

Inventory Management

*Alessandro Anzalone, Ph.D.
Hillsborough Community College, Brandon Campus*



Agenda

1. Introduction
2. Basic Concepts of Inventory
3. Categories of Inventory
4. The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)
5. Basic Independent Demand Inventory Reorder Models
6. Inventory Control
7. References

Introduction

Inventory management is one of the *major planning and control challenges* facing managers today, especially in manufacturing facilities. While *technically an asset* on the balance sheet of a company, most accountants or financial managers will quickly tell you that holding *inventory is also a major expense*, and should be minimized if possible. Even most service organizations have some amount of inventory, and retail operations especially find the management of inventory has a major role in effectively managing the retail operation. This goal of *low inventory investment to save inventory expense is often in direct contrast to the position of many sales and marketing personnel*, who often want the firm to maintain a very high inventory position in order to service customers very quickly.

Introduction



Introduction



Basic Concepts of Inventory

There are two important concepts that need to be clearly understood if one is to really take the proper perspective on managing inventory in a firm.

The first of these concepts is that *much of a firm's inventory is really stored capacity*. That means that most inventory represents the use of the firm's capacity to create a product ahead of the actual demand of that product. That concept is one of the major issues that makes the planning and control for a pure service firm so different from a manufacturing firm. The average service firm does not have the luxury of planning and using the capacity ahead of the demand for its use, but instead must use the capacity only once the demand is created.

The second concept is that *inventory is almost never a problem* in any company, in spite of the fact that it is often mentioned that "one of our problems is too much inventory." *In most firms, inventory exists as a symptom of the way the business is run.*

Basic Concepts of Inventory

Anecdotal example:

One production planning and control manager recently discussed one example from his early career, prior to his full understanding of inventory as a symptom of the way the business was being run. The company he worked for had experienced a slowdown in sales. The general manager of the company, concerned about profitability, asked the production planning and control manager to cut 15% of the inventory in order to bring inventory expense in line with the lower level of sales.

Basic Concepts of Inventory

Anecdotal example:

One production planning and control manager recently discussed one example from his early career, prior to his full understanding of inventory as a symptom of the way the business was being run. The company he worked for had experienced a slowdown in sales. The general manager of the company, concerned about profitability, asked the production planning and control manager to cut 15% of the inventory in order to bring inventory expense in line with the lower level of sales.

Without understanding, the production planning and control manager did what was asked of him—except that without a good understanding of the relationships between managerial approaches and inventory, he merely cut the inventory level without making any changes in the business processes. About 3 months after the initial request from the general manager, the planning and control manager was again approached by the general manager. The conversation went something like this:

Basic Concepts of Inventory

GENERAL MANAGER: “What are you doing to my production facility?”

PLANNING AND CONTROL MANAGER: “What do you mean?”

GENERAL MANAGER: “We have all kinds of new problems—lots of premium freight shipments from suppliers in response to all kinds of part shortages, split lots being frequently run on the equipment—which are drastically increasing our setup costs, a major falloff in labor efficiency, and other similar problems — what are you doing?”

PLANNING AND CONTROL MANAGER: “I’m getting rid of 15% of the inventory.”

GENERAL MANAGER: “Well, then, put it BACK!”

The point of this is that the Planning and Control Manager focused on the inventory as the problem and the focus of his efforts, not recognizing that it existed symptomatically. What he should have done was to first “fix” the system.

Basic Concepts of Inventory

Keeping these two major points in mind, we need to first look at the reasons inventory exists before we can really understand well how to manage it. To the untrained eye, inventory looks like inventory (“stuff” sitting around), to the accountant it is cost and money “tied up,” to the salespeople it is an opportunity, but to a good planning and control person it is a symptom of the way the business has been designed and is being managed. Once we understand WHY it is there (as a symptom), we can better understand HOW to manage and control it properly. Many of these reasons why inventory exists have categorical names related to several issues, including company policies, flexibilities, designs, customer responsiveness issues, and seasonal patterns.

Categories of Inventory

The first categorical division of inventory is based on the **source of demand**. There are essentially two ways to categorize inventory based on the source of demand:

- ✓ **Independent demand inventory.** The source of demand for this type of inventory is typically from sources outside the company itself, usually emanating from an external customer. It is called independent since the demand for it is essentially independent of any internal actions of the firm. In many cases these items are the end items of production, often a “sellable” finished good.
- ✓ **Dependent demand inventory.** The source of dependent demand inventory is directly dependent on internal decisions, primarily on the decision of how many of which product to produce at what time. It should be noticed that some may think this is still dependent on customers, but in fact many firms can decide to produce at far different times and at different rates than what represents the external customer demand. This goes back to the concept of inventory as stored capacity.

Categories of Inventory

The second categorical division is based on **the position of the inventory in the process**. The four general categories include:

Raw materials represent inventory that has been purchased for use in the production process, but have had no value added by the company’s production process.

Work in process (WIP) represent inventory that has had some value added, but still has additional processing to be completed before it can be used to meet customer demand.

Finished goods represent inventory that has completed all the processing from the firm. It is generally ready to be used to meet customer demand, with the possible exception of packaging.

Maintenance, repair, and operations (MRO) inventory is material used to support the company’s business and production processes, but typically will never be directly sold to a customer. It is made up of spare parts, machine oil, cleaning supplies, office supplies, and so forth.

Categories of Inventory

The third and final categorical division is the **function or use of inventory in the process**. The most common categories in this area include:

- ✓ **Transit inventory** is inventory in motion from one activity to another. Inventory in the transportation system is the most common form.
- ✓ **Cycle inventory** is inventory that exists because for any time period the rate of replenishment exceeds the demand — a situation often caused because of order costs, setup costs, or packaging considerations.
- ✓ **Buffer inventory** is also called safety stock, and exists just in case. There are many situations that can occur in a firm that can disrupt the normal flow of work in the operation. Workers can fail to come to work, suppliers can be late with shipments or ship the wrong product, quality problems can occur, machines can break down, and so forth. Inventory that is maintained explicitly to protect the organization just in case one or more of these problems occur is called buffer inventory or safety stock.

Categories of Inventory

- ✓ **Anticipation inventory** is inventory built up on purpose in anticipation of some demand in excess of the usual production output. The two most common uses for this are to accommodate seasonal demand or marketing promotions.
- ✓ **Decoupling inventory** is inventory that is purposely placed between operations to allow them to operate independently of one another.

FIGURE 5.1 Linked Operations with Different Production Rates

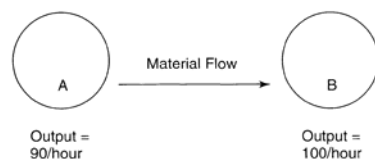
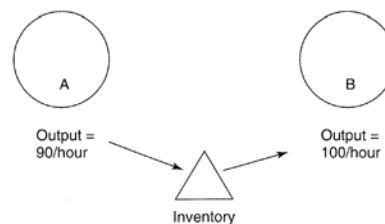


FIGURE 5.2 Operations A and B Decoupled



Categories of Inventory

“Any inventory in the system, regardless of the reason for its existence, can serve as decoupling inventory, even if that is not the intention.”

The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)

The basic economic order quantity model attempts to balance the costs of having inventory against the costs of not having the inventory, with the overall objective to minimize total cost. The following list outlines some of the more significant costs of having and not having inventory.

The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)

Costs of having inventory:

Storage, such as warehouse or stockroom expenses (in some cases this is not included because it may be considered a fixed cost of the operation)

Insurance

Taxes

Cost of capital— even if the firm uses its own money to finance the inventory (instead of borrowing funds to finance purchasing the inventory), there is still the opportunity cost, in that the money used to buy inventory is tied up and cannot be used in other ways to generate a return.

Obsolescence

Spoilage — even if the inventory has a very long shelf life, it can be damaged in moving, can get dirty, or decay from rust.

Cost of tracking inventory—whenever inventory exists, there are usually people and a system responsible for control of the inventory, both of which represent cost.

Shrinkage — this is when inventory “disappears” for some reason. While it certainly can be misplaced or incorrectly specified in the inventory data system, in some companies the reason for shrinkage is theft.

The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)

Costs of not having inventory:

Stockouts (and associated poor customer service)

Excessive setups (related to the need to produce small quantities to meet an immediate demand)

Backorders (the costs associated with documenting the need and finally closing the order at a later time when material is available)

Production rate problems (it’s difficult to have a good rate of production without adequate inventory to work on)

Poor facility utilization

Expediting costs to shorten normal production time

The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)

The basic **Economic Ordering Quantity (EOQ)** model tries to balance two basic costs of inventory, those being the cost of ordering and the cost of holding inventory. The cost of ordering will come typically from setup cost if the material is manufactured, while it represents the cost of making a purchase order if the material is purchased from an outside source. Holding cost is a combination of all the costs listed above, including the cost of capital, which is typically the largest element of the holding cost. Holding cost is sometimes expressed as a percentage per year of the actual cost of the item. The formula for total cost is often given as:

where:

$$TC = DC + \frac{Q}{2}H + \frac{D}{Q}S$$

TC is total cost per year

D is annual demand

C is cost per item

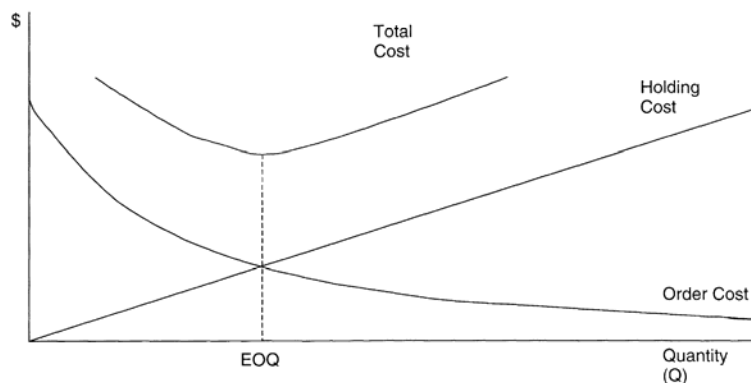
Q is the order quantity per order

H is the holding cost per year in dollars (where H is the item cost, C, times the annual percentage holding cost, i)

S is the order cost—cost to make a purchase order if purchased, setup cost per lot if manufactured

The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)

FIGURE 5.3 The Basic Inventory Cost Curves



The Basic Inventory Lot Sizing Model—Economic Order Quantity (EOQ)

$$EOQ = \sqrt{\frac{2DS}{H}}$$

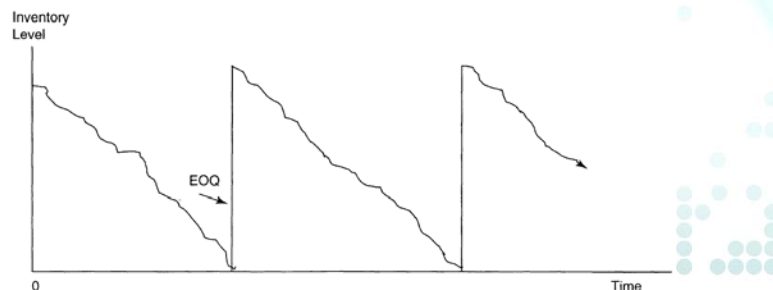
One of the big disadvantages with this model is that it assumes near perfect conditions that are seldom if ever met. Some of the key conditions include:

- ✓ Demand is constant and uniform
- ✓ Lead time is constant
- ✓ Price per unit is constant
- ✓ Inventory holding cost is based on average inventory
- ✓ Ordering and setup costs are constant
- ✓ No backorders are allowed

Basic Independent Demand Inventory Reorder Models

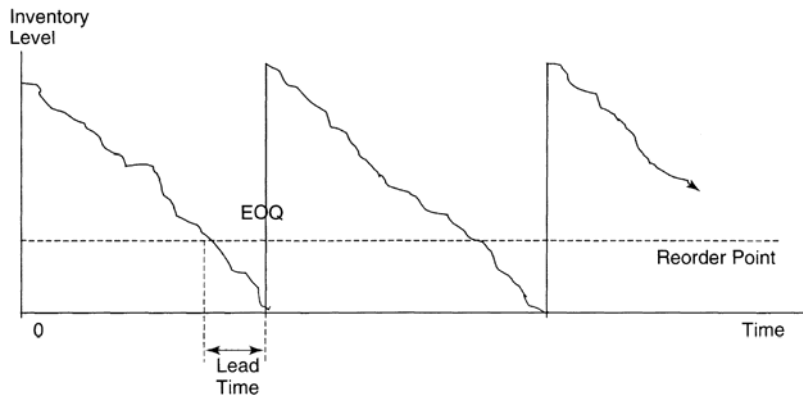
Quantity-based (continuous review) inventory models assume that a perpetual inventory position is monitored, so the inventory control system at any time can be used to tell exactly what the inventory position is. Given that these are models used for independent demand conditions, the basic assumption is that the demand is relatively uniform over time, producing the classic “saw-tooth” pattern of demand over time.

FIGURE 5.4 Typical Independent Demand Inventory Quantity Patterns over Time



Basic Independent Demand Inventory Reorder Models

FIGURE 5.5 Determination of the Reorder Point



Basic Independent Demand Inventory Reorder Models

The formula for the reorder point is fairly simple:

$$R = \bar{d}L$$

Where R is the reorder point, d is the average daily demand, and L is the lead time in days. The same formula works if the unit of time is anything other than days, as long as the unit of time for average demand and lead time are the same.

One common problem many people notice immediately with this model is that several things can happen to disrupt the conditions established. The two most common are that the supplier is late with the replenishment of supply and/or the demand for the item during the replenishment lead time can exceed that which is expected. Either condition can cause a stockout, which is clearly a potential problem for the maintenance of good customer service.

Basic Independent Demand Inventory Reorder Models

The approach to deal with the customer service issues in an environment of uncertainty is to maintain safety stock (buffer inventory). The amount of safety stock is generally dependent on two issues. First is the standard deviation of the demand during the lead time. The second issue is the level of customer service desired. The standard deviation can be calculated from past experience, but the customer service level desired is established by the management of the company, usually based on the probability of meeting customer demand during the order cycle. The standard safety stock assumes a normal distribution of demand during lead time, with the formula typically given as:

$$SS = z\sigma_L$$

where SS is safety stock, z is the statistical z-score corresponding to the stated customer service level, and σ_L is the standard deviation of demand during lead time. Some typical values for Z are:

- 90% customer service level, $z = 1.29$
- 95% customer service level, $z = 1.65$
- 99% customer service level, $z = 2.33$

Basic Independent Demand Inventory Reorder Models

When the typical reorder point is combined with safety stock, we have a new formula for the reorder point, taking into account the safety stock:

$$R = \bar{d}L + z\sigma_L$$

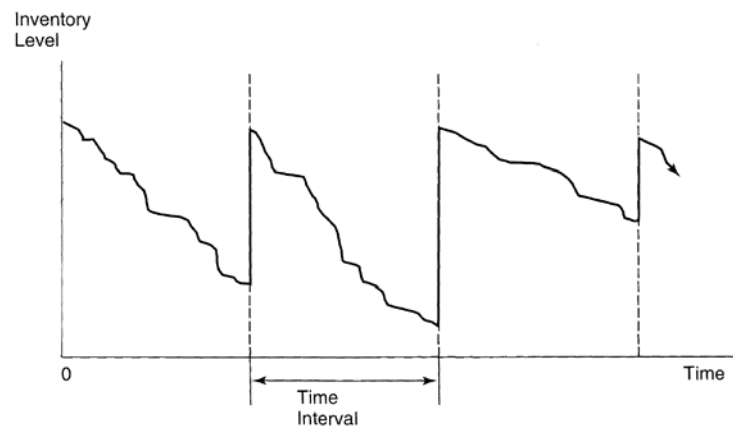
Basic Independent Demand Inventory Reorder Models

Time-based inventory models have the advantage of not requiring a perpetual inventory balance being maintained. As the name suggests, these models merely allow the inventory to be used without keeping records updated until a certain time has elapsed. When that time has elapsed, the approach is to count the inventory remaining and then determine the appropriate replenishment quantity, again taking into effect the lead time.

If we assume the EOQ calculations are essentially correct, we can use the EOQ to determine the time intervals involved. For example, if we use an average of 2,400 units in a year, and the EOQ is 200 units, then we should expect to order 12 times per year on average ($2400/200 = 12$). That means the time interval should equal one order per month. If the demand does follow a relatively constant pattern, then the time interval associated with (D/Q) orders per year will usually mean the correct order quantity will roughly equal the EOQ.

Basic Independent Demand Inventory Reorder Models

FIGURE 5.6 A Sample Time-Based Inventory Model



Basic Independent Demand Inventory Reorder Models

Time-based ordering is being *used less frequently in practice* for at least two reasons. First, there is *greater risk involved*. During the time period between checking the inventory it is possible that the demand could greatly exceed the normal pattern. In such a case, it is possible to run out of inventory before the time has elapsed to review, and many times people in the company do not even realize there is a potential problem. This generally implies the call for larger levels of safety stock, which will increase the overall inventory expense.

The second reason is that with new computer-based systems and bar coding, the task of *keeping good perpetual records is becoming easier and less expensive*. For example, the cash registers in many large retail establishments will often double as point-of-sale computer terminals, allowing the retail business to automatically deduct any sold item from perpetual inventory at the same time the receipt is generated for the customer.

Inventory Control

Methods for properly controlling inventory are often ignored or given little exposure in many operations management books, yet remain a critical issue for many modern planning and control systems. These modern planning and control systems (such as ERP systems) are highly integrated computer-based systems that can be extremely effective and provide great benefits for a company using them properly.

Unfortunately, they are also extremely sensitive to the accuracy and timeliness of the data used to generate their information. Far too many companies achieve far less benefit than is possible due to basic control problems, and inventory control is one of the most critical.

What level of accuracy is necessary? Clearly that is a matter of opinion, but most agree that an ongoing accuracy level in the very high 90 percentile range is required in order to maintain confidence in the accuracy of the information from modern planning and control systems.

Two clear *symptoms of inaccurate information* are *growth in inventory levels* (as people bring more in “just in case” the records are incorrect) and a corresponding *growth in expediting activity* as people are caught with inventory shortages when they thought adequate inventory existed for their need.

Inventory Control

The right perspective. The first issue that should be clearly understood is how to measure the accuracy level. Some take the accounting perspective resulting from the annual physical inventory. The following example illustrates the potential problem with that perspective. Suppose a firm has four items in their inventory — A, B, C, and D. The information they have on the item cost of those items and the number in inventory is given as follows:

<i>Item</i>	<i>Cost</i>	<i>Quantity</i>
A	\$2	10
B	\$5	4
C	\$1	22
D	\$3	8

RECORD			
<i>Item</i>	<i>Cost</i>	<i>Quantity</i>	<i>Actual Count</i>
A	\$2	10	15
B	\$5	4	0
C	\$1	22	17
D	\$3	8	13

Inventory Control

Location Approaches for Stockrooms and Warehouses

There are three basic approaches for locating items in a stockroom or warehouse, each with certain advantages and disadvantages. The three are **home base, random, and zoned random**.

Home base implies that each item has its own distinctive location, and that the item is always stored in just that location. The location is, therefore, dedicated to that specific item. The advantage of this approach is that the location is always known and therefore easy to find. The disadvantage is one of space. The location needs to be kept open for that item even if there are currently none in stock.

Inventory Control

Location Approaches for Stockrooms and Warehouses

Random is just the opposite approach. Whenever a new item is entered into the stockroom or warehouse, it is placed in whatever location is available (open space) anywhere in the storage area. This approach will generally maximize the efficient use of space, but there is one major disadvantage—namely, the location must be carefully noted and accurately placed into the location database.

Zoned random is a “hybrid” approach that attempts to combine the best of both approaches, and is generally applicable in all but the most extreme situations. The concept here is to identify a zone where items belonging to some defined class of goods (often commodity based) will all be stored. Within the zone, the items may be stored in a random fashion. The advantage is as follows—the random storage of parts within the zone allows for efficient use of space, while the zone concept allows for easier investigation should the location be in error on the system. If a location is incorrect, only the zone needs to be checked — not the entire stockroom.

Inventory Control

Maintaining Inventory Data Accuracy

One area of inventory control that is often underappreciated and sometimes even overlooked is that of keeping the inventory database accurate and timely. People will often either assume that the information in the system is accurate or else fail to realize how much poor accuracy will adversely impact the entire planning system.

The risky approach is that some companies regard inventory control and stockroom or warehouse work as a *mundane activity* requiring little skill or responsibility. In these environments the workers in the inventory control area are often low paid and given little training or education. Often the workers in these companies view the inventory job as a “foot in the door,” allowing them to later move into a “better” job as a machine operator, assembly worker, or some other job requiring more skill and better pay.

Whether that type of approach to inventory control is the cause or not, the fact remains that the costs of having poor inventory records will typically far exceed that of correcting the records and keeping them correct.

Inventory Control

Some of the symptoms of poor inventory records include:

Excessively high inventory levels. The more that people using the records to make decisions and plans suspect the accuracy of those records, the more they will have the tendency to request excessive amounts of inventory “just in case” the records are incorrect. One question commonly asked with respect to the issue of too much inventory is how can one tell that the level of inventory is excessively high? The starting point to answer that question begins with an analysis of the *inventory turns*. Turns are commonly calculated by taking the cost of goods sold for the year (from the income statement) and dividing it by the dollar value of the inventory on the books from the balance sheet. This figure can then be converted into the amount of inventory available in a time basis.

Inventory Control

Premium freight shipments. These commonly occur when the records indicate that a certain item supplied by an outside supplier is in stock and not in need of replenishment, and then the discovery is made that the stock position is much smaller than indicated. In these cases the firm often needs to place a rush order, and usually has to request shipment by the fastest means possible. The fastest method of shipment is often not the least expensive, causing excessive shipping costs.

Expediting. Expediting can occur for both internally produced and supplier products. While it is sometimes done in response to a customer request, it also often occurs when the actual inventory position is much less than indicated on the records. Expediting causes many people to bypass systems, create inefficiency, and in general expend a great deal of extra time and money to try to get the inventory replenished in a time frame much shorter than the usual replenishment time.

Inventory Control

Split lots. Often a result of expediting, split lots can occur when a normal production run has its setup broken to use the equipment to produce another part in short supply. Often the original setup has to be redone after the expedited run is complete so the rest of the normal production lot can be finished. The activity of setting up equipment twice for a single production run costs the company both time and money.

Inventory Control

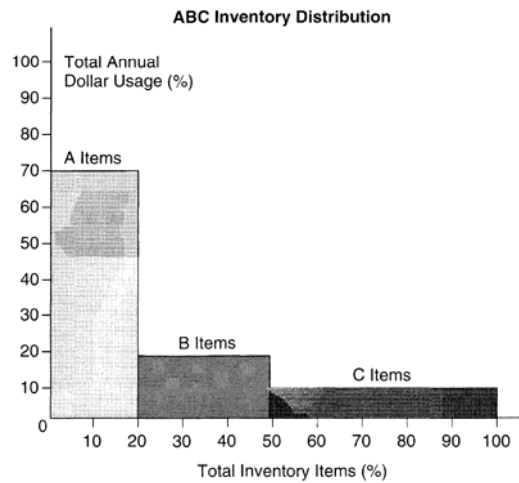
The Structured Approach

The first thing that should be understood is that all inventory accuracy is not alike. If you have some inventory that is worth several thousand dollars each, then even missing one unit is serious. On the other hand, a small screw worth \$0.005 is not worth bothering with. The process used to establish the relative importance of an item is called ABC inventory distribution. The concept is to separate the inventory based on the annual dollar usage. Annual dollar usage is, of course, the dollar value per item times the average number of items used per year.

There is no hard rule for the separation of A, B, and C items, but the “rule of thumb” that is often used is to list all items in order of highest annual dollar usage to lowest. The top 20% of the items will often represent the A items, those between 20 and 50% will be the B items, and the lowest 50% will be the C items. It is often found that the A items, while representing only 20% of the total items may represent from 70 to 80% of the annual dollar investment of the firm.

Inventory Control

FIGURE 5.7 A Sample ABC Inventory Distribution



Inventory Control

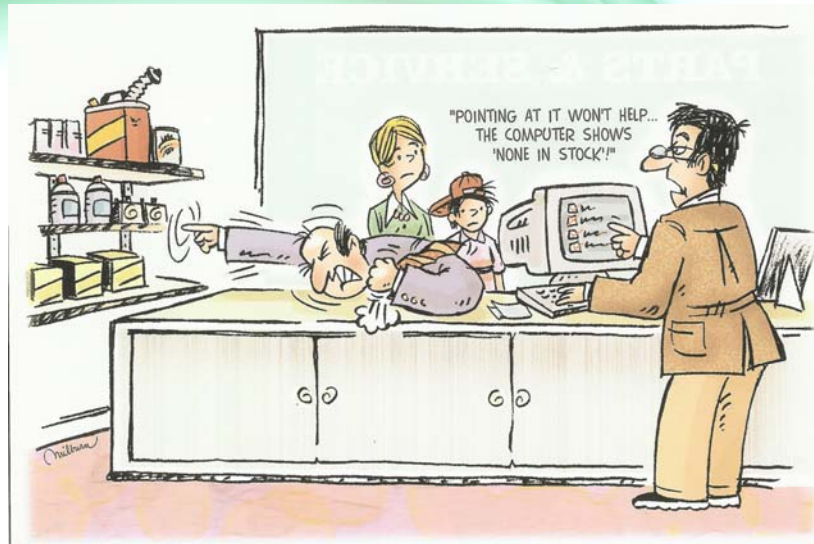
Obtaining Accurate Inventory Records

There are basically two methods to check records for accuracy and correct those found to be incorrect. Those methods are a complete (“wall-to-wall”) physical inventory and cycle counting.

“Wall-to-wall” physical inventory. This process involves establishing a fixed time period to physically count all the items in inventory for the entire operation. Often the production processes may need to be suspended for several days while this is being done, especially since the production workers are sometimes called on to assist with the count.

This process is often done at least once per year, often in conjunction with the accounting fiscal year cycle. The accounting system will typically require an accurate dollar value of the inventory, as it usually appears as a major asset on the accounting balance sheet of the firm.

Categories of Inventory



Inventory Control

Cycle counting. Cycle counting is often used as a highly preferable alternative to the wall-to-wall physical inventory approach by many companies. As the name implies, this approach is to count each item on a defined cycle throughout the year. Specific individuals are trained and assigned (often as a full-time job) to perform the cycle counts throughout the year. This is often done instead of, not in addition to, the annual physical inventory count.

Each day there are certain items identified to cycle count. These items are counted and inaccurate records corrected. Record correction is, however, not the primary purpose of the approach. *The primary purpose of cycle counting is to track down the cause of the incorrect record and fix the process so that the records have a better chance of being maintained correctly between count periods.*

Inventory Control

The primary purposes of cycle counting are, then, to:

- ✓ Identify the causes of record errors
- ✓ Correct the conditions in the processes that cause the errors
- ✓ Maintain a high level of inventory record accuracy for both count and location
- ✓ Provide a correct statement of assets for the accounting system

Inventory Control

There are several approaches that can be taken to identify the items that need to be counted during the cycle count on any given day. The more common methods include:

The ABC system. This implies the frequency and the definition of “accurate” will depend on whether the item has been classified as an A, B, or C item as described earlier. There is no hard and fast rule, but most will use something like the following:

Classification	Frequency of count	Accuracy level
A	Once a month or more frequent	1%
B	Every 3 months	5%
C	Once a year	10%

Inventory Control

- The reorder system.** This approach is to count items at the time when they are reordered, meaning their inventory is likely at a very low point and therefore much easier and quicker to count.
- The receiver system.** Similar to the reorder point approach, the inventory is likely to be low when new items are received, making the counting process easier.
- The zero or negative balance system.** When the record indicated a zero balance or a negative balance, it would be quite easy to check, since again the inventory should be quite low (if it exists at all). This becomes especially important if the record indicates a large negative balance.
- The transaction system.** Count when a specified number of transactions have occurred. The idea here is if there has to be some “detective” work done to find out the cause of any errors, the detection of the cause will be easier if there are not too many transactions involved.
- The zone system.** If the zone random system of location is used, sometimes a complete zone is targeted for a cycle count. This makes it easy to determine location identification problems.

Inventory Control

- Cycle count advantages.** There are numerous advantages to using an effective cycle count program. They include:
- ✓ Operations do not have to be suspended
 - ✓ The annual physical inventory can be eliminated
 - ✓ Errors can be more quickly discovered
 - ✓ The causes of errors can be tracked more effectively and quickly, and processes can be corrected more effectively
 - ✓ Records can be adjusted as necessary throughout the year
 - ✓ Overall record accuracy generally improves greatly
 - ✓ Correct statements of assets can be obtained throughout the year—no big year-end inventory “shrinkage” surprises
 - ✓ Improvement efforts can be concentrated in problem areas
 - ✓ Specialists (cycle counters) become effective in getting good counts and count procedures and can become effective problem solvers for process problems.

References

1. Stephen N. Chapman, *The Fundamentals of Production Planning and Control*, Prentice Hall, 2006, ISBN-13: 978-0130176158.
2. <http://dpwhelan.com/blog/wp-content/uploads/2008/05/inventory.jpg>
3. <http://www.transittrak.com/images/reinforced-plastic-inventory.jpg>
4. <http://www.soundadviceblog.com/wp-content/uploads/2007/08/inventory.jpg>
5. <http://www.cartoonstock.com/newscartoons/cartoonists/rma/lowres/rman1562l.jpg>
6. http://www.accuratetrailerhitch.com/Images/03_News/jokes/04_inventory.jpg