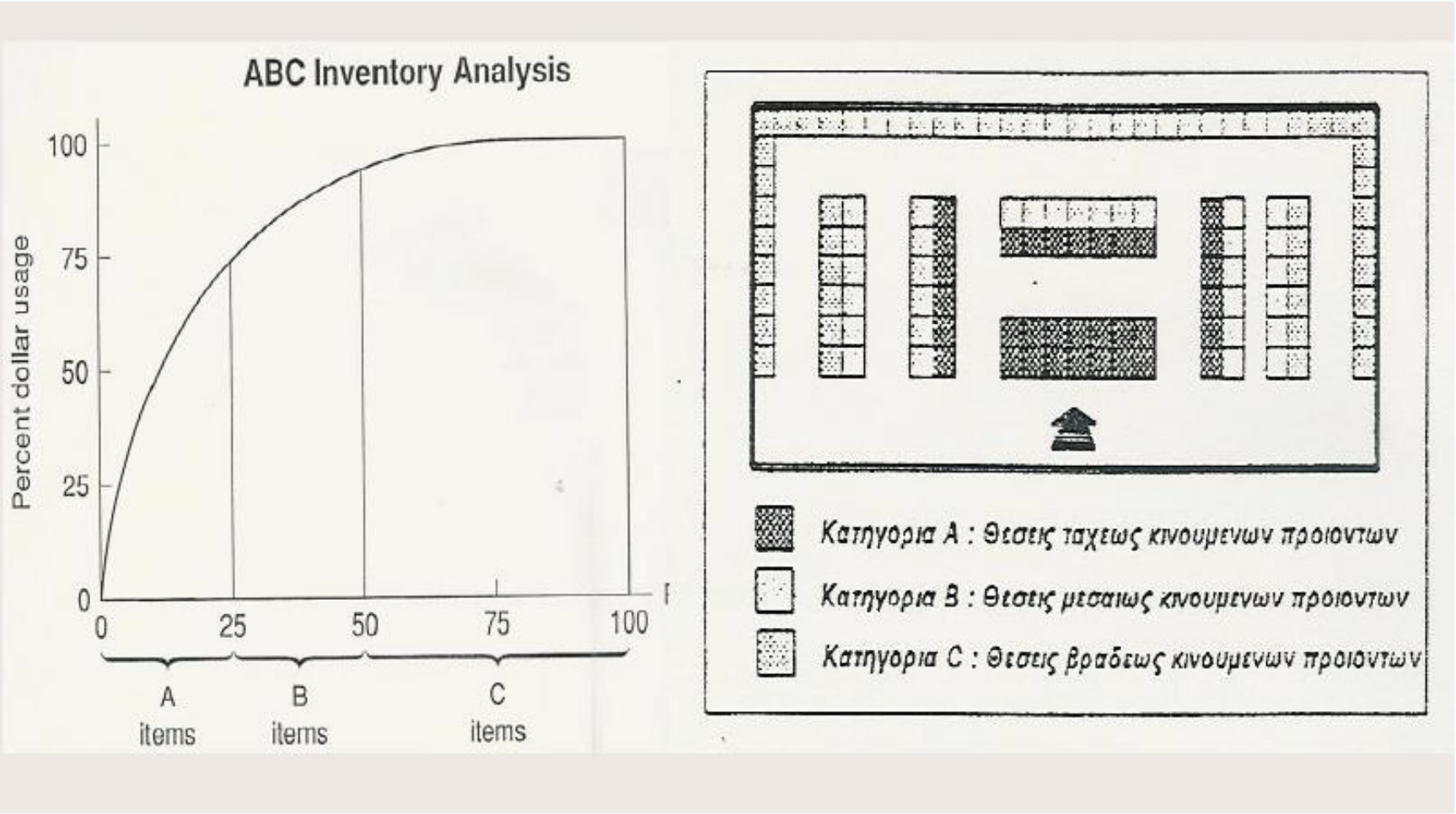
Example ABC Analysis

Item Stock Number	Percent of Number of Items Stocked	Annual Volume (units)	x	Unit Cost	=	Annual Dollar Volume	Percent of Annual Dollar Volume		Class
#12572		600		$ 14.17		$ 8,502	3.7%		C
#14075		2,000		.60		1,200	.5%		C
#01036	50%	100		8.50		850	.4%	5%	C
#01307		1,200		.42		504	.2%		C
#10572		250		.60		150	.1%		C
		8,550				$232,057	100.0%		

ABC Analysis: criteria*

- ☑ Other criteria than annual monetary volume may be used
  - ☑ Anticipated engineering changes
  - ☑ Delivery problems
  - ☑ Quality problems
  - ☑ High unit cost

ABC Analysis: Pareto Chart



Cycle Counting*

- ☑ Items are counted and records updated on a periodic basis rather than once a year
- ☑ Often used with ABC analysis to determine cycle
- ☑ Has several advantages
  - ☑ Eliminates shutdowns and interruptions
  - ☑ Eliminates annual inventory adjustment
  - ☑ Trained personnel audit inventory accuracy
  - ☑ Allows causes of errors to be identified and corrected
  - ☑ Maintains accurate inventory records

Cycle Counting Example

5,000 items in inventory, 500 A items, 1,750 B items, 2,750 C items

***Policy** is to count A items every month (20 working days), B items every quarter (60 days) and C items every six months (120 days)*

Item Class	Quantity	Cycle Counting Policy	Number of Items Counted per Day
A	500	Each month	500/20 = 25/day
B	1,750	Each quarter	1,750/60 = 29/day
C	2,750	Every 6 months	2,750/120 = 23/day
			77/day

Inventory costs*

- ☑ **Holding costs** - the costs of holding or "carrying" inventory over time
- ☑ **Ordering costs** - the costs of placing an order and receiving goods
- ☑ **Setup costs** - cost to prepare a machine or process for manufacturing an order

Inventory Usage Over Time

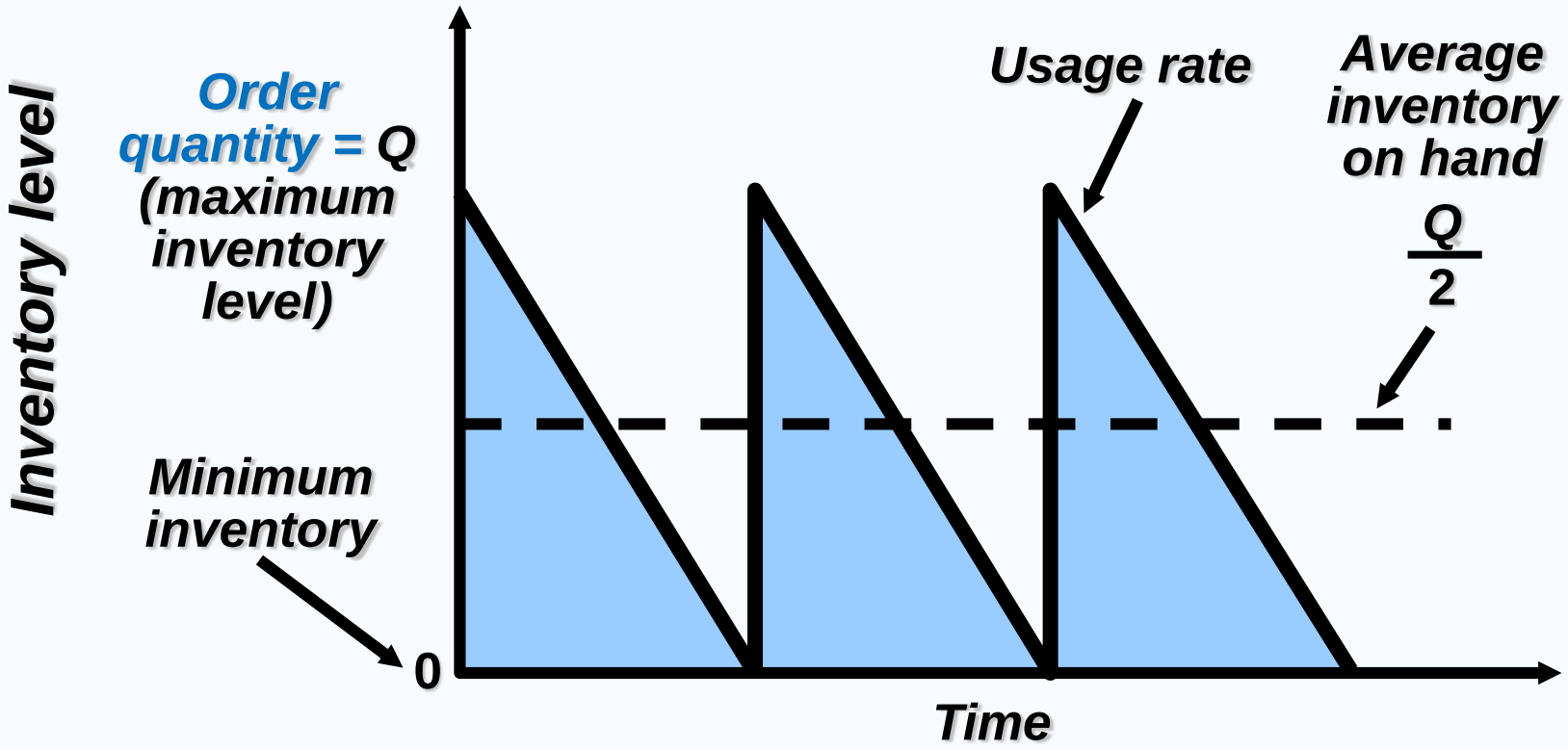


Figure 12.3

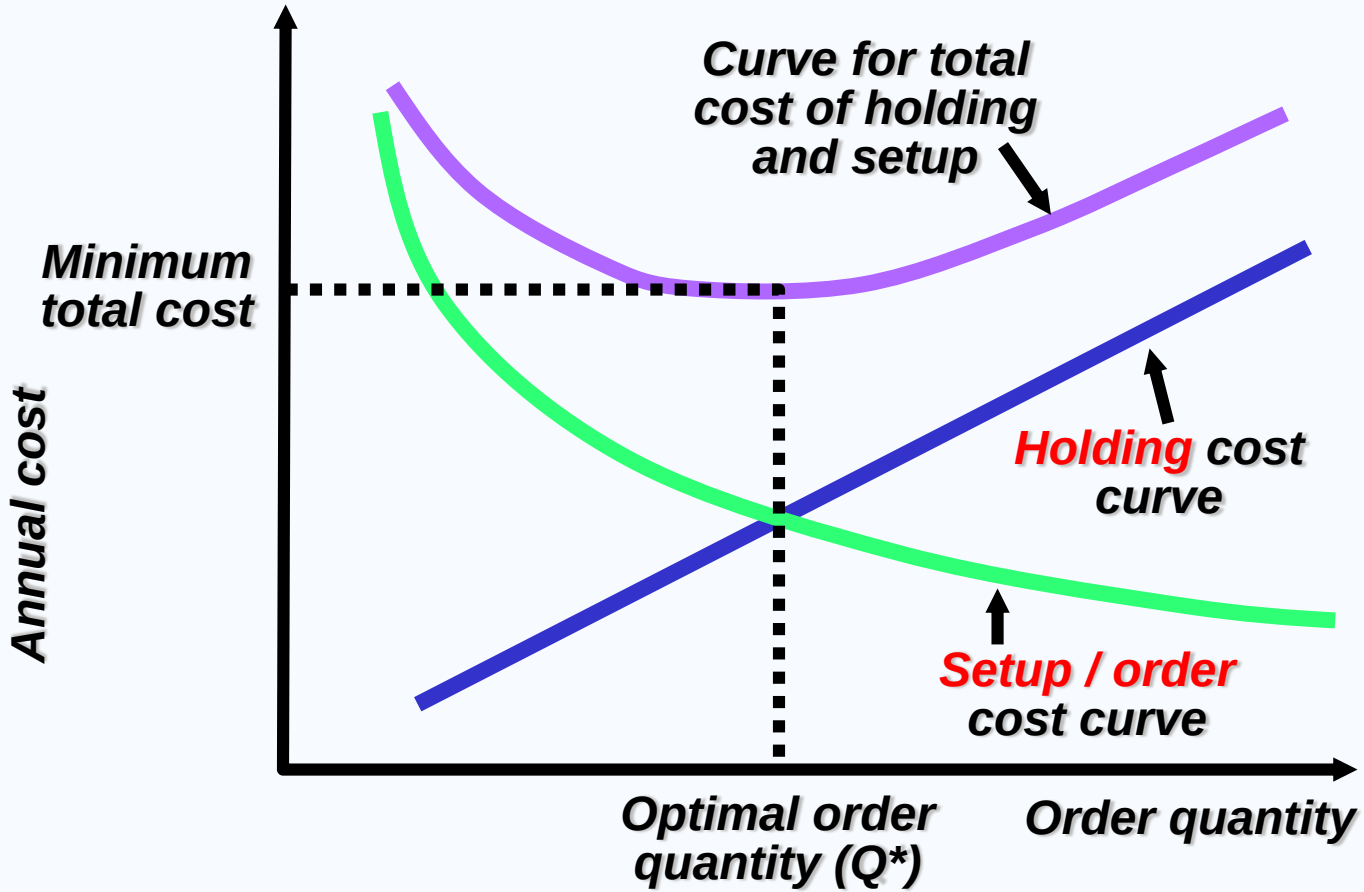
Basic EOQ Model

Important assumptions

1. ***Demand is known, constant and independent***
2. ***Lead time is known and constant***
3. ***Receipt of inventory is immediate and complete***
4. ***No quantity discounts***
5. ***Only variable costs are setup and holding***
6. ***Stockouts can be completely avoided***

EOQ objective: Minimizing Total Costs

Objective is to minimize total costs per year



The EOQ Model*

Find quantity where:

Period's setup cost **= Period's holding cost**

(Qty orders / period) x (Order cost / order) = (Average inventory) x (Holding cost / unit / period)

$$\left(\frac{D}{Q}\right)(S) = \left(\frac{Q}{2}\right)(H)$$

Q : Number of pieces per order
D : Demand in units for the inventory item per period
S : Setup or ordering cost for each order
H : Holding or carrying cost per unit per period
P : Cost per purchased item

Solving for Q*

$$2DS = Q^2H$$

$$Q^2 = 2DS/H$$

$$Q^* = \sqrt{2DS/H}$$

An EOQ Example: Order quantity

Determine optimal quantity of needles to order

$D = 1{,}000$ *units*

$S = \$10$ *per order*

$H = \$.50$ *per unit per year*

$$Q^* = \sqrt{\frac{2DS}{H}}$$

$$Q^* = \sqrt{\frac{2(1{,}000)(10)}{0.50}} = \sqrt{40{,}000} = 200 \text{ units}$$

An EOQ Example: Number of orders

Determine optimal number of orders

D = 1,000 units **Q^* = 200 units**

S = \$10 per order

H = \$.50 per unit per year

$$\text{Expected number of orders} \quad N = \frac{\text{Demand}}{\text{Order quantity}} = \frac{D}{Q^*}$$

$$N = \frac{1{,}000}{200} = 5 \text{ orders per year}$$

An EOQ Example: time between orders

Determine the expected time between orders

D = 1,000 *units*

S = \$10 *per order*

H = \$.50 *per unit per year*

Q^* = 200 *units*

N = 5 *orders per year*

250 working days / yr

$$\text{Expected time between orders } T = \frac{\text{Number of working days per year}}{N}$$

$$T = \frac{250}{5} = 50 \text{ days between orders}$$

An EOQ Example: Total cost

Determine minimal total cost:

D = 1,000 *units*
S = $10 *per order*
H = $.50 *per unit per year*
P = $ 10 per unit

*Q** = 200 *units*
N = 5 *orders per year*
T = 50 *days*

Total annual cost = Setup cost + Holding cost + Purchase cost

$$TC(Q) = DS/Q + HQ/2 + PD$$

$$TC(Q^*) = DS/Q^* + HQ^*/2 + PD$$

$$TC(200) = \$50 + \$50 + \$10{,}000$$

$$TC(200) = \$\ 10{,}100$$

Another EOQ Example

A local distributor for a national tire company expects to sell approximately 9600 steel-belted radial tires of a certain size and tread design next year. Annual carrying cost is $16 per tire, and ordering cost is $75. the distributor operates 288 days a year.

a) What is the EOQ?

b) How many times per year does the store reorder?

c) What is the length of an order cycle?

d) What is the total annual cost if the EOQ is ordered?

Another EOQ Example

D = 9600 tires per year

H = $16 per unit per year

S = $75 per order

a) Q_0 = $$\sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(9600)75}{16}} = 300$$

b) Number of order per year: D/Q_0 = 9600/300 = 32 order

c) Length of order cycle: Q_0/D = 300/9600= =1/32 of a year , which is 1/32 (288 days a year) = 9 workdays

Another EOQ Example

d) $TC(Q_0)$ = Carrying cost + Ordering cost

$= (Q_0/2)\,H + (D/Q_0)\,S$

$= (300/2)\,16 + (9600/300)\,75$

$= 2400 + 2400$

$= \$4800$

When to Reorder with EOQ

- *The EOQ models answer the question of how much to order, but not the question of when to order. The latter is the function of models that identify the reorder point (ROP) in terms of a quantity: the reorder point occurs when the quantity on hand drops to a predetermined amount.*
- *That amount generally includes expected demand during lead time and perhaps an extra buffer of stock, which serves to reduce the probability of experiencing a stock-out during lead time.*
- *In order to know when the reorder point has been reached, a perpetual inventory is required.*
- *The goal of ordering is to place an order when the amount of inventory on hand is sufficient to satisfy demand during the time it takes to receive that order (lead time).*

When to Reorder with EOQ

- ***Reorder Point*** *- When the quantity on hand of an item drops to this amount, the item is reordered*
- ***Safety Stock*** *- Stock that is held in excess of expected demand due to variable demand rate and/or lead time.*
- ***Service Level*** *- Probability that demand will not exceed supply during lead time*

Determinants of the Reorder Point

- *The rate of demand*
- *The lead time*
- *Demand and/or lead time variability*
- *Safety stock*

Safety Stock

When demand or lead time are random variables, it is possible for the actual demand to exceed expected demand. Consequently, it becomes necessary to carry additional inventory, called "safety stock", to reduce the risk of running out of stock during lead time.

Safety Stock

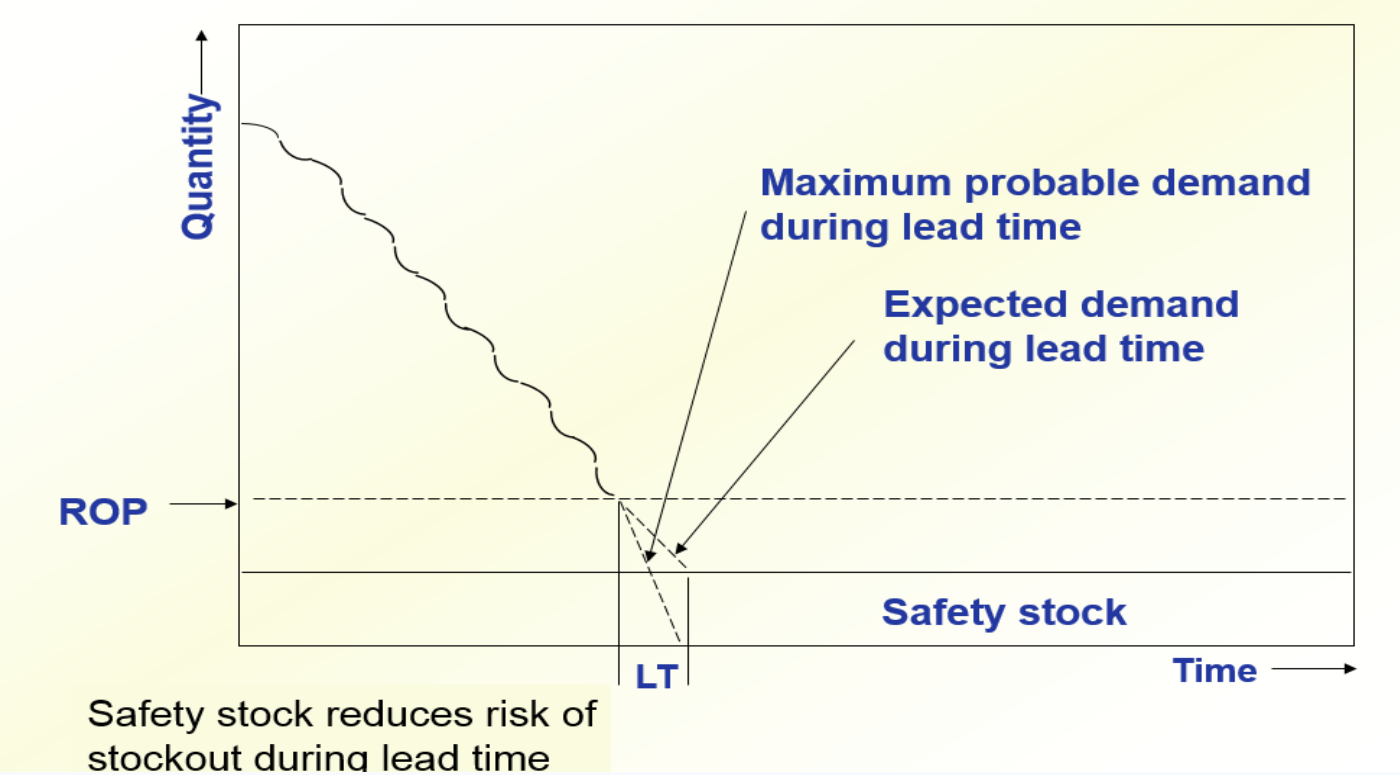
- *The reorder point then increases by the amount of the safety stock:*

  ROP = expected demand during lead time + safety stock

- *Since it costs money to hold safety stock, a manager must carefully weigh the cost of holding safety stock against the reduction in stock out risk it provides.*
- *The customer service level increases as the risk of stock out decreases.*
- *The order cycle "service level" can be defined as the probability that demand will not exceed supply during lead time. This means a service level 95% implies a probability of 95% that demand will not exceed supply during lead time.*
- *The "risk of stock out" is the complement of "service level"*
- *The amount of safety stock depends on:*

1. *The average demand rate and average lead time*
2. *Demand and lead time variability*
3. *The desired service level*

Safety Stock



Reorder Points*

- ☑ EOQ answers the "how much" question
- ☑ When there is lead time, the reorder point (ROP) tells when to order, or at what level of inventory.

$$ROP = \begin{pmatrix} \text{Demand} \\ \text{per day} \end{pmatrix} \begin{pmatrix} \text{Lead time for a} \\ \text{new order in days} \end{pmatrix}$$

$$= d \times L$$

$$d = \frac{D}{\text{Number of working days in a year}}$$

Reorder Point Example

Demand = 8,000 *iPods per year*
250 *working day year*
Lead time for orders is 3 *working days*

$$d = \frac{D}{\text{Number of working days in a year}}$$

$$= 8{,}000/250 = 32 \text{ units}$$

$$\text{ROP} = d \times L$$

$$= 32 \text{ units per day} \times 3 \text{ days} = 96 \text{ units}$$