ESSENTIALS OF INVENTORY MANAGEMENT

MAX MULLER

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Library of Congress Cataloging-in-Publication Data

Muller, Max.
Essentials of inventory management / Max Muller.
p. cm.
ISBN 0-8144-0751-X
1. Inventory control. I. Title.
TS160 .M83 2003
658.7'87—dc21
2002014951

Printing number

10 9 8 7 6 5 4 3 2 1

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About This Book

Essentials of Inventory Management and Control has been written to introduce the (i) new stockroom/warehouse manager; (ii) non-financial inventory control individual; or (iii) the small business owner to the fundamental nature of inventory from a financial, physical, forecasting, and operational standpoint. The ultimate goal of this book is to present immediately usable information in the areas of forecasting, physical control and layout, problem recognition, and resolution. These materials should enable you to:

- Understand that modern practice discourages holding large quantities of inventory and encourages only having amounts on-hand required for current needs.
- Grasp the significance of controlling actual, on-hand inventory as both a physical object (shelf count) and as an intangible object (record count and monetary worth).
- Understand the fundamental differences between finished goods inventories in the retail/distribution sectors and raw materials and work-in-process inventories found in the manufacturing environment.

CHAPTER 1

Inventory as Both a Tangible and an Intangible Object

Introduction

The objective of this chapter is to provide you with a basic understanding of the nature of inventory as both a tangible, physical item actually kept within the facility ("real life" or "shelf count") and as an intangible item existing within the company's records ("paper life" or "record count"). Since you frequently make purchasing, sales, customer service, production planning, and other decisions based on whether or not an item is shown as being in-house *as per your records*, an item's paper life can be just as important as its real life.

Inventory—Who Needs It?

All organizations keep inventory. "Inventory" includes a company's raw materials, work in process, supplies used in operations, and finished goods.

Inventory can be something as simple as a bottle of glass cleaner used as part of a building's custodial program or something complex such as a mix of raw materials and subassemblies used as part of a manufacturing process.

Inventory Costs

Inventory brings with it a number of costs. These costs can include:

- Dollars
- Space
- Labor to receive, check quality, put away, retrieve, select, pack, ship, and account for
- Deterioration, damage, and obsolescence
- Theft

Inventory costs generally fall into ordering costs and holding costs. Ordering, or acquisition, costs come about regardless of the actual value of the goods. These costs include the salaries of those purchasing the product, costs of expediting the inventory, and so on. For a complete discussion of ordering costs see Chapter 5, Planning and Replenishment Concepts. For a complete discussion of carrying costs see Chapter 2, Inventory As Money.

As discussed in Chapter 2, holding costs include the cost of capital tied up in inventory (the opportunity cost of money[1]); storage costs such as rent; and costs of handling the product such as equipment, warehouse and stockkeeping staff, stock losses/wastage, taxes, and so on.

As discussed in Chapter 5, acquisition/ordering costs come about regardless of the actual value of the goods. These costs in-

clude the salaries of those purchasing the product, costs of expediting the inventory, and so on.

The Purpose of Inventory

So why do you need inventory? As discussed in a just-in-time manufacturing environment, inventory is considered waste. However, in environments where an organization suffers from poor cash flow or lacks strong control over (i) electronic information transfer among all departments and all significant suppliers, (ii) lead times, and (iii) quality of materials received, inventory plays important roles. Some of the more important reasons for obtaining and holding inventory are:

- *Predictability:* In order to engage in capacity planning and production scheduling, you need to control how much raw material, parts, and subassemblies you process at a given time. Inventory buffers what you need from what you process.
- *Fluctuations in demand:* A supply of inventory on hand is protection: You don't always know how much you are likely to need at any given time, but you still need to satisfy customer or production demand on time. If you can see how customers are acting in the supply chain, surprises in fluctuations in demand are held to a minimum.
- *Unreliability of supply:* Inventory protects you from unreliable suppliers or when an item is scarce and it is difficult to ensure a steady supply. *Whenever possible* unreliable suppliers should be rehabilitated through discussions or they should be replaced. Rehabilitation can be accomplished through master purchase orders with timed product releases, price or term penalties for nonperformance, better verbal and electronic communications between the parties, etc. This will result in a lowering of your on-hand inventory needs.

• *Price protection*: Buying quantities of inventory at appropriate times helps avoid the impact of cost inflation. Note that contracting to assure a price does not require actually taking delivery at the time of purchase. Many suppliers prefer to deliver periodically rather than to ship an entire year's supply of a particular stockkeeping unit (SKU) at one time. (Note: The acronym "SKU," standing for "stockkeeping unit," is a common term in the inventory world. It generally stands for a specific identifying numeric or alpha-numeric identifier for a specific item.)

• *Quantity discounts:* Often bulk discounts are available if you buy in large rather than in small quantities.

• *Lower ordering costs:* If you buy a larger quantity of an item less frequently, the ordering costs are less than buying smaller quantities over and over again. (The costs of holding the item for a longer period of time, however, will be greater.) See Chapter 5, Planning and Replenishment Concepts. In order to hold down ordering costs and to lock in favorable pricing, many organizations issue blanket purchase orders coupled with periodic release and receiving dates of the SKUs called for.

Types of Stock

Inventory basically falls into the overall categories of raw materials, finished goods, and work-in-process. Remember:

• *Raw materials:* Used to produce partial products or completed goods.

• *Finished product:* This is product ready for current customer sales. It can also be used to buffer manufacturing from predictable or unpredictable market demand. In other words, a manufacturing company can make up a supply of toys during the year for predictably higher sales during the holiday season.

• *Work-in-process (WIP):* Items are considered to be WIP during the time raw material is being converted into partial product, subassemblies, and finished product. WIP should be kept to a minimum. WIP occurs from such things as work delays, long movement times between operations, and queuing bottlenecks.

Other categories of inventory should be considered from a functional standpoint:

• *Consumables:* Light bulbs, hand towels, computer and photocopying paper, brochures, tape, envelopes, cleaning materials, lubricants, fertilizer, paint, dunnage (packing materials), and so on are used in many operations. These are often treated like raw materials.

• *Service, repair, replacement, and spare items (S&R Items):* These are after-market items used to "keep things going." As long as a machine or device of some type is being used (in the market) and will need service and repair in the future, it will never be obsolete. S&R Items should not be treated like finished goods for purposes of forecasting the quantity level of your normal stock.

Quantity levels of S&R Items will be based on considerations such as preventive maintenance schedules, predicted failure rates, and dates of various items of equipment. For example, if an organization replaced its fluorescent tubes on an as-needed, on-failure basis, it would need a larger supply of these lights on hand at all times. However, if the same company relamped all of its ballasts once per year, it would buy a large quantity of tubes at one time and only keep a small supply on hand on an ongoing basis.

Since S&R Items are never "obsolete" or "dead" until the

equipment or device they are to be used for is no longer in service, these items should not be included in calculating dead stock levels. See Chapter 2, pages 34–38.

- *Buffer/safety inventory:* This type of inventory can serve various purposes, such as:

—compensating for demand and supply uncertainties.

—holding it to "decouple" and separate different parts of your operation so that they can function independently from one another. See Exhibit 1–1.

- *Anticipation Stock:* This is inventory produced in anticipation of an upcoming season such as fancy chocolates made up in advance of Mother's Day or Valentine's Day. Failure to sell in the anticipated period could be disastrous because you may be left with considerable amounts of stock past its perceived shelf life.
- *Transit Inventory:* This is inventory en route from one place to another. It could be argued that product moving within a facility is transit inventory; however, the common meaning of the concept concerns items moving within the distribution channel toward you and also outside of your facility or en route from your facility to the customer.

Transit stock highlights the need to understand not only how inventory physically moves through your system, but also how and when it shows up in your records. If, for example, 500 widgets appeared as part of existing stock while they were still en route to you, your record count would include them while your shelf count would be 500 widgets short.

How could stock show up as being a part of inventory before it actually arrives? The answer lies in when did title to the

Exhibit 1-1. Points Along the Channel of Distribution Where Buffer Stock Is Needed to Decouple Operations

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Suppliers	Allows Procurement time to prepare purchase orders, place orders, and control timing and modes of delivery. Protects against uncertainties in lead times.	**Procurement (purchasing)**
Procurement (purchasing)	Provides time to plan and produce items while Procurement is interacting with Suppliers. Prevents downtime and allows for a continuous flow.	**Production**
Production	Provides Marketing with product to sell while Production is producing items for future sale.	**Marketing**
Marketing	Provides Distribution with the product Marketing has sold. Immediate customer satisfaction.	**Distribution**
Distribution	Offers the Intermediary items to deliver to the Consumer/End User.	**Intermediary (e.g., UPS, truck line, rail line, etc.)**
Intermediary (e.g., UPS, truck line, rail line, etc.)	Satisfies the Consumer/End User with product while it is waiting for deliveries from the Intermediary.	**Consumer/End User**

widgets transfer to you? Did title transfer when the product left the shipper's dock, or did it transfer only after the items arrived at your site and were signed for? If title transferred when the

What Article 2-319 States	What It Means
(1) Unless otherwise agreed, the term "F.O.B." (which means "free on board") at a named place, even though used only in connection with the stated price, is a delivery term under which:	
(a) when the term is F.O.B. the place of shipment, the seller must at that place ship the goods in the manner provided in this article and bear the expense and risk of putting them into the possession of the carrier; or	**This is F.O.B. Origin and means that title shifts to the buyer when the goods are deliverd to the carrier. Risk of loss while the product is in transit then shifts to the buyer. When the buyer receives notice of the shipment having been made the goods are then often shown as being a part of the buyer's total inventory. The transit inventory now has a paper life within the buyer's system even though it is still not in the buyer's facility. Buyers will purchase F.O.B. Origin in order to control shipping methods, timing, and costs.**
(b) when the term is F.O.B. the place of destination, the seller must at his own expense and risk transport the goods to that place and there tender delivery of them in the manner provided in this article.	**This is F.O.B. Destination and means that title and risk of loss while the goods are in transit stay with the seller until the product reaches the buyer's dock and is accepted. Unless the buyer's system reflects items in transit, the goods have neither a real nor a paper life within the system.**

product left the shipper's dock, and it was then counted as part of your total inventory, your total record count would not match your shelf count. For example, (a) a stockkeeper did not understand that an item's paper life had floated ahead of its real life and (b) did not have a breakdown of items on hand, on order, in transit, and immediately available, the (c) stockkeeper would find a mismatch between the shelf and record counts. Inappropriate adjustments might then be made.

The Uniform Commercial Code (UCC) governs the transfer of title to product. The UCC has been adopted by most states. Article 2 of the UCC covers the sale of goods.

Tracking the Paper Life

In order for you to gain an understanding of the relationship between an item's real life and its paper life within your own system, you should follow a single item on its path through that system. In other words, track an item's physical movement through your facility while noting what is happening to its paper life during that same time period. You will be able to discover when one of these lives moves ahead of the other and when there are system errors such as an item is moved but there is no paperwork authorizing that action.

Exhibit 1–2 provides an example of what could happen if an item's paper life and real life begin to leapfrog ahead or behind one another without the stockkeeper understanding the process.

As can be seen from the example in Exhibit 1–2, an item's real life and paper life can leapfrog around one another. It is important to understand that these lives can exist independently of one another, and to comprehend your own system, you must trace how both product and information move through the sys-

Exhibit 1-2. Real Life and Paper Life Leap Frog

Carr Enterprises operates six days per week, Monday through Saturday. It has an inventory system that is updated at 4:45 P.M. every day. In spite of the daily updating, the record count and the shelf count in Small Stock Room #1 are often out of balance.

Carr's warehouse manager, Nate, has decided to count everything in Small Stock Room #1 every Friday. He does so for two months. At the end of that time he is angry—the numbers still don't match.

Carr hires Shawn, an ace inventory detective, to help track down the source of the problem. Nate is flabbergasted. He believes he is counting very carefully, and if there is a problem, it is with the computer. Nate declares to anyone who will listen that "the computer is always wrong."

On Monday at 5:15 P.M., Shawn suggests that they examine an item that seems to be out of balance from the previous week's count.

Nate declares, "I'll show you one." Thrusting a brand new inventory Stock Status Report in front of Shawn's nose, Nate states, "Look at these widgets. It says there are 12 of them in stock. When we counted them last week there were 12 of them. I looked at this report this morning, and it said there were 13 of them. Now it says there are 12 of them, but I just looked in the stock room and there are actually 15 of them. See, I told you—the computer's always wrong."

Shawn asks if he can see Nate's count sheet with the widgets on it from the previous week. The sheet looks like this:

Stock Status Report					
Location	**Part Number**	**Description**	**U/M**	**Quantity**	
AB1002	9063	Gidgets	ea	127	
AB1003	2164	Gadgets	ctn	36	
AB1004	1878	Widgets	ea	~~10~~	12
AB1005	9201	Doodads	dz	98	
AB1006	5769	Whoohahs	pkg	~~105~~	101

Shawn asks what the notations mean.

Nate replies that when the wrong quantity was on the count sheet, he would "X" it out, write in the correct quantity, and turn the sheet into data entry.

Shawn asked when Nate turned his sheets in. Nate replied, "Friday—why?"

Shawn said, "I understand that you turn the sheets in on Friday. I'm asking, what *time* do you turn them in?" Nate says he does it at about 5 P.M. Thinking Shawn is criticizing him, Nate defensively states, "Hey, they're busy in data entry from 4:30 or so. They're doing cut-off and updates and stuff like that. So I wait until they're done."

Shawn asks when Nate's count sheets are keyed into the system. Nate says he doesn't know.

Shawn asks Hillary, the data entry clerk, when Nate's sheets are keyed in. Hillary replies that she doesn't put Nate's work on the front burner, "if you know what I mean." Shawn persists. He asks again, "who keys Nate's count sheets in and when are they done?" Hillary replies that she works on Saturday but leaves the sheets for Carolyn, the other data entry clerk, to input on Monday.

Shawn asks Hillary if she entered any widgets into the system on Saturday. She says she entered three of them into the system on Saturday.

Shawn asks Carolyn how she handles inputting Nate's

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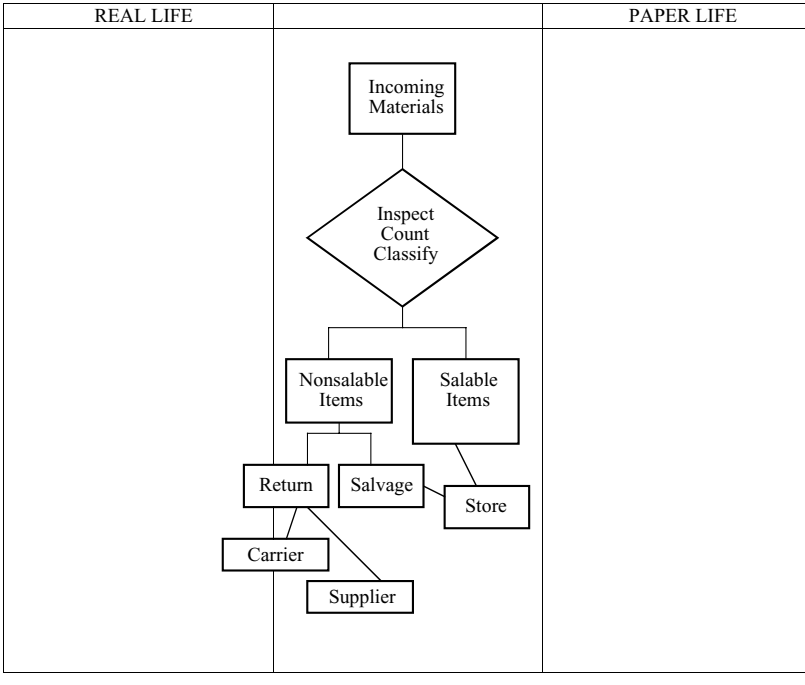
information. She replies that she pulls up the item on her computer screen, checks to see if the total in the computer matches Nate's handwritten amount and if it doesn't, she changes the amount in the system to match Nate's number.

Shawn charts-out the flow of real life and paper life for the widgets, and he comes up with the following:

Day	Record Count	Shelf Count	Notes
Friday @ close of business	**10**	**12**	**At the start of business on Friday, the system believes there are 10 widgets. There are actually 12. Nate does not note a plus or minus amount on his count sheet. He X's through the 10 and writes in 12. He does not turn in his count sheets until after the system has been updated forthat day. At the close of business on Friday, the system still believes there are 10 widgets. There are actually 12.**
Saturday @ close of business	**13**	**15**	**No one enters Nate's information on Saturday. Nate does not know this—he hasn't checked. Three widgets are added into the system on Saturday. At the close of business on Saturday, the system believes there are 13 widgets in stock. There are actually 15.**
Monday morning	**13**	**15**	**Monday morning's Stock Status Report reflects Saturday's numbers. During the day on Monday, Carolyn wipes out the record of 13 and enters the quantity of 12 from Nate's sheets.**
Monday @ close of business	**12**	**15**	**When the system is updated at 4:45 P.M. on Monday, the stock record and new Stock Status Report reflects that there are 12 widgets. There are actually 15. When Nate began counting on Friday the system was off by 2, and when all was said and done, it was off by 3![2]**

Exhibit 1-3. Tracking the Paper Life

Instructions: At each stage of the flow chart below note:



1. Where is the item physically?

2. What pieces of paper(s) authorize that?

3. When is information entered into your computer system?

4. Who is supposed to write something down? What are they supposed to write down? When were they supposed to write it down? Who are they supposed to give the piece of paper to? What is that person supposed to do with it? When are they supposed to pass the piece of paper along?

5. Does any item change its unit of measure within the

Cont. on page 14

Cont. from page 13

system even though it retains the same physical form. For example: Item *X* is purchased by the master case. When it is entered into the database, a conversion table converts each case into the four cartons within the master case. However, for ease of handling, the cartons remain in the master case for storage. Visually this item appears as a single unit while it will be sold or used as four separate items.

6. After the paper chase, where is the item physically?

tem. See Exhibit 1–3 for a simple method of breaking down a portion of your system to gain an understanding of your physical item and data base float times.

Electronic Data Interchange

Stockkeepers who do not understand how and when an item's paper life is first created within a system become even more confused if there is no hard paper copy audit trail they can follow. How could:

- an order be placed?
- an order be accepted?
- confirmation of the order be given?
- shipping instructions be given?
- notice of shipping arrangements be given?
- a paper life be created for an item in advance of it entering the facility?

All occur without there being any hard paper copies of these transactions existing. All of these events and more can occur in a paperless environment through electronic data interchange.

Electronic data interchange (EDI) is where routine business transactions are sent over standard communication lines (such as telephone lines) between computers within a company or between your computer and that of a vendor.

An example of EDI within a company is at the time of order entry, information about that order is electronically transmitted to shipping or operations for order selection and shipping, to accounting for billing purposes, to sales for order verification, and so on.

An example of EDI with a vendor is you electronically place an order directly from your computer into the vendor's computer. The vendor's computer then electronically confirms the order and transmits information about the order to the vendor's shipping and accounting departments. The vendor's computer also electronically notifies a carrier of the upcoming shipment. The carrier's computer electronically confirms the pickup and provides the vendor with pickup and delivery information. The vendor's computer then notifies your computer of the date, time, etc. of the upcoming delivery. All of this would be accomplished without any human intervention other than the original placement of the order.

For EDI to work, all of the system participants must agree to strict rules regarding message content, format, and structure.

recap The objective of this chapter was to point out that inventory exists within your system as both a physical item and as an item existing within your records.

There are many reasons for obtaining and holding inventory, and inventory can play a variety of roles within the life of any organization.

In order to control and manage the items coming into, through, and out of your facility, it is important to understand not only where an item is physically located at any given time, but also how that existence is being acknowledged within the system.

? REVIEW QUESTIONS

1. Inventory costs generally fall into: 1. (d)
- **(a)** sales expenditures.
- **(b)** work in process.
- **(c)** line during the annual physical inventory.
- **(d)** ordering costs and holding costs.

2. True or False
EDI is where routine business transactions are sent over standard communication lines. 2. (a)
- **(a)** True
- **(b)** False

3. True or False
Service and repair stock must never be retained beyond 5 years from date of purchase. 3. (b)
- **(a)** True
- **(b)** False

4. True or False

Anticipation stock is inventory en route from one place to another. 4. (b)

(a) True

(b) False

5. Which Article of the Uniform Commercial Code governs the sale of goods? 5. (c)

(a) 9

(b) 1

(c) 2

(d) 117

Notes

1. If you have $2 million tied up in inventory, you cannot earn money (interest) on that money. If you could earn 10 percent interest on that $2 million, you could earn $200,000. Not being able to is an opportunity cost.

2. If you are going to note stock quantity changes but the information will not be input before there are intervening inventory events, you must use a "plus/minus" notation system, e.g., +3; –4; ±0. By using a plus/minus notation system, the data entry clerk will add or subtract from the then current amount, which will already include any intervening events.

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CHAPTER 2

Inventory as Money

Introduction

Why should you care about the financial aspects of inventory? Because inventory is money.

Even if you do not have a financial background, it is important to understand and appreciate that inventory information in financial statements can be useful in the operation of your business. A basic understanding of how inventory appears on the balance sheet and its impact on the income statement and cash flow statement will improve your ability to have the right item in the right quantity in the right place at the right time.

Accounting for Inventories

There are three basic types of inventory:

1. Raw Materials—**raw materials inventory** is made up of goods that will be used in the production of finished products, e.g., nuts, bolts, flour, sugar.

2. Work in Process —**work in process inventory, or WIP,** consists of materials entered into the production process but not yet completed, e.g., subassemblies.

3. Finished Goods—**finished goods inventory** includes completed products waiting to be sold, e.g., bar stools, bread, cookies.

Most inventory fits into one of these general buckets, yet the amount of each category varies greatly depending on the specifics of your industry and business. For example, the types of inventory found in distribution environments are fundamentally different from those found in manufacturing environments. Distribution businesses tend to carry mostly finished goods for resale while manufacturing companies tend to have less finished goods and more raw materials and work in progress. Given these differences, it is natural that the accounting choices vary between distribution and manufacturing settings.

How Inventory is Valued

In order to assign a cost value to inventory, you must make some assumptions about the inventory on hand. Under the federal income tax laws, a company can only make these assumptions once per fiscal year. Tax treatment is often an organization's chief concern regarding inventory valuation. There are five common inventory valuation methods:

1. **First-in, First-out (FIFO)** inventory valuation assumes that the first goods purchased are the first to be used or sold regardless of the actual timing of their use or sale. This method is most closely tied to actual physical flow of goods in inventory. See Exhibit 2–1.

2. **Last-in, First-out (LIFO)** inventory valuation assumes that the most recently purchased/acquired goods are the first to be used or sold regardless of the actual timing of their use or sale. Since items you have just bought often cost more than those purchased in the past, this method best matches current costs with current revenues. See Exhibit 2–1.

3. **Average Cost Method** of inventory valuation identifies the value of inventory and cost of goods sold by calculating an average unit cost for all goods available for sale during a given period of time. This valuation method assumes that ending inventory consists of all goods available for sale. See Exhibit 2–2.

Average Cost = Total Cost of Goods Available for Sale ÷ Total Quantity of Goods Available for Sale

4. **Specific Cost Method (also Actual Cost Method)** of inventory valuation assumes that the organization can track the actual cost of an item into, through, and out of the facility. That ability allows you to charge the actual cost of a given item to production or sales. Specific costing is generally used only by companies with sophisticated computer systems or reserved for high-value items such as artwork or custom-made items.

5. **Standard Cost Method** of inventory valuation is often used by manufacturing companies to give all of their departments a uniform value for an item throughout a given year. This method is a "best guess" approach based on known costs and expenses such as historical costs and any anticipated changes coming up in the foreseeable future. It is not used to calculate actual net profit or for income tax purposes. Rather, it is a working tool more than a formal accounting approach.

Inventory on the Balance Sheet

The balance sheet shows the financial position of a company on a specific date. It provides details for the basic accounting equation: Assets = Liabilities + Equity. In other words, assets are a company's resources while liabilities and equity are how those resources are paid for.

- Assets represent a company's resources. Assets can be in the form of cash or other items that have monetary value—including inventory. Assets are made up of (a) current assets (assets that are in the form of cash or that are easily convertible to cash within one year such as accounts receivable, securities, and inventory), (b) longer-term assets such as investments and fixed assets (property/plant/equipment), or (c) intangible assets (patents, copyrights, and goodwill).
- Liabilities represent amounts owed to creditors (debt, accounts payable, and lease-term obligations).
- Equity represents ownership or rights to the assets of the company (common stock, additional paid-in capital, and retained earnings).

Inventory is typically counted among a company's *current assets* because it can be sold within one year. This information is used to calculate financial ratios that help assess the financial health of the company (see pp. 27–31). Note, however, that the balance sheet is not the only place that inventory plays a role in the financial analysis of the company. In fact, inventory shows up on the income statement in the form of *cost of goods sold*.

Inventory on the Income Statement

The income statement is a report that identifies a company's revenues (sales), expenses, and resulting profits. While the balance sheet can be described as a snapshot of a company on *a specific date* (June 30, for example), the income statement covers *a given period of time* (June 1 through June 30). The *cost of goods* sold is the item on the income statement that reflects the cost of inventory flowing out of a business.

The old saying, "it costs money to make money," explains the cost of goods sold. You make money by using or selling inventory. That inventory costs you something. Cost of goods sold (on the income statement) represents the value of goods (inventory) sold during the accounting period. See Exhibit 2–3.

The value of goods that are *not sold* is represented by the ending inventory amount on the balance sheet calculated as:

Ending Inventory = Beginning Inventory + Purchases – Cost of Goods Sold

This information is also useful because it can be used to show how a company "officially" accounts for inventory. With it, you can back into the cost of purchases without knowing the actual costs by turning around the equation as follows:

Purchases = Ending Inventory – Beginning Inventory + Cost of Goods Sold

Or, you can figure out the cost of goods sold if you know what your purchases are by making the following calculation:

Cost of Goods Sold = Beginning Inventory + Purchases – Ending Inventory

Finally, as you sell/use inventory and take in revenue for it, you subtract the cost of the items from the income. The result is your gross profit.

Exhibit 2–1 FIFO vs. LIFO vs. Average Cost Method of Inventory Valuation Example

Assume the following inventory events:

- November 5 Purchased 800 widgets at $10.00/unit—Total *cost* $8,000
- November 7 Purchased 300 widgets at $11.00/unit—Total *cost* $3,300
- November 8 Purchased 320 widgets at $12.25/unit—Total *cost* $3,920
- November 10 Sold 750 units of goods at $15.00/unit
- November 14 Sold 460 units of goods at $15.55/unit
- November 15 Purchased 200 widgets at $14.70/unit—Total *cost* $2,940
- November 18 Sold 220 units of goods at $14.45/unit

Basic Events:

	Units Purchased		
Date	**#Units**	**Cost/Unit**	**Total Cost**
11/5	**800**	**$10.00**	**$8,000**
11/7	**300**	**11.00**	**3,300**
11/8	**320**	**12.25**	**3,920**
11/15	**200**	**14.70**	**2,940**
Total	**1,620**	**N/A**	**$18,160**

	Units Sold		
Date	**#Units**	**Cost/Unit**	**Total Cost**
11/10	**750**	**Varies By**	
11/14	**460**	**Valuation**	
11/18	**220**	**Method**	
Total	**1,430**	**N/A**	**N/A**

Exhibit 2–1 FIFO vs. LIFO vs. Average Cost Method of Inventory Valuation Example

	Basic Events			FIFO Method of Accounting				
	Units Purchased			Units Sold			Ending Inventory	
Date	# Units	Cost/Unit	Total Cost	# Units	Cost/Unit	Total Cost	# Units	Total Cost
11/5	800	$ 10.00	$ 8,000				800	$ 8,000
11/7	300	11.00	3,300				1,100	11,300
11/8	320	12.25	3,920				1,420	15,220
11/10				750	$ 10.00	$ 7,500	670	7,720
11/14				50	10.00	500	620	7,220
				300	11.00	3,300	320	3,920
				110	12.25	1,348	210	2,573
11/15	200	14.70	2,940				410	5,513
11/18				210	12.25	2,573	200	2,940
				10	14.70	147	190	2,793

LIFO Method of Inventory Valuation:

	Basic Events			LIFO Method of Accounting				
	Units Purchased			Units Sold			Ending Inventory	
Date	# Units	Cost/Unit	Total Cost	# Units	Cost/Unit	Total Cost	# Units	Total Cost
11/5	800	$ 10.00	$ 8,000				800	$ 8,000
11/7	300	10.25	3,075				1,100	11,075
11/8	320	9.85	3,152				1,420	14,227
11/10				320	$ 9.85	$ 3,152	1,100	11,075
				300	10.25	3,075	800	8,000
				130	10.00	1,300	670	6,700
11/14				460	10.00	4,600	210	2,100
11/15	200	10.22	2,044				410	4,144
11/18				200	10.22	2,044	210	2,100
				20	10.00	200	190	1,900

Average Cost Method of Inventory Valuation:

Average Cost	= Total Cost of Goods Available for Sale	÷	Total Quantity of Goods Available for Sale
	= $18,160	÷	1,620 units
	= $11.21/unit		

Ending Inventory

	Basic Events			Average Cost Method of Accounting				
	Units Purchased			Units Sold			Ending Inventory	
Date	# Units	Cost/Unit	Total Cost	# Units	Cost/Unit	Total Cost	# Units	Total Cost
11/5	800	$ 10.00	$ 8,000				800	$ 8,000
11/7	300	11.00	3,300				1,100	11,300
11/8	320	12.25	3,920				1,420	15,220
11/10				750	$ 11.21	$ 8,407	670	,813
11/14				460	11.21	5,157	210	1,656
11/15	200	14.70	2,940				410	4,596
11/18				220	11.21	2,466	190	2,130

Exhibit 2–2 Calculating Cost of Goods Sold

	FIFO	LIFO	Avg Cost Method
Cost of Goods Purchased	**$18,160**	**$18,160**	**$18,160**
Minus: Ending Inventory	**2,793**	**1,900**	**2,130**
Cost of Goods Sold	**$15,367**	**$16,260**	**$16,030**

Exhibit 2–3 Sample Balance Sheet and Income Statement

Balance Sheet (assumes FIFO Method of Accounting)

Assets		Liabilities and Equity	
Cash	$5,000	Accounts Payable	$10,000
Accounts Receivable	11,500	Notes Payable	7,500
Inventory (per FIFO method)	2793	Current Portion of Long Term Debt	3,050
Other Current Assets	7,000	Total Current Liabilities	20,550
Total Current Assets	26,293	Long Term Debt	30,500
Investments	1,800	Long Term Lease Obligations	12,250
Property, Plant, & Equipment (net)	53,000	Total Liabilities	$63,300
Deferred Charges	1,000		
Patents, Goodwill	1,200	Shareholders' Equity	$19,993
Total Assets	$83,293	Total Liabilities and Equity	$83,293

Income Statement	FIFO	LIFO	Avg. Cost Method
Revenues	$21,582	$21,582	$21,582
Less: Cost of Goods Sold	15,367	16,260	16,030
Gross Profit	6,215	5,322	5,552
Less: Selling, General and Administrative Expenses	2,500	2,500	2,500
Depreciation and Amortization Expenses	1,250	1,250	1,250
Goodwill Expense	553	553	553
Profit Before Taxes	1,912	1,019	1,249
Less: Federal Income Tax (assume 40%)	765	408	500
After-Tax Income	$1,147	$611	$749

Conclusions

1. By valuing its inventory under the FIFO method of inventory valuation, this company would have earned an extra $536 or $398 in after-tax income than under the LIFO or Average Cost methods of inventory valuation, respectively.

2. By valuing its inventory under the LIFO method of inventory valuation, this company would pay $357 or $92 less in federal income taxes than under the FIFO or Average Cost methods of inventory valuation, respectively.

Ratio Analyses and What They Mean

Is something good or is it bad? To answer this question we often compare one thing to another. That is what a "ratio" is: It is an expression of how many of one item is contained within another.

Ratios can be used in the business world by selecting parts of an organization's finacial statements and comparing one set of financial conditions to another. A company's financial statements contain key aspects of the business. By reviewing these aspects, you can determine an organization's economic well-being. One way of reviewing these financial conditions is to compare one to another through dividing one by the other. For example, if you had $200 cash and $100 worth of debts, you could divide the cash (assets) by the debt (liabilities) getting a ratio of 2 to 1. In other words, you have twice as many assets as you do liabilities.

Ratios are useful tools to explain trends and to summarize business results. Often third parties, such as banks, use ratios to determine a company's credit worthiness. By itself, a ratio holds little meaning. However, when compared to other industry and/or company-specific figures or standards, ratios can be powerful in helping to analyze your company's current and historical results. Companies in the same industry often have similar liquidity ratios or benchmarks, as they often have similar cost structures. Your company's ratios can be compared to:

1. Prior period(s)
2. Company goals or budget projections
3. Companies in your industry
4. Companies in other industries
5. Companies in different geographic regions

In particular, here are three ratios that are useful when assessing inventory.

1. **Current Ratio.** The current ratio assesses the organization's overall liquidity and indicates a company's ability to meet its short-term obligations. In other words, it measures whether or not a company will be able to pay its bills. Technically speaking, the current ratio indicates how many dollars of assets we have for each dollar of liabilities that we owe. The current ratio is calculated as follows:

Current Ratio = Current Assets ÷ Current Liabilities

Current Assets, refers to assets that are in the form of cash or that are easily convertible to cash within one year, such as accounts receivable, securities, and inventory. *Current Liabilities* refers to liabilities that are due and payable within twelve months, such as accounts payable, notes payable, and short-term portion of long-term debt.

Standards for the current ratio vary from industry to industry. Companies in the service industry that carry little or no inventory typically have current ratios ranging from 1.1 to 1.3—that is, $1.10 to $1.30 in current assets for each dollar of current liabilities. Companies that carry inventory have higher current ratios. Manufacturing companies are included in this latter group and often have current ratios ranging from 1.6 to 2.0; not only do they have inventory in the form of finished goods ready for sale, but they also carry inventory of goods that are not yet ready for sale. Generally speaking, the longer it takes a company to manufacture the inventory and the more inventory it must keep on hand, the higher the current ratio.

What the current ratio might mean:

A low current ratio may signal that a company has liquidity problems or has trouble meeting its short- and long-term obligations. In other words, the organization might be suffering from a lack of cash flow to cover operating and other expenses. As a result, accounts payable may be building at a faster rate than receivables. Note, however, that this is only an indicator and must be used in conjunction with other factors to determine the overall financial health of an organization. In fact, some companies can sustain lower-than-average current ratios because they move their inventory quickly and/or are quick to collect from their customers and therefore have good cash flow.

A high current ratio is not necessarily desirable. It might indicate that the company is holding high-risk inventory or may be doing a bad job of managing its assets. For example, fashion retailers may have costly inventory, but they might also have significant trouble getting rid of the inventory—if the wrong clothing line was selected for example. This makes it a high-risk company, forcing creditors to require a bigger financial cushion.

Further, if a high current ratio is a result of a very large cash account, it may be an indication that the company is not reinvesting its cash appropriately. Even if the current ratio looks fine, other factors must be taken into consideration, as liquidity problems might still exist. Since ratios look at quantity, not quality, it is important to look at what the current assets consist of to determine if they are made up of slow-moving inventory. In order to assess inventory's impact on liquidity, another test of liquidity should be taken into account—the Quick Ratio (or Acid Test).

2. **Quick Ratio or Acid Test.** The quick ratio compares the organization's most liquid current assets to its current liabilities. The quick ratio is calculated as follows:

Quick Ratio = (Current Assets – Inventories) ÷ Current Liabilities

Assume that an industry that sells on credit has a quick ratio of at least 0.8. In other words, the company has at least 80¢ in liquid assets (likely in the form of accounts receivable) for every $1 of liabilities. Industries that have significant cash sales (such as grocery stores) tend to be even lower. As with the current ratio, a low quick ratio is an indicator of cash flow problems, while a high ratio may indicate poor asset management as cash may be properly reinvested or accounts receivable levels are out of control. An organization's ability to promptly collect its accounts receivable has a significant impact on this ratio. The quicker the collection the more liquidity it has.

3. **Inventory Turnover Ratio.** The inventory turnover ratio measures, on average, how many times inventory is replaced over a period of time. In its simplest sense, an inventory turn occurs every time an item is received, is used or sold, and then is replaced. If an SKU came in twice during the year, was used/sold, and then replenished, that would be two turns per year. If this happened once per month, it would be twelve turns per year, and so forth.

Inventory turnover is an important measure since the ability to move inventory quickly directly impacts the company's liquidity. Inventory turnover is calculated as follows:

Inventory Turnover Ratio = Cost of Goods Sold ÷ Average Inventory

Essentially, when a product is sold, it is subtracted from inventory and transferred to cost of goods sold. Therefore, this ratio indicates how quickly inventory is moving for accounting purposes. It does not necessarily reflect how many times actual physical items were handled within the facility itself. This is true because the cost of goods sold number may include items you sold but never physically handled. For example, items that we purchase and

then have drop-shipped directly at our customer's site aren't ever handled within our facility. A more accurate measure of how many times actual physical inventory turned within the site would be:

Actual Physical Inventory Turnover Ratio = **Cost of Goods Sold from Inventory Only** ÷ **Average Inventory**

Note that if the inventory has increased or decreased significantly during the year, the average inventory for the year may be skewed and not accurately reflect your turnover ratio going forward. Also, if the company uses the LIFO method of accounting, the ratio may be inflated because LIFO may undervalue the inventory.

Unlike the current ratio and quick ratio, the inventory turnover ratio does not adhere to a standard range. Organizations with highly perishable products can have inventory turns of 30 times a year or more. Companies that retain large amounts of inventory or that require a long time to build their inventory might have turns of only two or three times a year. In general, the overall trend in business today is to reduce carrying costs by limiting the amount of inventory in stock at any given time. As a result, both individual inventory turnovers and industry averages in this area have increased in recent years.

It is important to understand, however, that many factors can cause a low inventory turnover ratio. The company may be holding the wrong type of inventory, its quality may be lacking, or it may have sales/marketing issues.

Obsolete Stock

Any stockkeeper who has had to repeatedly move really slow moving or outright dead stock out of the way or finds herself

hurting for space because obsolete product eats up square foot after square foot knows that these items "just gotta go."

Why You Have Been Told Not to Dispose of It

Why is the dead stock still here? The three reasons most often given as to why the product can't be disposed of are:

1. It's already paid for.
2. We might use it someday.
3. We might sell it someday.

These explanations seem logical and the idea of throwing away dead stock may be counterintuitive. Indeed, there are some very real practical problems with simply hauling it off to the dumpster.

Problems with Convincing Decision Makers That "Its Gotta Go"

Decision makers often have difficulty with disposing of dead inventory because it will adversely impact the balance sheet and deplete resources considered to be valuable for lending purposes.

• *Impact of write off* Anything that appears as an asset on the balance sheet has an accounting value. This value, consisting of an item's original cost minus depreciation, is called the "book value." It is irrelevant that the item may actually be worthless to either a customer or as part of a manufacturing process. If it has a one-dollar value on the books, then disposing of dead inventory has an accounting consequence to our organization.

If we sell dead inventory that has a monetary value at a deep discount, throw it away, or give it away to a charity, we will

have to immediately write-off the book value of those items, which will, of course, have a negative impact on the financial statements.

If your organization is sensitive to making extraordinary adjustments to the balance sheet and never or seldom writes off dead inventory, you may have a difficult time ever convincing any decision maker to dispose of these items. The decision maker will simply not be willing to "take the hit on the books."

• *Organization's capital structure* Almost everyone has heard the expression, "cash is king." The problem for many organizations is that cash flow doesn't always keep up with our needs.

Often organizations raise operating capital by borrowing against (a) their accounts receivable and (b) the book value of the inventory they are carrying.

"Accounts receivable" are the amounts due from customers resulting from normal sales activities. Depending on the industry, banks will generally lend up to 75 percent of the value of accounts receivable due in ninety days or less.

Bankers will also lend against the book value of inventory. The willingness to lend against this asset is not as straightforward as with accounts receivable. The more complex nature of these transactions comes from the fact that in accordance with accepted accounting practices, we should value inventory at the *lower* of cost or fair market value. Therefore, dead stock should logically be valued at a fair market value of zero dollars no matter what it originally cost.

In spite of generally accepted accounting practices and even though parts of your inventory have no real market value (and should be valued at zero dollars), bankers will often loan your organization 50 to 60 percent of the value of the inventory *as that value is shown on the books*. So, companies will sometimes continue to carry dead stock so as to retain this artificial value on

the books. This is an area most stockkeepers will not have any direct control over. However, the arguments below may overcome the need to keep inventory values artificially high.

Arguments in Favor of Disposing of Dead Stock

Strong arguments can be made in favor of disposing of nonproductive stock including recapture of space, better use of labor and equipment, plus a reduction in the costs associated with having inventory sitting around.

- Recapture of space

  In terms of space utilization, there are some simple mathematical facts to keep in mind:

  —Multiplying an item's length times its width tells you the amount of square feet the item is occupying.

  —Multiplying an item's length times its width times its height tells you the amount of cubic space it is occupying.

If you were to actually figure out the cubic space taken up by dead product, you would gain a powerful argument in favor of disposing of this inventory. To bolster the argument, you may want to ask your organization's financial officer how much the company is paying per square foot for rent. Multiplying the square footage being consumed by dead product times the rent per square foot often results in a truly eye-opening dollar amount. Providing actual numbers to a decision maker is far more effective than speaking in generalities like, "dead stock is taking up a lot of space." Pointing out that obsolete stock is "taking up 4,000 square feet" or "represents $2,000 per month in per square foot costs" should help you convince your decision maker that "its gotta go."

- Efficient utilization of labor and machine resources

  Not only does obsolete inventory take up a lot of space, it can also get in the way of workers. Repeatedly moving obsolete product out of the way hurts efficient use of both labor and machine time.

  Too often, in trying to argue against keeping obsolete stock, stockkeepers will state generalities like, "it takes us a lot of time to move that stuff around." How long is "a lot of time"? Is it an hour a day, four hours per week? Without specific numbers your arguments will sound hollow.

  As many business writers have noted, "You cannot control what you do not measure." There are two things to do to get specific time and dollar amounts you need to:

  —During each week for one month, every time you or your staff move dead product out of the way, measure the amount of direct labor that goes into that effort. Remember, if two workers are working together to move the items and they work for fifteen minutes, that represents fifteen minutes times two, or thirty minutes of direct labor.

  —At the end of the month, divide the total amount of labor hours by four to determine a weekly average. To determine the amount of yearly labor involved in moving dead stock, multiply the weekly average times the number of weeks in a year your company operates.

Once again, obtain base information from your financial officer and multiply the average hourly wage you pay your workers, including benefits, times the annual labor number. The result will make a rather impressive argument as to how the organization can save thousands of dollars per year by disposing of its dead stock.

- Reduction of carrying costs (the K Factor)
  The K Factor represents the number of pennies per inventory dollar per year a company is spending to house its inventory. It is generally expressed as a percent. In other words, a K Factor of 25 percent means that you are spending 25¢ per inventory dollar per year to house your inventory. A one dollar dead item that sits on your shelf for a year would cost you 25¢ that year, a total of 50¢ at the end of the second year, a total of 75¢ at the end of the third year, and so on.

There are two ways of computing the K Factor—a traditional method in which you add together various expenses directly related to carrying inventory and a rough rule-of-thumb method. See Exhibit 2–4.

Exhibit 2–4 Methods of Determining the Cost of Carrying Inventory

Traditional Accounting Method		Rule-of-Thumb Method
Warehouse Space	$ 130,000	20% + Prime Lending Rate = K Factor
Taxes	65,000	
Insurance	40,000	
Obsolescence/Shrinkage	23,000	
Material Handling	64,800	
Cost of Money Invested	200,000	
Total Annual Costs	$ *522,800*	
$\frac{\text{Total Annual Costs}}{\text{Ave Inventory Value}} = \frac{\$522,800}{\$2,000,000} =$		26% K Factor

Since it always costs something to carry inventory, it is obvious that the longer dead stock remains in your facility, the more it will cost. Two approaches can be used to effectively argue this point:

1. Demonstrate the impact of carrying costs on your existing dead stock. This addresses the "We've already paid for it," argument in favor of retaining dead stock. See Exhibit 2–5 and Exhibit 2–6.

Exhibit 2–5 Demonstrating the Impact of the K Factor on Existing Dead Stock

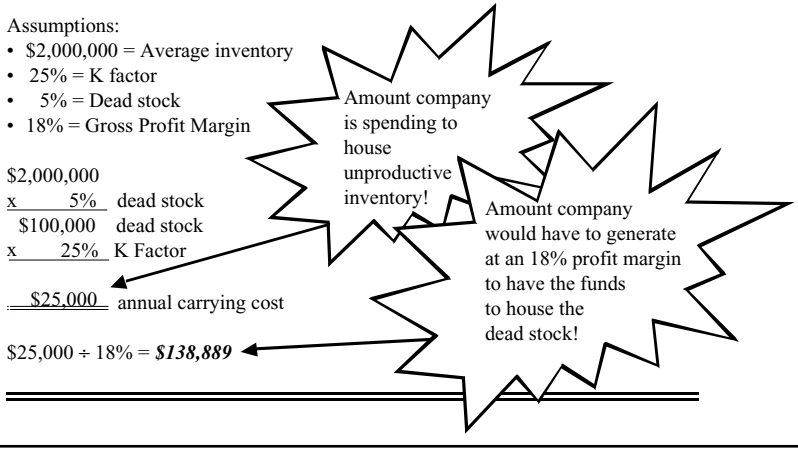


Exhibit 2–6 Creating an Inventory Analysis Report Listing Dead Stock

SKU #	DESCRIPTION	QUANT ON HAND	UNIT COST	DOLLAR VALUE OF PRODUCT IN HOUSE	MONTHLY USAGE	PROJECTED ANNUAL USAGE	MONTHS SUPPLY ON HAND

2. Demonstrate that if the product remains long enough, even selling it at a profit will not recapture your original cost. This addresses the "We might need it someday," and, "We might sell it someday," arguments in favor of retaining dead stock. See Exhibit 2–7.

In Exhibit 2–5, a percentage is used to indicate the amount of dead stock in the facility. Note, however, it is always more convincing to a decision maker if you use actual lists and dollar amounts to demonstrate those items that are dead rather than using a generality like a rough percentage. See Exhibit 2-6.

Methods of Disposal

Various approaches to disposing of dead stock exist:

- Sell at net price
- Temporarily raise commissions for salespeople
- Discount the price
- Return to vendor
- Donate it
- Write it off
- Auction

It is important to remember something about convincing decision makers of anything. Ordinarily, when reports or other information flow up a chain of command, the level of detail at each level *decreases*. Generally, each higher level of management wants to see less and less information with which to make decisions. You should resist providing only minimal data in making arguments regarding dead stock. This is a time to let the detail do the talking.

Exhibit 2–7 Demonstrating the Impact of the K Factor on Items Sold at a Profit but after Remaining in Stock for Long Periods of Time

Assumptions:

- 720 pairs of earmuffs purchased at $2.25 per pair ($1,620 original cost)
- Earmuffs have remained unsold for 2 years
- We hope to sell at a 30% gross profit per pair ($2.93 pair)
- 25% K factor

$1,620 x 25% = $405 per year in carrying cost

$405 ÷ 720 pairs = 56¢ per year, per pair in additional carrying cost expense

Additional cost after one year:
$2.25 + $0.56 = $2.81/pair (720 pairs x $2.81/pair = $2,023)

Additional cost after two years:
$2.81 + $0.56 = $3.37/pair (720 pairs x $3.37/pair = $2,426)

Costs are going up $0.002 per day ($0.56 ÷ 365 days/yr)

$2.93 sales price
–2.25 original cost
$0.68 gross profit expected

$0.68 ÷ $0.002 = breakeven at 340 days—after 340 days there is no profit at all!

Original cost: $2,500

Cost including carrying costs after two years:
$4,449 ($2,023 + $2,426)
Revenue from selling earmuffs at $2.93/pair: $2,110 ($2.93/pair x 720 pairs)

Loss on sale made after inventory has been in-house for two years even though sale made at 30% gross profit on original cost: $2,339

Carrying Cost and Purchasing

Although you should only have the minimum amount of inventory on hand required for either production or distribution, be careful not to purchase small quantities over and over again. Buying small amounts frequently will lead to an excessive cost of replenishment (the "R Factor").

A simple example of how an excessive R Factor can be created would be the following:

Assumptions:

It costs a certain amount of money per line item, per purchase order to buy something. Assume $2.59 per line item, per purchase order for this example. See Exhibit 2-8, Determining the R Factor.

You Purchase 1 million widgits per year.

If you bought all 1 million widgits at one time, the R Factor would be $2.59 since there was only one purchase order with one line item on it.

If you bought 250,000 widgits at a time, the R Factor would be $10.36. That is because you would have four purchase orders with one line item each at a cost of $2.59 each.

If you bought 1 million widgits one at a time at an R Factor of $2.59 each the replenishment cost would be $2,590,000!

Because of the R Factor, modern purchasing dictates that you buy larger quantities on fewer purchase orders, but with suppliers releasing items on a prearranged schedule or on demand.

Ultimately, the point at which your cost of carrying inventory matches the cost of purchasing it is the proper economic order quantity of that item. See Chapter 5, Planning and Replenishment Concepts, Replenishment Costs.

recap The objective of this chapter was to provide you with highlights of the most basic accounting concepts you, as a stockkeeper, must understand to successfully discuss and plan inventory values with your colleagues.

Although you may never participate in the preparation of month- or year-end financial statements, it is in your own self-interest to review these statements and think about how the inventory values reflected impact your operation.

And finally, whenever discussing either buying more stock or getting rid of dead stock, it is always more persuasive to use actual numbers than to deal in generalities. Remember, "if you can measure it, you can control it."

? REVIEW QUESTIONS

1. A balance sheet is best described as: 1. (b)

(a) A report that identifies a company's revenues (sales), expenses, and resulting profits for a given period of time.

(b) A report that shows the financial position of a company on a specific date.

(c) A report that shows the relationship between inventory on-hand and on-order.

(d) A report that identifies the number of items per level and number of tiers of product on a pallet.

2. An income statement is best described as: 2. (a)

(a) A report that identifies a company's revenues (sales), expenses, and resulting profits for a given period of time.

(b) A report that shows the financial position of a company on a specific date**.**

(c) A report that shows the relationship between inventory on-hand and on-order.

(d) A report that identifies the number of items per level and number of tiers of product on a pallet.

3. True or False 3. (a)

The K Factor represents the number of pennies per inventory dollar per year a company is spending to house its inventory.

(a) True

(b) False

4. True or False 4. (a)

The K Factor is generally expressed as a percent.

(a) True

(b) False

5. Current Assets ÷ Current Liabilities is the formula for which ratio? 5. (b)

(a) Inventory Turn Ratio

(b) Current Ratio

(c) Quick Ratio

CHAPTER 3

Physical Location and Control of Inventory

Introduction

If you can't find an item you can't count it, fill an order with it, or build a widgit with it. This chapter is about setting up a system that allows you to put items where they will do the most good for your organization.

If you cannot control the location of your product or raw materials from both a physical and a recordkeeping standpoint, then your inventory accuracy will suffer.

To sustain inventory accuracy on an ongoing basis you must:

1. formalize the overall locator system used throughout the facility
2. track the storage and movement of product from
   a. receipt to storage
   b. order filling to shipping or to staging at a point-of-use
3. maintain timely records of all item storage and movement

The objective of this chapter is to provide you with a working knowledge of (i) three key stock locator systems (which relate to the overall organization of SKUs within a facility and their impact on space planning); (ii) item placement theories dealing with the specific arrangement of products within an area of the warehouse (should the box be over here or over there?); and (iii) some practical methods of attaching addresses to stock items and how to tie an item number to its location address.

Common Locator Systems

The purpose of a material locator system is to create procedures that allow you to track product movement throughout the facility. Although going by many names, the most common "pure" systems are *memory*, *fixed*, and *random*. A type of fixed system is the *zone* system. The *combination* approach is a common mixture of the fixed and random systems.

In considering which locator system will work best, you should attempt to maximize:

- Use of space
- Use of equipment
- Use of labor
- Accessibility to all items
- Protection from damage
- Ability to locate an item
- Flexibility
- The reduction of administrative costs

Maximizing all of these considerations at the same time is difficult, if not impossible. Often each of these concerns creates

Exhibit 3–1 Examples of Valid Storage Considerations in Conflict

• Scenario One—*Accessibility versus Space*: Charmax, Inc. wishes to have its entire product as easy to get to as possible for order filling purposes. It therefore attempted to have a "picking face" (a front line, visible position from which the product can easily be selected) for each item. In order to actually create a picking face for each SKU, Charmax would have to assign a specific location for every product appearing on all of its pick tickets, with no two items being placed one on top of another, and no item being placed behind another. Charmax quickly realized that it lacked sufficient space in its facility to have a specific position for every item it carried.

• Scenario Two—*Use of Labor Versus Protection from Damage*: Alana Banana Enterprises wishes to reduce labor hours by putting into place efficient product handling procedures. Its intent is to develop standard operating procedures so that workers will only handle SKUs four times: once when it is received, once when stored, once when

Cont. on page 46

conflicts with one or more of the others. For example, you may wish to store all cylinders together in order to utilize the same equipment to handle them or locate them together for ease of getting to and retrieving them. However, if the chemical nature of the contents of these cylinders prohibits them from being stored in the same area, safety and protection of property concerns overcome other considerations . Exhibit 3–1 provides scenarios in which several valid considerations are in conflict.

Cont. from page 45

picked, and once when loaded. However, in order to protect SKUs from bruising, items must be placed into protective cartons for storage. SKUs are not picked in full carton quantities so workers have to remove various quantities at different times from the cartons. Empty cartons must then be stacked, cleaned, restacked, and taken back to the receiving area for reuse. These protective measures add a number of labor intensive steps to the process.

- Scenario Three—*Ability To Locate an Item Versus Space Utilization*: Racquetballers America wants to assign a specific home to each of its products for inventory control purposes. However, it has a small stockroom. Racquetballers realizes that if it uses a fixed storage location approach it must assign sufficient space to store the maximum amount of any one of its SKUs that will ever be on hand at one time in that location. If it uses a random location approach where items can be placed one on top of another or behind one another, then it will maximize its use of space. Racquetballers decides using its limited space is more important than putting in the extra labor and administration necessary to keep track of where everything is as it moves around the floor.

The stockkeeper should select a locator system that provides the best solution given the tradeoffs between conflicting objectives. No one system is "right." What is best will depend on considerations such as:

- Space available
- Location system (See the "Impact On Physical Space" discussions in this chapter.)

- Dimensions of product or raw materials stored
- Shape of items
- Weight of items
- Product characteristics, such as stackable, toxic, liquid, crushable
- Storage methods, such as floor stacked, racks, carousels, shelving
- Labor availability
- Equipment, including special attachments available
- Information systems support

Every company has a limited amount of space available for stock storage. Some locator systems use space more effectively than do others. When choosing your locator system, you need to think carefully about how much space it will use. The following pages show several types of locator systems and evaluate the strengths and weaknesses of each type.

Memory Systems

Basic Concept—Memory Systems

Memory systems are solely dependent on human recall. Often they are little more than someone saying, "I think it's over there."

The foundations of this locator system are simplicity, relative freedom from paperwork or data entry, and maximum utilization of all available space. Memory systems depend directly on people and only work if several or all of the conditions listed in Exhibit 3–2 exist at the same time.

Exhibit 3–2 Conditions Under Which Memory Systems Will Work

- Storage locations are limited in number.
- Storage locations are limited in size.
- The variety of items stored in a location is limited.
- The size, shape, or unitization (e.g., palletization, strapping together, banding, etc.) of items allows for easy visual identification and separation of one SKU from another.
- Only one or a very limited number of individuals work within the storage areas.
- Workers within the storage area do not have duties that require them to be away from those locations.
- The basic types of items making up the inventory does not radically change within short time periods.
- There is not a lot of stock movement.

Impact on Physical Space—Memory Systems

The most complete space utilization is available through this system. Why? Because no item has a dedicated location that would prevent other SKUs from occupying that same stock location position if it were empty (either side-to-side or up-and-down).

Pros—Memory Systems

- Simple to understand
- Little or no ongoing paper-based or computer-based tracking required

- Full utilization of space
- No requirement for tying a particular stocking location, identifier, bin, slot, drawer, rack, bay, spot, to a specific SKU
- Requirements of single item facilities (such as a grain silo) can be met

Cons—Memory Systems

- The organization's ability to function must strongly rely on the memory, health, availability, and attitude of a single individual (or a small group of people).
- Significant and immediate decreases in accuracy result from changes in the conditions set out in Exhibit 3–2.
- Once an item is lost to recall, it is lost to the system.

Despite its limitations, a memory system may be as efficient as any other, particularly if there are only a limited number of different SKUs within a small area.

Fixed Location Systems

Basic Concept—Fixed Location Systems

In pure fixed location systems, every item has a home and nothing else can live there. Some (not pure) fixed systems allow two or more items to be assigned to the same location, with only those items being stored there.

Impact on Physical Space—Fixed Location Systems

If quantities of any given SKU are large, then its "home" may consist of two or more storage positions. However, collectively all of these positions are the only places where this item may ex-

ist within the facility, and no other items may reside there. Basically, everything has a home and nothing else can live there.

Fixed location systems require large amounts of space. There are two reasons for this:

- Honeycombing
- Planning around the largest quantity of an item that will be in the facility at one time

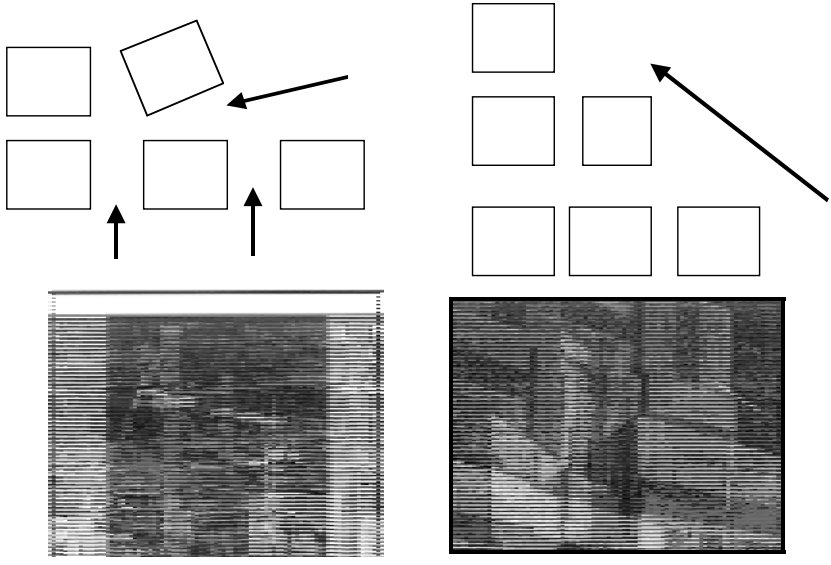
Honeycombing is the warehousing situation where there is storage space available but not being fully utilized due to:

Cause	Description
• Product shape	Physical characteristics cut down on stackability and prevent use of cubic space or prevent placing one item against another.
• Product put away	Product not stacked or placed in a uniform manner causing loss of vertical or horizontal space.
• Location system rules	Situation where a location is empty but no other item may be placed there since it is not the second item's assigned home.
• Poor housekeeping	Trash, poorly placed desks, etc. force empty space around it.

Honeycombing is unavoidable given location system tradeoffs, product shape, and so on. The goal of a careful layout is to minimize how often and to what extent this happens.

Honeycombing occurs both horizontally (side-to-side) and vertically (up-and-down), robbing us of both square feet and cubic space. See Exhibit 3–3.

Exhibit 3–3 Honeycombing



There are two simple methods of determining the level of honeycombing within your own facility. One deals with a simple ratio analysis, the other with cubic space. See Exhibits 3–4 and 3–5.

The other thing that causes the fixed system to require significant space is the necessity of planning around the largest quantity of an item that will be in the facility at one time. Each SKU will have an assigned location or locations. This "home" must be large enough to contain the total cubic space the item will fill-up at the time that the largest quantity of that item will be in the facility at one time. In other words, if a thousand cases of widgits are all in the warehouse at the same time, the home of the widgits has to be large enough to hold them all. Therefore, the total space required for all items in a fixed system will be the total cubic space of one hundred percent of all SKUs as though the maximum quantity of each of them was in the facility at one time.

Exhibit 3–4 Determining Impact of Honeycombing—Ratio Method

Determine the impact of honeycombing on your present facility.

1. Count the number of locations you currently have set up to store items—both horizontally and vertically. Include all locations whether full, partially full, or empty.
2. Count the number of empty positions.
3. Divide the number of empty locations by the total storage positions you have. The result will be your honeycombing ratio.

$$\text{Honeycombing Ratio} = \frac{\text{Empty Storage Locations}}{\text{Total Storage Locations}}$$

$$\text{Example: } \frac{847}{1{,}200} = .294 \text{ or about } 30\% \text{ Honeycombing Ratio}$$

That ratio represents the percentage of empty space within the storage portion of your stockroom(s). Determining this ratio provides you with a baseline. If you decide to change your storage philosophy, change your storage mechanisms (for example, from racks to floor stacking, or from racks to shelving). You can then determine the new ratio and measure improvement in space utilization.

Space planning for an entire inventory in a dedicated location environment is done around a one year time period. Stated differently, all of the space needed for all of the widgits has to be added

Exhibit 3–5 Determining Impact of Honeycombing—Square Footage Method

Globus, Inc. has 16,000 cubic feet (ft^3) of storage space. Globus has a fixed locator system and has divided the storeroom into 490 storage locations with the following sizes (and empty locations):

No of Locations	Ft^3	Total Cu Ft	Empty Locations
400	20	8,000	65
50	50	2,500	15
25	100	2,500	5
15	200	3,000	8
490		16,000	93

The honeycombing ratio on a location basis is:

$$\frac{\text{Empty Spaces}}{\text{Total Spaces}} = \frac{93}{490} = \mathbf{19\%}$$

Cont. on page 54

to all of the space needed for the gidgits, and that space has to be added to all of the room needed for the doodads, and so on.

Pros—Fixed Location Systems

- Immediate knowledge of where all items are located (This system feature dramatically reduces confusion as to where "to put it," "where to find it," which increases

Cont. from page 53

The honeycombing ratio on a ft^3 basis is:

$$\frac{\text{Empty Spaces x } ft^3}{\text{Total } ft^3} = \frac{(65 \times 20\ ft^3) + (50 \times 15\ ft^3) + (5 \times 100\ ft^3) + (8 \times 200\ ft^3)}{16{,}000\ ft^3}$$

$$= \frac{1{,}300 + 750 + 500 + 1{,}600}{16{,}000}$$

$$= \frac{4{,}150}{16{,}000}$$

$$= \mathbf{26\%}$$

The ratio method is a relatively simple approach to determining a rough estimate of honeycombing. However, the ratio method doesn't account for the fact that storage spaces within a given facility come in various sizes. A more precise method to determine honeycombing is to calculate the amount of unused cubic feet.

efficiency and productivity, while reducing errors in both stocking and order fulfillment.)

- Training time for new hires and temporary workers reduced.
- Simplifies and expedites both receiving and stock replenishment because predetermined put-away instructions can be generated.

- Allows for controlled routing of order fillers. Exhibit 3–5 provides an example of how a fixed location system can assist an organization in fulfilling an order quickly.
- Allows product to be aligned sequentially (for example, SKU001, SKU002, SKU003).
- Allows for strong control of individual lots, facilitating *first in first out* ("FIFO") control, if that is desired. Lot control can also be accomplished under a random location system. However simpler, more definitive control is possible using the dedicated location concept.
- Allows product to be positioned close to its ultimate point-of-use. Product positioning is discussed in the "Item Placement Theories" section of this chapter.
- Allows product to be placed in a location most suitable to an SKU's size, weight, toxic nature, flammability, or other similar characteristics.

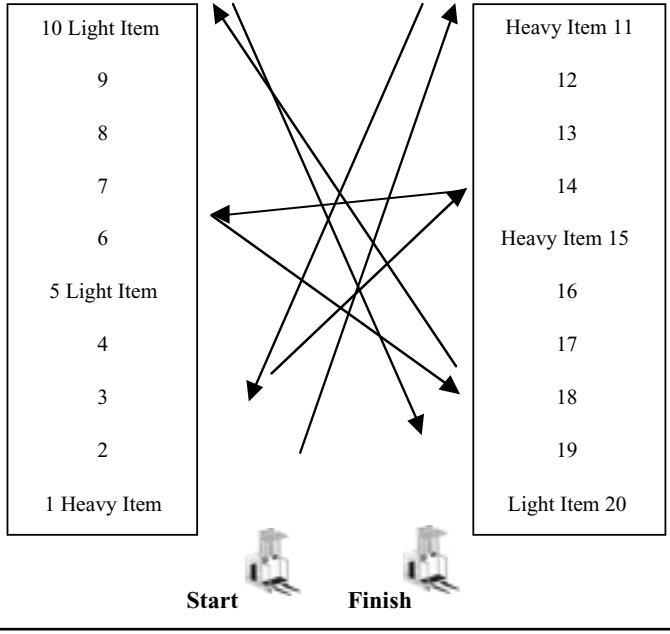
Cons—Fixed Location Systems

- Contributes to honeycombing within storage areas.
- Space planning must allow for the total cubic volume of all products likely to be in a facility within a defined period of time.
- Dedicated systems are somewhat inflexible. If you have aligned product by sequential numbering and then add a subpart or delete a numbered SKU, then you must move all products to allow for the add-in or collapse out locations to fill-in the gap.

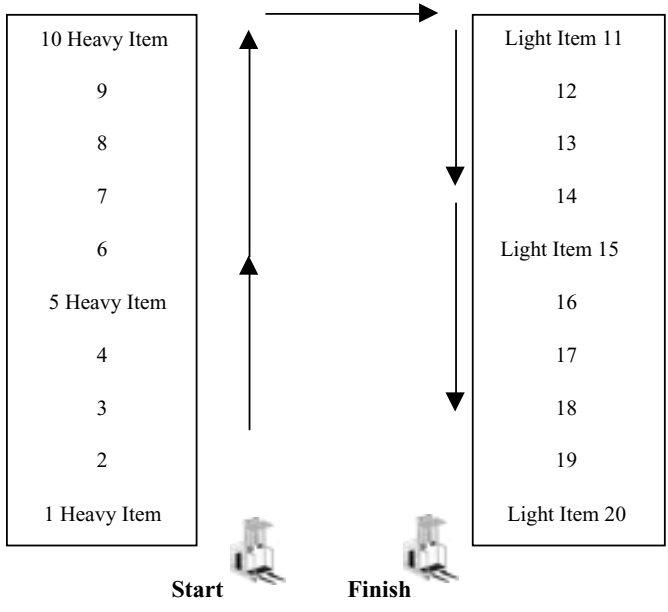
Basically, fixed or dedicated location systems allow for strong control over items without the need to constantly update location records. That control must be counterbalanced by the amount of physical space required by this system.

Exhibit 3–6 Controlling Order Filling Operations Through Specific Item Placement

Scenario One Shawn Michael Irish Linens, Inc. has two sections of select rack on which it randomly places product. This organization uses the *whole order* method of order filling in which a single picker pulls each item on the pick ticket/work order for an entire order, marshalling it together as the order filler travels from storage location to storage location. No planning has gone into item placement. Consequently, heavy items that should be picked first are commingled with light, crushable items that should be selected last. In addition, work orders/pick tickets do not display SKUs to be picked in any particular order. The filler must run up and down the aisle trying to pull product in some semblance of order. Therefore, a typical order run, where product was located in positions 1, 5, 10, 11, 15, and 20 may look like this:



If product was placed into assigned positions with the heaviest items appearing first, lighter ones last, and the pick ticket routed the filler sequentially, then the pull would look more like this:



This layout and route will decrease travel time and will allow for efficient use of labor and for product protection.

Zoning Systems

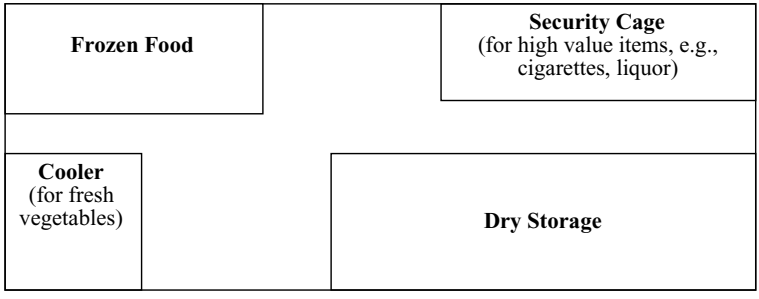
Basic Concept—Zoning Systems

Zoning is centered around an item's characteristics. Like a fixed system, only items with certain characteristics can live in a particular area. Items with different attributes can't live there.

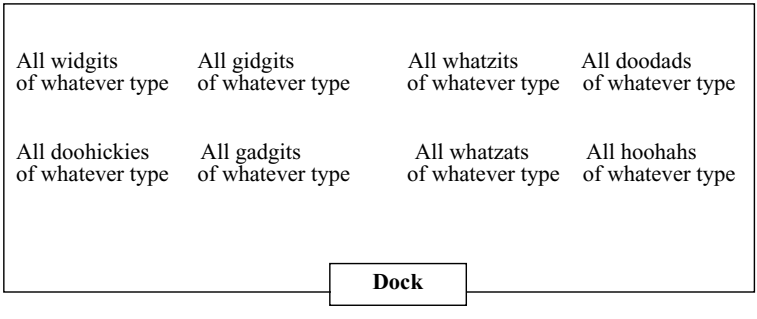
An SKU's characteristics would cause the item to be placed within a certain area of the stockroom or at a particular level

Exhibit 3–7 Examples of zoning system layouts

1. Natural zones created by the nature of the product



2. Zones created by assigning related types of SKUs to specific areas



within a section of shelving or rack section. See Exhibit 3–7. For example, irregular shaped SKUs might be placed in lower levels to ease handling, or all items requiring the use of a forklift for put away or retrieval might be located in a specific area and on pallets.

Impact on Physical Space—Zoning Systems

As with dedicated systems, (see the discussion for *Impact on Physical Space*—**Fixed Location Systems** on pages 53–55) the

more you tightly control where a particular item will be stored, the more you will contribute to honeycombing or to the need to plan around maximum quantities.

Pros—Zoning Systems

- Allows for the isolation of SKUs according to such characteristics as size, variety, flammability, toxicity, weight, lot control, private labeling, and so on.
- Allows for flexibility moving items from one zone to another quickly or in creating different zones efficiently.
- Allows for the addition of SKUs within a zone (unlike a fixed system) without having to move significant amounts of product to create room within an assigned location or within a sequentially numbered group of items. It also does not require the collapsing of space if an item is deleted.
- Allows for flexibility in planning: Although items are assigned to a general zone, because they do not have a specific position they must reside in, there is no need to plan around one hundred percent of any given item's cubic requirements.

Cons—Zoning Systems

- Zoning is not always required for efficient product handling. You may be adding needless administrative complexity by utilizing zoning.
- Zoning may contribute to honeycombing.
- Zoning requires updating of stock movement information.

Basically zoning allows for control of item placement based on whatever characteristics the stockkeeper feels are important.

Random Location Systems

Basic Concept—Random Location Systems

In a random system nothing has a home, but you know where everything is. Pure random location systems allow for the maximization of space since no item has a fixed home and may be placed wherever there is space. This allows SKUs to be placed above or in front of one another and for multiple items to occupy a single bin/slot/position/rack. The primary characteristic of a random locator system that makes it different from a memory system is that each SKU identifier is tied to whatever location address it is in while it is there. In other words, memory systems tie nothing together, except in the mind of the stockkeeper. Random systems have the flexibility of a memory system coupled with the control of a fixed or zone system. Essentially an item can be placed anywhere so long as its location is accurately noted in a computer database or a manually maintained paper-based card file system. When the item moves, it is deleted from that location. Therefore, an SKU's address is the location it is in while it is there.

Impact on Physical Space—Random Location Systems

Because items may be placed wherever there is space for them, random locator systems provide us with the best use of space and maximum flexibility while still allowing control over where an item can be found.

Planning space around a random locator system is generally based on the cubic space required for the average number of SKUs on-hand at any one time. Therefore, in planning space requirements around a random locator system, you need to discern from our inventory records what our average inventory levels are and what products are generally present within that

Exhibit 3–8 Planning a Storage Area Around a Fixed or a Random Location System

Hammer Company manufactures widgits. It has broken down its bill-of-materials, the listing of all of the pieces and parts required to build a widgit, and has come up with the following list:

SKU #	Description	Container	Dimensions	Total Cubic Ft	Maximum Expected At One Time	Total Cubic Ft Req Fixed System	Total Ft Space Req Random System
12345	Gidgit	Box	2'x3'x1'	6 cu ft	50	300	90
54321	Whazzit	Carto•	4'x4'x4'	64 cu ft	100	6,400	1,920
67890	Whozzit	Case	3'x4'x2'	24 cu ft	25	600	180
09876	Doodad	Box	2'x3'x1'	6 cu ft	50	300	90
						7,600	2,280

If Hammer Co was going to store product in fixed positions, it would have to plan around a minimum of 7,600 cubic feet of actual storage space. Although each of these items is required to produce Hammer Company's products, they are not all needed at the same time. On average Hammer only has on-hand 30 percent of any of the above items at any one time. If it used a random locator system it would plan for approximately 2,280 cubic feet of actual storage area.

average. By multiplying the cubic footage of each of those items by the quantity of each usually onhand, you can determine our space required. See Exhibit 3–8.

Pros—Random Location Systems

- Maximization of space.
- Control of where all items are at any given time.

Cons—Random Location Systems

- Constant updating of information is necessary to track where each item is at any given time. Updating must be accomplished through manual paper-based recording, bar code scanning, or data entry intensive updating. See pages 84–86 regarding maintenance of product location information.
- May be unnecessarily complicated if your organization has a small number of SKUs.

Basically, random location systems force a tradeoff between maximization of space and minimization of administration.

Combination Systems

Basic Concept—Combination Systems

Combination systems enable you to assign specific locations to those items requiring special consideration, while the bulk of the product mix will be randomly located. Very few systems are purely fixed or purely random.

Conceptually you are trying to enjoy the best features of the fixed and random systems. You achieve this by assigning only selected items to fixed homes—but not all items. Therefore, you only have to plan around the maximum space required by the

selected items instead of that required by all items. For the items not in fixed homes, you can plan around the average quantities you expect to have on a daily, ongoing basis. So, the fixed system is used for the selected items and the random system for everything else.

A common application of the combination system approach is where certain items are an organization's primary product or raw materials line and must be placed as close as possible to a packing/shipping area or to a manufacturing work station. Those items are assigned a fixed position, while the remainder of the product line is randomly positioned elsewhere. See Exhibit 3–9 for typical scenarios for utilizing a combination locator system.

Exhibit 3–9 Typical Scenarios Involving Combination Location Systems

Scenario One: Barash Foods decided to speed up its order filling efforts by changing where product was located in relationship to the shipping dock. First it determined which 15 percent–20 percent of its product lines showed up on 80 percent of its orders. (See "A-B-C Categorization" on pages 66–67 for an explanation of the 80/20 Pareto's Law concept.) These items would be assigned to fixed positions close to the point-of-use (shipping dock), while those items found in only 20 percent of the orders would be randomly stored.

Barash had to decide if these fixed homes would be large enough to hold 100 percent of the cubic space necessary to house a product if the maximum quantity of it was in the facility at one time during the year. The company decided it could not devote that much space per product in

Cont. on page 64

Cont. from page 63

the limited area closest to the point-of-use. It therefore decided to allow for 100 percent of the space needed for one week's worth of product movement for the fixed location SKUs. In other words, while still having to follow the fixed location system rule that space must exist for 100 percent of the cubic space required for the maximum quantity of an item expected during a given time period, it controlled the space and quantity by shortening the time frame.

Random items were stored in accordance with the general rule that random space is planned around the average quantity expected in an area during a defined time period. In this case the time period was one year.

Scenario Two: Charmax Manufacturing is a "job shop" electronics manufacturer. It manufactures special order items and often will only produce one, never to be repeated run of an item. Therefore, some specific raw materials inventories required for any given production run may never be needed in the future. However, the company uses many common electronics components such as resisters, transistors, and solder in most of the final assemblies it produces. Its physical plant is very small.

Charmax carefully reviews its master production schedule to determine when various subassemblies and final assemblies will be produced. It then analyzes the bill-of-materials (the recipe of components) for the sub- or final assemblies, and orders as much specific purpose items as possible on a to be delivered just-in-time basis. This holds down the quantity of nonstandard inventory it will have in-house at any one time.

Charmax then establishes fixed positions for working

stock, both special order and standard stock items, during a production cycle around the appropriate workstations. Where working stock would consume too much space around a work area, working reserve stock is placed in zone locations close to the workstations. Regular, general use product, such as resisters and transistors, is stored in random order.

This combination location system—which is comprised of fixed, zone and random storage for working, working reserve and general stock—allows Charmax to maximize its use of space at any given time.

Common Item Placement Theories

Locator systems provide a broad overview of where SKUs will be found within a facility. Physical control of inventory is enhanced by narrowing the focus of how product should be laid out within any particular location system. As with locator systems, item placement theories (where should a particular item or category of items be physically positioned) go by many different names in textual as well as in trade literature. By whatever name, most approaches fall into one of three concepts: inventory stratification, family grouping, and special considerations.

Inventory Stratification

Inventory stratification consists of two parts:

- A-B-C categorization of SKUs.
- Utilizing an SKU's unloading/loading ratio.

A-B-C Categorization

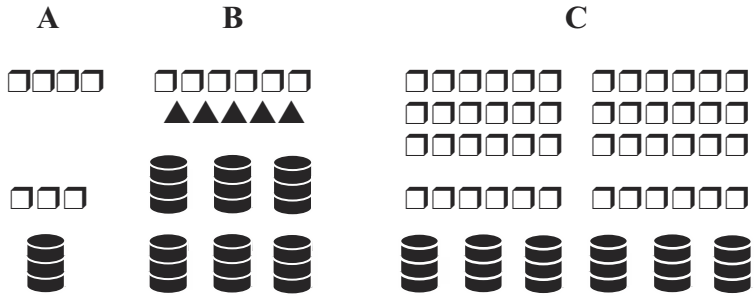
This item placement approach is based on "Pareto's Law." In 1907, an Italian sociologist and economist by the name of Vilfredo Pareto (1848–1923) wrote his belief that 80 to 85 percent of Italy's money was held by only 15 to 20 percent of the country's population. He called the small, wealthy group the "vital few" and everyone else the "trivial many." This ultimately came to be known as the "80–20 Rule" or Pareto's Law. The concept stands for the proposition that within any given population of things, approximately 20 percent of them have 80 percent of the "value" of all of the items concentrated within them, and that the other 80 percent only have 20 percent of the value concentrated within them. "Value" can be defined in various ways. For example, if the criterion is money, then 20 percent of all items represent 80 percent of the dollar value of all items. If the criterion is usage rate, then 20 percent of all items represent the 80 percent of the items most often used/sold.

Accordingly, for efficient physical inventory control, using popularity (speed of movement into and through the facility) as the criterion, the most productive overall location for an item is a storage position closest to that item's point-of-use. SKUs are separated into A-B-C categories, with "A" representing the most popular, fastest moving items (the "vital few"), "B" representing the next most active, and "C" the slow-movers.

Providing product to outside customers is often the chief objective of a distribution environment. Therefore, the point-of-use would be the shipping dock, with SKUs being assigned in the manner shown in Exhibit 3–10. In a manufacturing environment, a work station would become the point-of-use, with the most active, most often required raw materials positioned in near proximity to it.

In order to separate an inventory into A-B-C categories, it is

Exhibit 3–10 A-B-C Placement of SKUs



necessary to create a sorted matrix that presents all SKUs in descending order of importance and allows for the calculation of those items representing the greatest concentration of value. Exhibit 3–11 represents selected rows of a complete listing of SKUs shown in Appendix A.

Before attempting to understand how the matrix is mathematically constructed, you first have to explore what information the matrix is presenting. Unless otherwise stated, all references are to Exhibit 3–10.

What the Matrix Shows

- Column A is merely a sequential listing of the number of SKUs in the total population. In the example there are 300 items. If an organization had 2,300 SKUs, Column A of its matrix would end with row 2,300.

- Recall that there are two components within Pareto's Law. The first component refers to the percentage of all items that a certain number of items represent, and the second component represents the percentage value that the same grouping of items has when compared to the value of all other items combined.

Exhibit 3–11 Categorization for Item Placement by Popularity *

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
1	Part 79	Product A	8,673	8,673.00	6.3%	0.3%
2	Part 133	Product B	6,970	15,643.00	11.3%	0.7%
3	Part 290	Product C	5,788	21,431.00	15.5%	1.0%
.						
.						
.						
17	Part 70	Product Q	1,896	64,915.00	47.0%	5.7%
18	Part 117	Product R	1,888	66,803.00	48.4%	6.0%
19	Part 134	Product S	1,872	68,675.00	49.7%	6.3%
20	Part 170	Product T	1,687	70,362.00	50.9%	6.7%
21	Part 182	Product U	1,666	72,028.00	52.1%	7.0%
22	Part 28	Product V	1,646	73,674.00	53.3%	7.3%
.						
.						
.						
30	Part 278	Product AD	997	82,919.00	60.0%	10.0%
.						
.						
.						
93	Part 295	Product CJ	325	123,350.00	89.3%	31.0%
94	Part 30	Product CK	325	123,675.00	89.5%	31.3%
95	Part 11	Product CL	323	123,998.00	89.8%	31.7%
96	Part 192	Product CM	321	124,319.00	90.0%	32.0%
97	Part 96	Product CN	321	124,640.00	90.2%	32.3%
98	Part 40	Product CO	298	124,938.00	90.4%	32.7%
.						
.						
.						
272	Part 86	Product JG	6	138,053.00	99.9%	90.7%
273	Part 32	Product JH	6	138,059.00	99.9%	91.0%
274	Part 129	Product JI	5	138,064.00	99.9%	91.3%
275	Part 164	Product JJ	5	138,069.00	100.0%	91.7%
276	Part 283	Product JK	5	138,074.00	100.0%	92.0%
277	Part 252	Product JL	5	138,079.00	100.0%	92.3%
.						
.						
.						
298	Part 151	Product KG	—	138,134.00	100.0%	99.3%
299	Part 61	Product KH	—	138,134.00	100.0%	99.7%
300	Part 165	Product KI	—	138,134.00	100.0%	100.0%

**Complete listing shown in Appendix A.*

Column G reflects the first aspect. For example, 30 items represent 10 percent of 300. Therefore, Column G, Row 30 shows 10 percent of all 300 items.

Column F reflects the second aspect. For example, the first three items (Rows 1, 2, and 3) of Column A have a combined value (usage rate) of 15.5 percent. That 15.5 percent is shown at Row 3 of Column F. (How the 15.5 percent is arrived at is explained below in "Creating the Matrix.")

- After creating the matrix, a review of Column F leads to decisions as to where the cut-off should be for each (A-B-C) category. There is no rule of thumb. The decision is a common sense, intuitive one. In Exhibit 3–11, since 19 of all items represented almost 50 percent of the value of all items (see Row 19, Column F), it seems appropriate to cut off the A category at that number. It would have been just as appropriate to cut it off at Row 20, Column F, which shows 50.9 percent.

Creating the Matrix

- Most application software programs include a report generator module that allows various fields of information, such as SKU identifiers, descriptions, and quantities, to be extracted from the general database and saved in a generically formatted (ASCII)[1] file. This information may then be exported into one of the commonly available spreadsheet software programs such as Excel,® or Lotus.® Rather than undertaking the data entry required to input the information found in Columns B, C, and D, you should use your report generator to obtain this information, and then export it into a spreadsheet program.

- Column A—reflects the number of SKUs being analyzed. It is organized in ascending numeric sequence (1, 2, 3 . . .).
- Column B—SKU number/identifier.

- Column C—SKU description.
- Column D—Annual usage quantity of the SKU.

In a retail/distribution environment where the inventory is comprised of finished goods, Column D will contain the immediately preceding 12 months' usage quantities. This is based on the rule of thumb that the product lines will remain relatively unchanged during the upcoming 12-month period. The immediately preceding 12 months' usage rates will reflect any product trends and is more timely than using the immediate past calendar year's rates.

In a manufacturing environment, raw materials, components, and sub-assemblies used during the past 12 months may not be required during the upcoming 12 months. Therefore, the data for Column D must be derived from the master production schedule (the projection of what is to be built and in what quantities). After determining what will be built and in what quantities, examine the bill-of-materials (BOM), the recipe of what pieces and parts will actually go into the items to be manufactured. The data necessary for Column D is ascertained by multiplying the appropriate items in the BOM times the quantity of items to be built.

Column D is sorted in descending order, with the highest use item appearing at the top and the most inactive item at the bottom.

Column D is the sort field. However, if only Column D was sorted, the information in it would become disassociated from the SKUs the data represents, which information is reflected in Columns B and C. Therefore, the sort range includes columns B, C, and D so that all related information is sorted together.

- E—Cumulative total of Column D.

In order to derive the percentage value that a number of items have compared to the value of all items, it is necessary to

establish that overall value as well as the value that any given number of items added together may possess. This is what Column E does.

Note that the first row of Column E is the same as the first row of Column D. Note that adding together the first two rows of Column D results in the second row of Column E. The sum of the first three rows of Column D equals the third row of Column E. The sum of the first seventeen rows of Column D results in the data in row seventeen of Column E, and so forth.

The data shown in row 300 of Column E reflects the usage value of all 300 items added together. The information on any given row of Column E reflects the value of all of the preceding SKUs added to the value of that specific row's value.

• F—This is the second aspect of Pareto's Law. It reflects the percentage value that a grouping of items has when compared to the value of all other items.

Column F is derived by dividing every row of Column E by the last value of Column E. In other words, the first value in Column F (6.3 percent) results from dividing the first row of Column E (8,673) by the last row of Column E (138,134). The value found in row two of Column F is derived from dividing the amount shown in row two of Column E (15,643) by the last row of Column E (138,134), and so forth. Using arithmetic terminology, each row of Column E acts as a numerator, the last row of Column E is the denominator, and the quotient is found in Column F.

• G—This is the first aspect of Pareto's Law. It reflects the percentage of all items compared with all other items. In other words, 3 is 1 percent of 300.

Column G is derived by dividing every row of Column A by the last number in Column A. In other words, the first value

in Column G (0.3 percent) results from dividing the first row of Column A (1) by the last row of Column A (300). The value found in row two of Column G is derived from dividing the amount shown in row two of Column A (2) by the last row of Column A (300), and so forth.

- After creating the chart, you look down Columns F and G and decide where you want to place the cutoff for categories A, B, and C. Product would then be arranged according to which category it is in.
- Appendix B sets out the formulae necessary to create the matrix for 300 SKUs in Microsoft Excel®.

Utilizing an SKU's Unloading/Loading Ratio

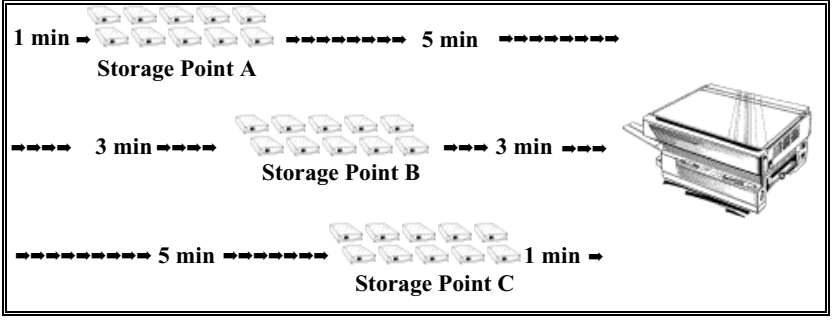
Even more efficiency in physical inventory control can be achieved through placing items within the A-B-C zones according to that SKU's unloading to loading ("unloading/loading") ratio. The unloading/loading ratio reflects the number of trips necessary to bring an item to a storage location compared with the number of trips required to transport it from a storage point to a point-of-use. If one trip was required to bring in and store a case of product, but 10 trips were required to actually take its contents to a point-of-use, the unloading/loading ratio would be 1 to 10 (1:10). Substantial reductions in handling times can be achieved through application of this principle. See Exhibit 3–12.

The closer the unloading/loading ratio is to 1:1, the less it matters where an item is stored within an A-B-C zone because the travel time is the same on either side of the storage location. The more the ratio increases, the more critical it is to place an item closer to its point-of-use. Assuming 7 productive hours of labor within an 8-hour work shift, a reduction of even 30 sec-

Exhibit 3–12 Unloading/Loading Ratio Time Savings

Assumptions:

- One case of photocopying machine paper brought in and stored
- Case holds 10 reams
- Only using one ream of a paper at a time



POINT A	POINT B	POINT C
10 items x 1 trip x 1 min = 10 min	10 items x 1 trip x 3 min = 30 min	10 items x 1 trip x 5 min = 50 min
10 items x 10 trips x 5 min = 500 min	10 items x 10 trips x 3 min = 300 min	10 items x 10 trips x 1 min = 100 min
510 min	330 min	150 min
	180 min saved over Point A	360 min saved over Point A
	180/60 = 3 hours saved	360/60 = 6 hours saved

onds in travel time every 5 minutes will result in a timesaving of 42 minutes. See Exhibit 3–13.

Family Grouping

An alternative to the A-B-C approach is the family grouping/like product approach. This approach to item placement positions items with similar characteristics together. Theoretically, similar characteristics will lead to a natural grouping of items, which will be received/stored/picked/shipped together.

Exhibit 3–13 Practical Effect of Inventory Layout Changes

If a change in procedure, layout, product design, paperwork, or any other factor saved 30 seconds every 5 minutes, how much time would you save each day?

- Assume 7 actual work hours per day
- 60 minutes x 7 hours = 420 minutes
- 420 minutes / 5 minutes = 84 segments
- 84 x 30 seconds = 2,560 seconds
- 2,560 seconds / 60 seconds = 42 minutes

Saving 30 seconds every 5 minutes saves 42 minutes per day!

Groupings can be based on:

- Like characteristics—widgits with widgits, gidgits with gidgits, gadgits with gadgits.
- Items that are regularly sold together—parts needed to tune-up a car.
- Items that are regularly used together—strap with sports goggles.

Pros—Family Grouping

- Ease of storage and retrieval using similar techniques and equipment.
- Ease of recognition of product groupings.
- Ease of using zoning location systems.

Cons—Family Grouping

- Some items are so similar they become substituted one for the other such as electronics parts.

- Danger of properly positioning an active item close to its point-of-use but consuming valuable space close to that area by housing far less active "family member" items with their popular relative.
- Danger of housing an active product with its inactive relatives far from the popular SKU's point-of-use, all for the sake of keeping like items together.
- An item can be used in more than one family.

Using Inventory Stratification and Family Grouping Together

Effective item placement can often be achieved through tying both the inventory stratification and family grouping approaches together. For example, assume order-filling personnel travel up and down a main travel aisle, moving into picking aisles to select items, and then back out to the main aisle to proceed further. Also assume that there are 12 brands of Gidgits that are all stored in the same area for purposes of family grouping. Pareto's Law indicates that not all brand of Gidgits will be equally popular. Consequently, using both the inventory stratification and family grouping concepts together, the most popular Gidgit brands are positioned closer to the main travel aisle and the least popular furthest from it. The end result is a more efficient overall layout.

Special Considerations

A product's characteristics may force us to receive/store/pick/ship it in a particular manner. The product may be extremely heavy or light, toxic or flammable, frozen, odd in shape, and so on.

Even with items requiring special handling or storage such as frozen food stored in a freezer, the inventory stratification and

family grouping concepts can and should be employed to ensure efficient inventory layout.

Location Addresses and Sku Identifiers

Significance

You simply cannot control what you can't find. Major contributing factors to the success of inventory systems are:

- Adequate, appropriate identification markings on SKUs, including both SKU number and stockkeeping unit of measure. These markings allow a worker to quickly and easily identify an item without having to read and translate product descriptions and confusing pack size designations. This ease of recognition reduces errors and the time required for either stock selection of put-away.
- Adequate, appropriate identification markings on bin/slot/floor/rack/drawer/shelf locations. Just like the address on a house, the address of a specific location in the stockroom lets you quickly find the "tenant" or "homeowner" SKU you are looking for.
- Procedures tying any given SKU to the location it is in at any given time. How does the post office know where to send mail to someone after they have moved? Obviously, the relocated person fills out a change of address form. In much the same manner, you must set up a procedure that tells your system where a product lives, and if it moves—where to.
- Procedures tying a single SKU to multiple locations in which it is stored. If you have two homes, you let your friends know the addresses. Your friends then put that information together in their address books. You must do the same thing for products residing in two or more locations within the building.

- A system for tracking items, on a timely basis, as they change locations. Whatever form your "change of address" form takes, it has to be filled out and processed quickly.
- Package advertising that does not obscure SKU identifier codes.
- Use of simple marking systems that are easy to read and understand. You should avoid complicated marking systems that are difficult to read, understand, recall, or are conducive to numerical transposition. For example, markings such as "12/24 oz" and "24/12 oz" are quantity oriented coding employing numbers describing the quantity and size of the inner packages. However, such numbers are easily reversed or transposed, and are not intuitively understood.

If you incorporate these elements into your inventory systems, you can expect:

- Decreased labor costs related to search time for product. These search-time savings manifest themselves not only when you search for an individual item, but most definitely when product is located in multiple unspecified locations.
- Decreased labor costs associated with searching for appropriate storage locations.
- Elimination of the unnecessary purchase of items that are already in the facility but are undiscovered when needed.
- Correct selection of SKUs during order filling.
- Correct selection of pack size(s) during order fulfillment.

All of the above lead to more accurate inventory tracking, less wasted time to correct errors, and an increase in customer satisfaction.

Keys to Effectively Tying Together SKUs and Location Addresses

In order to keep track of where SKUs are at any given time, it is necessary to:

1. Clearly mark items with an SKU identifier.

2. Clearly mark items with a unit of measure such as pack size.

3. Clearly mark location addresses on bins/slots/shelves/racks/floor locations/drawers/and so on.

4. Tie SKU numbers and location addresses together either in a manual card file system or within a computerized database.

5. Update product moves on a real-time basis with bar coding coupled with radio frequency scanners (see Chapter 4, The Basics of Bar Coding) or with stock movement reporting (see the section in this chapter on *updating product moves*, pages 84–86).

Clearly Mark Items with an SKU Identifier; Clearly Mark Items with a Unit of Measure

Too often managers believe that workers can read a product's markings and packaging and actually understand what they are looking at. The end result of this belief is error after error. To eliminate many of these identification miscues, you need to clearly mark out items with an identifying number and a unit of measure. Workers will make far fewer errors matching a number on a box to the same number on a piece of paper than they will trying to match words or abbreviated descriptions.

The SKU identifier is generally an organization's own internal identifying code for the item rather than a manufacturer's or customer's number for that SKU. Although the SKU number

Exhibit 3–14 Marking SKUs

By manufacturer

- Manufacturer prints or affixes plain, human readable label on the item and/or a bar code label with coding on the items. Manufacturer obtains labels or you provide them.

At vendor site

- Vendor from whom you obtain the product prints or affixes your plain, human readable label on the item and/or a bar code label with coding on the items. Manufacturer obtains labels or you provide them.

At time of receiving

- Everything comes through receiving—it is a natural node. That convergence allows you the opportunity to affix plain, human readable label on the item and/or a bar code label with coding on the items.
- You can have all product that turns even once during the year marked in this manner, with faster moving items (12 turns a year) all marked within a few weeks.

itself is often adequate for identification purposes, in manufacturing it may be necessary to also include lot and serial numbers to aid in quality control. Lot and serial numbers make it possible to track manufacturing batch, date, location, and inspector. Exhibit 3–14 reflects various methods of getting items actually labeled or marked.

Markings related to unit of measure (such as each/pair/dozen/barrel/ounce/pound/cylinder/barrel/case) also serve to greatly reduce error in picking and shipping.

Exhibit 3–15 Alpha-Numeric Variations

0 ➜ 9 = 10	
00 ➜ 99 = 100	10 x 10 = 100
000 ➜ 999 = 1,000	10 x 10 x 10 = 1,000
A ➜ Z = 26	
AA ➜ ZZ = 676	26 x 26 = 676
AAA ➜ ZZZ = 17,576	26 x 26 x 26 = 17,576

Clearly Mark Location Addresses On Bins/Slots/Shelves/Racks/Floor Locations/Drawers

Just as you could not find a house in a city if its address was not clearly identified, you cannot find a storage location unless its address is clearly marked or easily discerned in some other manner. The addressing or location system you choose should have an underlying logic that is easy to understand. Addresses should be as short as possible, yet they should convey all needed information.

You should first consider whether the system will be all numeric, all alphabetic (alpha), or alpha-numeric. In deciding which system to adopt, consider the following:

• All numeric systems require sufficient digit positions to allow for future growth. Because each numeric position only allows for 10 variations (0-9), numeric systems sometimes become too lengthy. In other words, since a single numeric position only allows 10 variations, if you required 100 different variations (for 100 different SKUs), you would need 2 digit positions, representing 00 through 99 (10 x 10). One thousand variations would require three numeric positions, 000 through 999, and so on. See Exhibit 3–15, Alpha-Numeric Variations.

• Systems that are completely alphabetic allow for 26 variations per position, A through Z (assuming only capital letters). Two alphas together, AA through ZZ (26 x 26), allow for 676 variations. Three alphas, AAA through ZZZ, allow for 17,576 variations. See Exhibit 3–15, Alpha-Numeric Variations. Although alphas provide numerous variations in a short address, systems that are completely alphabetic are visually confusing (HFZP).

• Alpha-numeric systems often provide for visual differentiation while allowing sufficient variations in a short address.

• *Caution:* While alpha systems require fewer characters to hold the same number of variations, they are more error prone. For example: Is that the number zero or the letter *O*? A "one" or the letter *l*? A two or the letter *Z*? A *P* or an *R*? A *Q* or an *O*? If you are only dealing with a computer system, then characters are "cheap," and you could use only numerics to avoid confusion. However, if part of your system will involve human readable labels, placards, or markings where a long string of numbers might present a problem or where you are trying to keep a bar code label short, you might have to balance out the merits of shorter alpha-numeric systems against longer pure numeric systems.

Exhibit 3–16 presents some common location addressing systems for racks or shelving.

Exhibits 3–17 and 3–18 present common location addressing systems for bulk storage.

Tie SKU Numbers and Location Addresses Together

The placement of identifiers on both product and physical locations creates an infrastructure by which you can track product as it moves. The next step is marrying together an SKU number

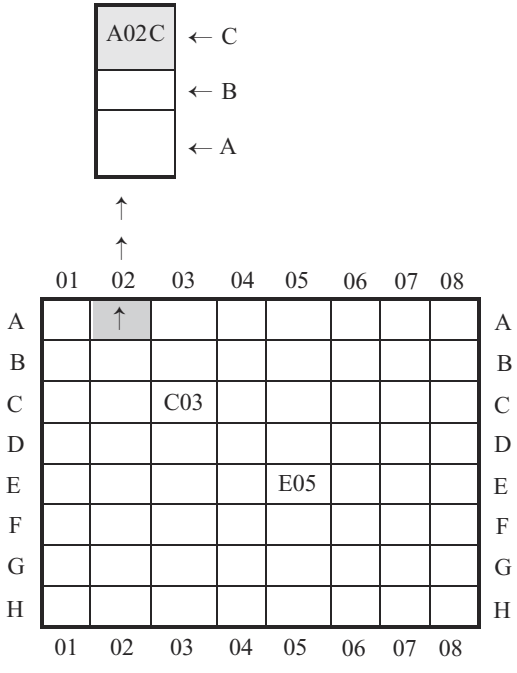
Exhibit 3–16 Addressing Racks, Drawers, and Shelving

APPROACH	EXPLANATION
"Street Address" 03A02B02	03 Room (City) · A Aisle (Street) · 02 Rack (Building) · B Tier (Floor) · 02 Slot (Apartment) Although this is a lengthy address if an automated storage and retrieval system (AS/RS) is used, then detailed exact spot information is required for the selector arm to find the desired load.
"Rack-Section-Tier-Bin" 030342	03 Rack · 03 Section* · 4 Tier · 2 Bin *A rack section is that portion of the weight bearing horizontal support between two upright supports.
Room/Bldg-Rack-Bin AA001	A Rm/Bldg · A Rack · 001 Bin
Rack-Bin AA001	AA Rack · 001 Bin These last two systems are short, simple, and easy to remember, but they do not provide tier information.

and the location(s) where that item is located. This can be easily accomplished by using a simple 3 x 5 card file system (which should be computerized as soon as possible). See Exhibit 3–19.

Exhibit 3–17 Bulk Storage Grid Addressing System

Address: A02C = A (Aisle) 02 (Cross Aisle) C (Tier)

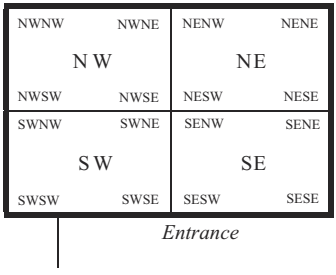


• In bulk storage areas, you can utilize a simple grid denoted with placards on walls or on the building's structural supports to find an address on the floor. This is done through two lines bisecting on a flat plain.

• For vertical addresses, you triangulate three lines.

• The above is applied geometry (Cartesian Coordinates) developed by René Descartes, the famous French mathematician.

Exhibit 3–18 Bulk Storage Quadrant Addressing System



Quadrant addresses are read right to left—the Northeast Quadrant of the Southeast Quadrant is written as "SENE."

Update Product Moves

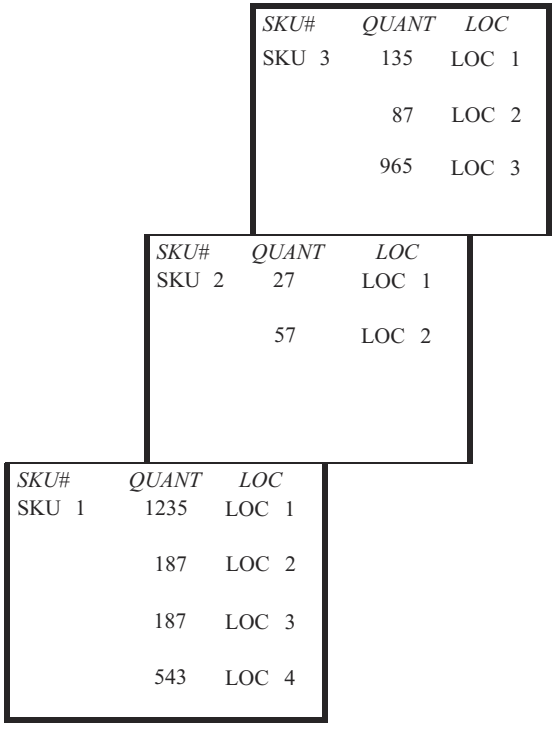
A final step in managing inventory is tracking it as it is added to, deleted, or moved. This challenge exists for any organization whether or not the company uses manual tracking, computerized approaches, or bar coding.

The best generally available approach for real-time tracking of items as they move is using bar coding mobile scanners with radio frequency (RF) capability. See Chapter 4, The Basics of Bar Coding.

If RF capable bar coding is not available, then updating can be accomplished as follows:

• Portable bar code scanners that capture the information within the scanner mechanism or on a disk in the scanner. The information is then uploaded into the computerized database either through the communications ports on the scanner and computer, or by loading the scanner disk into the computer.

Exhibit 3–19 Simple Card File Tracking System



Cards are marked with all SKU numbers. Cards will be indexed in ascending number sequence—lowest SKU number in the front of the file box and the highest SKU number appearing last. All locations and quantities for that specific item are noted. As SKUs are added-to or moved, card file information is updated as often as possible. Updates should occur at least twice daily, for example, during the lunch hour and at the end of the workday.

- Manually captured, paper-based information (see Exhibit 3–20) is entered into the database through keying (data entry by a human being).

Exhibit 3–20 Simple Stock Movement Report

STOCK MOVEMENT REPORT

SKU# _____

DATE _____ **TIME** _____

QUANT _____

FROM _____ **TO** _____

• Manually captured, paper-based information is manually written onto file cards.

No matter what method is used, it is imperative that information relative to inventory additions, deletions, or movement be inputted into the system as soon as possible. To the greatest extent possible, the shelf count (what is actually in the facility and where it is) should match the record count (the amount reflected in the main database records). The longer the time lag between inventory movement and information capture and updating of the record count, the greater the chance for error, lost product, and increased costs.

recap Organizations should carefully consider specific item placement within an overall location system in order to maximize each SKU's accessibility while being mindful of that item's point-of-use, unloading/loading ratio, relationship to similar items, or characteristics requiring special handling.

Organizations lacking procedures that identify the location of each SKU within the facility suffer from excessive labor costs, "lost" product causing additional items to be purchased to cover for those on-site but unavailable when required, poor customer service, and general confusion. Controlling product location and movement centers around establishing an overall locator system that effectively reflects the organization's basic inventory nature such as finished goods in a retail/distribution environment or raw materials and sub-assemblies in a manufacturing facility. Often legitimate operational and storage objectives are in conflict with one another resulting in final location system decisions made on the basis of a series of tradeoffs.

And finally, each item's present location must be identified with that SKU's identifier, with address and quantity changes being updated on an ongoing, timely basis.

? REVIEW QUESTIONS

1. Honeycombing is best described as: 1. (c)
   (a) product unevenly stacked.
   (b) matrix racking or shelving layout.
   (c) empty space in usable storage areas.
   (d) the number of items per level and the number of tiers of product on a pallet.

2. Memory location systems: 2. (b)
   (a) are simple and efficient.
   (b) are human dependent.
   (c) require updating of location information.
   (d) are useful when a large number of different SKUs must be quickly located.

3. Regarding random locator systems,: 3. (b)

(a) each item has an assigned home in a random zone.

(b) an item's home is the location it is in while it is there.

(c) an SKU's storage location must be planned around the maximum quantity of that item expected to be on-site during a defined time period.

(d) only certain items may be placed in the bulk storage areas of the facility.

4. In relationship to its unloading/loading ratio, an SKU should be placed closer to its point of use if the ratio is: 4. (a)

(a) 1:28.

(b) 1:1.

(c) 3:15.

(d) 28:28.

5. Pareto's Law holds that: 5. (c)

(a) 80 percent of all items account for 80 percent of the dollar value of 20 percent of those items.

(b) 20 percent of all items account for 20 percent of the usage value of 80 percent of those items.

(c) 80 percent of all items contain 20 percent of the value of those items.

(d) a fixed locator system is operationally efficient 20 percent of the time for 80 percent of all items.

Note

1. American Standard Code of Information Interchange (ASCII) is the basic 128 character set understood by all computer systems.

CHAPTER 4

The Basics of Bar Coding

Introduction

Errors and time increase dramatically the more often a human being is involved in identifying an object, inputting that information into a database, and then modifying the knowledge to keep track of changes in location, pack size, quantity, and so on.

The less you rely on human intervention to identify items, input information, and track data, the more timely and accurate your records will be. Bar coding is a major tool in capturing critical data quickly and accurately.

The time and dollar savings that would be realized if your organization could eliminate the time and errors noted above will often pay for a bar coding system. See Exhibit 4–1. The speed of information capture and the accuracy of bar coding are often sufficient reasons to cost justify installing bar coding within your operation.

Exhibit 4–1 Data Entry Comparisons Assuming a 12-Character Field

	Key-Entry	OCR	BAR Code
Speed	6 seconds	4 seconds	.3 seconds to 2 seconds
Error Rate	1 character error in 300 characters entered	1 character error in 10,000 characters entered	1 character error in 15,000 to 36 trillion characters entered

Bar coding is an optical method of achieving automatic identification. It relies on visible or invisible light being reflected off of a printed pattern. The dark bars or dark areas within the pattern absorb light, and the intervening spaces or areas reflect light. The contrasting absorption and reflection is sensed by a device that "reads" this reflected pattern and decodes the information.

Bar coding is not the only automated method of identifying inventory. For example, there is also optical character reading, machine vision, magnetic stripe, surface acoustic wave, and radio frequency tags. See Exhibit 4–2.

This text will only deal with one dimensional, linear bar coding—probably the most commonly used method of automated inventory identification and control.

Bar code systems generally consist of three components: the code itself, the reading device(s), and the printer(s). The objective of this chapter is to provide you with a working knowledge of (i) elements of a bar code symbol; (ii) the fundamentals of the more commonly used linear bar code languages/symbologies in the inventory control world; (iii) printing and scanning (reading) basics; and (iv) some practical bar code applications.

Exhibit 4–2 Various Automated Methods of Identifying Inventory

Technology	How It Works	For Your Information
Optical Character Reading (OCR)	**Numbers, letters, and characters are printed in a predetermined, standard character style or font. Like a bar code the image is illuminated and the reflection is sensed and decoded.**	• **Allows for both human and machine readability** • **10 characters per inch data density** • **Slower read rate than bar codes** • **Higher error rate than bar codes** • **Very sensitive to print quality**
Machine Vision	**Cameras take pictures of objects, encode, and send them to a computer for interpretation.**	• **Very accurate under the right light conditions** • **Reads at moderate speed** • **Expensive**
Magnetic Stripe	**A magnetic stripe, like those on credit cards, is encoded with information.**	• **Proven technology** • **Readable through grease and dirt** • **Relatively high density of information—25 to 70 characters per inch** • **Information can be changed** • **Must use a contact reader making high speed reading of many items impractical** • **Not human readable**

Cont. on page 92

Cont. from page 91

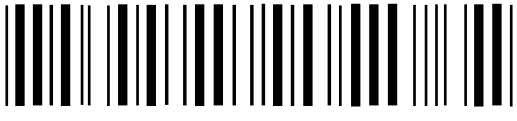
Surface Acoustic Wave (SAW)	**Data is encoded on a chip that is encased in a tag. In response to a radar pulse from a reader with a special antenna, the tag converts the pulse to an ultrasonic acoustic wave. Each tag is uniquely programmed so that the resulting acoustic wave has an amplitude matching the chip's code. The wave is converted back to an electromagnetic signal sent back to the reader.**	• **Can be used in highly hazardous environments such as high heat and acid baths** • **Can be read up to 6 feet away** • **No line of sight required** • **Physically durable**
Radio Frequency Tag	**Data is encoded on a chip that is encased in a tag. In response to a radar pulse from a reader with a special antenna, a transponder in the tag sends a signal to the reader.**	• **Tags can be programmable or permanently coded** • **Can be read up to 30 feet away** • **No line of sight required** • **Physically durable—life in excess of 10 years**

Elements of a Bar Code Symbol

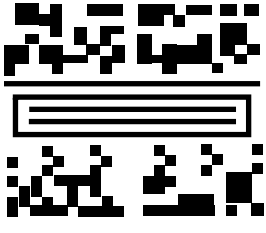
Why can you easily read the sentence, "Inventory control is fun"? You can read that sentence because you recognize the alphabet used and understand the rules of grammar and sentence construction utilized. A bar code "symbology" or language is very similar because it has a fixed alphabet made up of various patterns of dark bars and intervening light spaces coupled with rules for how it is presented.

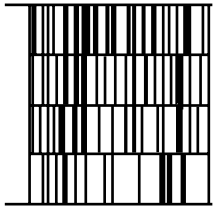
There are many types of bar codes, not all of which are the linear symbols most commonly found in the inventory control world. For example:

Appearance of common one-dimensional, linear types of bar code patterns:



Appearance of common two-dimensional, matrix and stacked bar code patterns:

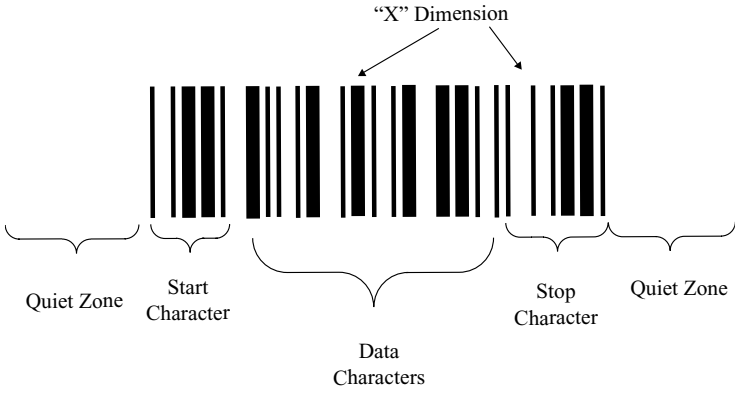




Presently, linear bar codes are the most commonly used for general inventory control purposes.

Structure of a Generic Bar Code Symbol

The entire pattern is called the "symbol." Each bar or space is called an "element."



Quiet Zone

Symbols can be read from left to right or right to left. A bar code scanner (reader) must make a number of measurements in order to decode the symbol accurately. The quiet zones on each side of the symbol gives the scanner a starting point from which to start its measurement.

Start and Stop Characters

In order for codes to be read from either direction or top to bottom or bottom to top in a vertically oriented symbol ↕, start and stop characters tell the scanner where the message begins. It is customary for the character on the left or at the top of the symbol to be the start character, and the one on the right or bottom to be the stop character.

Data Characters

The data characters are the actual message within the code. These can be letters of the alphabet, numbers, symbols (+, –, /, =), or a combination of all three.

"X" Dimension

The narrowest bar or space in a bar code is called the "X" dimension. This width can run from 5 mils to 50 mils. A mil is one-thousandth of an inch.

This is a very important width because it determines how wide each narrow and wide bar or space will be. The narrow bars/spaces are a single "X" in width, while the wide bars/spaces can be two, three, or four "Xs" wide. Therefore, an element (a bar or space) can be a single "X" or several "Xs."

The larger the "X" dimension of a symbol the easier it is to read.

Symbologies—Bar Coding Structural Rules

Just as there are rules for how an English sentence is structured, for the relationship of upper case to lower case letters, and for punctuation, there are similar rules governing bar codes. These rules are set out in a "symbology." A symbology controls how information will be encoded in a bar code symbol.

Just as there are different languages such as French, English, Spanish, Italian, Russian, Japanese, and Chinese, there are different symbologies. Common symbologies found in the inventory world are Code 39, Code 128, Interleaved 2 of 5, and UPC.

Symbologies are like typefaces with different character sets and separate printing characteristics. Some symbologies only present numbers. Some have numbers, uppercase alphabetics (A–Z), and limited special characters. Others have both upper and lowercase alphabetics (A–Z, a–z), numbers, and a wide range of special characters. Some symbologies only allow for a set number of characters in a pattern, while others allow for variable length messages.

Discrete and Continuous Symbologies

Bar codes can either be discrete or continuous. Characters in a discrete code start with a bar and end with a bar, and they have a space between each character. Characters in a continuous code start with a bar, end with a space, and have no gap between one character and another. The primary significance of the difference is that a discrete code is easier to print and read, but you can get more characters per inch with a continuous code.

Which of the following is easier to read?

Symbologies Symbologies Symbologies Symbologies

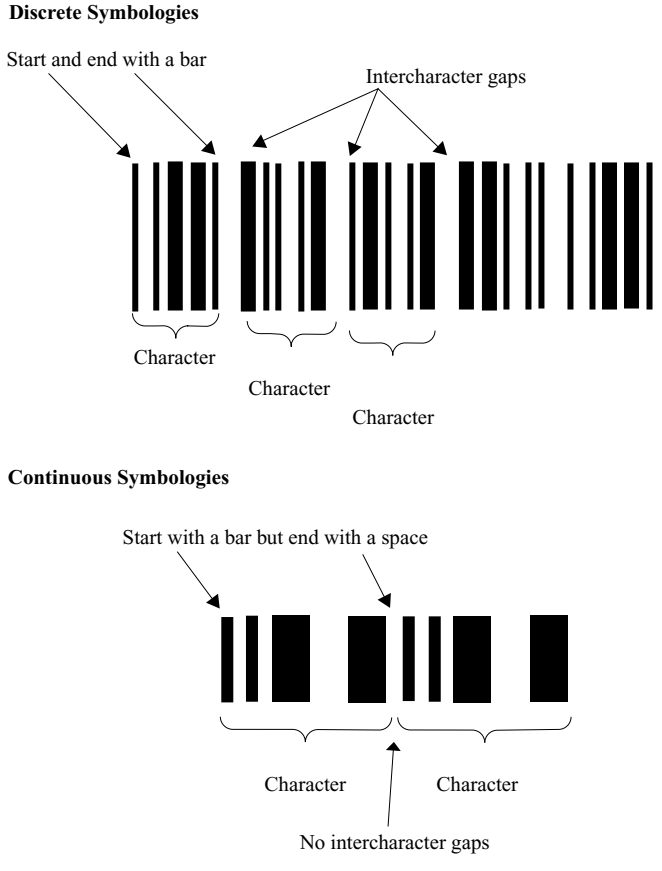
The word on the far left is the most difficult to read but has the greatest amount of information in the smallest amount of space, which is a good thing on a bar code label with limited space available. The word on the far right is the easiest to read, would allow for a more forgiving print job (for example, if the ink spread on the label surface between each letter, we would still be able to read it), but it takes up more space. Discrete symbologies are easier to print and read, but they take up more space.

Symbology Summary

The rules of a particular symbology control are:

- Character set—which alphabetics, numbers, and special characters are in the symbology?
- Symbology type—discrete or continuous? See Exhibit 4–3.
- Number of element widths—how many different "Xs" are there in the wide bars/spaces?

Exhibit 4–3 Structural Differences—Discrete Versus Continuous Bar Code Symbologies



- Fixed or variable lengths of characters in a pattern?
- Density—how many characters can appear per inch?

Popular Symbologies Found in the Inventory World

There are dozens of bar code symbologies. Many have failed in the marketplace because a large number of printer and scanner suppliers will not support them. Others are owned by individ-

ual companies that control and limit their use. Others have specialized uses like Postnet used by the U.S. Postal Service. Some are widely supported and accepted in the inventory control world.

Universal Product Code/European Article Numbering System

Without question, when dealing with point-of-sale identification of product (as in a grocery or other retail store), the bar code used is the Universal Product Code (UPC). A very similar code, which will eventually be interchangeable with UPC, is the European Article Numbering System (EAN).

The UPC symbology is highly structured and controlled, and it is only used in general merchandise retailing. It is an all numeric, fixed length (11 characters) symbology. The UPC symbol is physically arranged into two halves. The left half has six numbers that identify the manufacturer or packager. The right half identifies the product. See Exhibit 4–4. You have to license the right to use the UPC from the Uniform Code Council (UCC), an organization created by the grocery industry.

The UPC is not suitable for inventory control use within a warehousing or manufacturing facility where there is a need for variable length messages, alpha-numeric coding, flexible identification patterns, and so on.

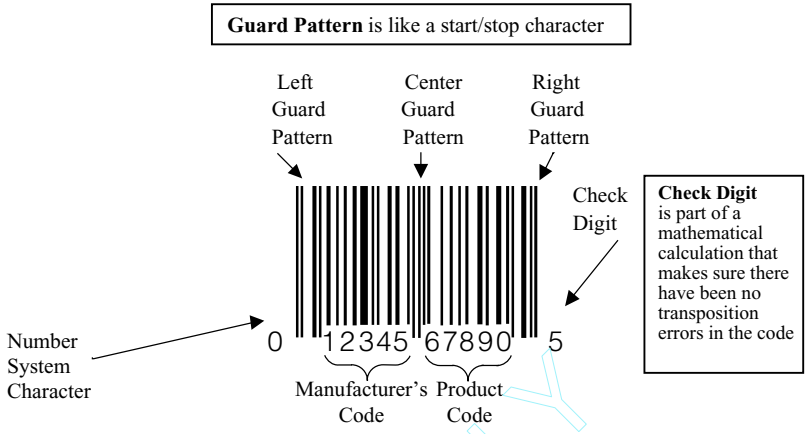
Code 39

This symbology is the most widely used bar code in nonretail applications. It was first introduced in 1975.

Most stockkeepers will be able to find a Code 39 software to interface with their existing application software systems. In other words, you should be able to find a Code 39 bar code package that will allow you to continue to use your existing in-house software, numbering systems, and internal procedures.

Code 39 is sometimes referred to as "3 of 9 Code" because

EXHIBIT 4–4 Structure of the Universal Product Code Symbol



Number System Character
If you see this number in the "Number System Character" position, it means

#	Meaning
0	92,000 manufacturer identification numbers; 8,000 locally assigned numbers
1	Reserved
2	Random weight consumer packages
3	Drug products
4	In-store marking
5	UPC coupons
6	100,000 manufacturer identification numbers
7	100,000 manufacturer identification numbers
8	Reserved
9	Reserved

Manufacturer's Code
is assigned by the Uniform Code Council; a unique code to each company.

Product Code
is assigned by the manufacturer

three of the nine elements (bars or spaces) making up a Code 39 character are wide and the other six are narrow.

Code 39 was the first alphanumeric symbology developed. Among its most important features are:

- Entire alphabet in uppercase letters
- All numerics, e.g., 0 through 9
- Seven special characters: –, ., *, $, /, +, %, and a character representing a blank space

- Discrete symbology
- Allows variable length symbols
- Allows two messages to be decoded and transmitted as one ("concatenation")
- Can be printed in a wide variety of technologies
- Although there are only 43 data characters in the basic Code 39 set, by using certain characters as internal codes, it is possible to encode all 128 ASCII (American Code of Information Interchange) characters used by computers. This feature is cumbersome and is not widely used.
- Self checking, which means a single printing defect cannot cause an error where one character is mistaken for another

Code 128

This code, introduced in 1981, is the preferred symbology for most new bar code applications. It is one you should seriously consider if your business is going to enter into the world of bar coding.

This symbology has many desirable features, such as:

- It uses three start codes to allow the encoding of all 128 ASCII characters without cumbersome procedures. Therefore, you can use the entire alphabet in both upper and lower case, all ten numerics, and all special characters. Each printed character can one of three meanings.
- There is high data density and continuous symbology that uses the least amount of label space for messages of six or more characters
- Tests have shown this to be a highly readable code with high message integrity.

- Code 128 has become one of the two standard bar code symbologies used to identify the contents of corrugated boxes. (The other standard for corrugated shipping boxes is Interleaved 2 of 5 symbology.)
- Code 128 allows for concatenation.

Which Symbology is Right for Your Organization?

Each symbology has its strengths and weaknesses. There is no one "right" bar code language that will fit every organization's needs.

A starting point in reviewing appropriate symbologies actually begins with your own industry. Has your industry selected a particular type of symbology? For example, the automotive industry has been using Code 39 since 1980. You can obtain guidance from trade associations in your industry segment.

The reason to start with a symbology accepted by your industry is that direct application software and hardware will have been written or created for the specific requirements of your business. It is the old question, "Why recreate the wheel?"

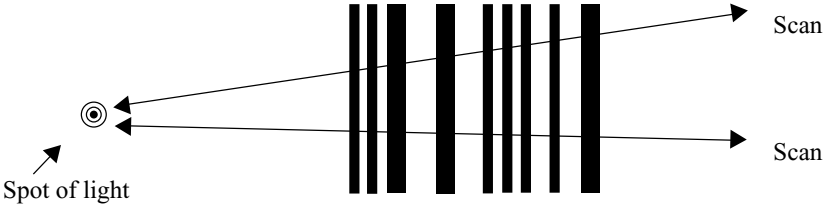
If no symbology dominates your industry, then the real questions become What do you want the system to do for you? and How large is your budget?

Scanning Basics

Something has to read a bar code. That something is a scanner. These electro-optical devices include a means of illuminating the symbol and measuring reflected light.

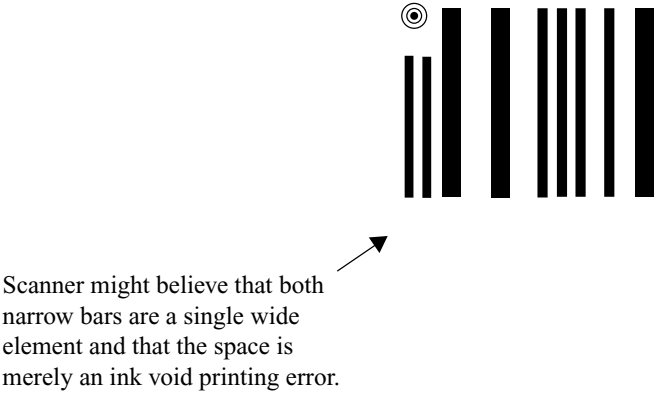
A scanner projects a tiny spot of light that crosses the bar code symbol and then measures the exact width of the bars and spaces. The measurement is determined by the amount of re-

flectance off of the dark and light bars and spaces. Software in either the scanner or in a separate plug-in device then translates the visual (analog) signal into a digital one a computer can understand, and it decodes what symbology (language) it is reading and the message contained in the pattern.



Light reflected is converted from an analog voltage (visual) format to a digital waveform for decoding.

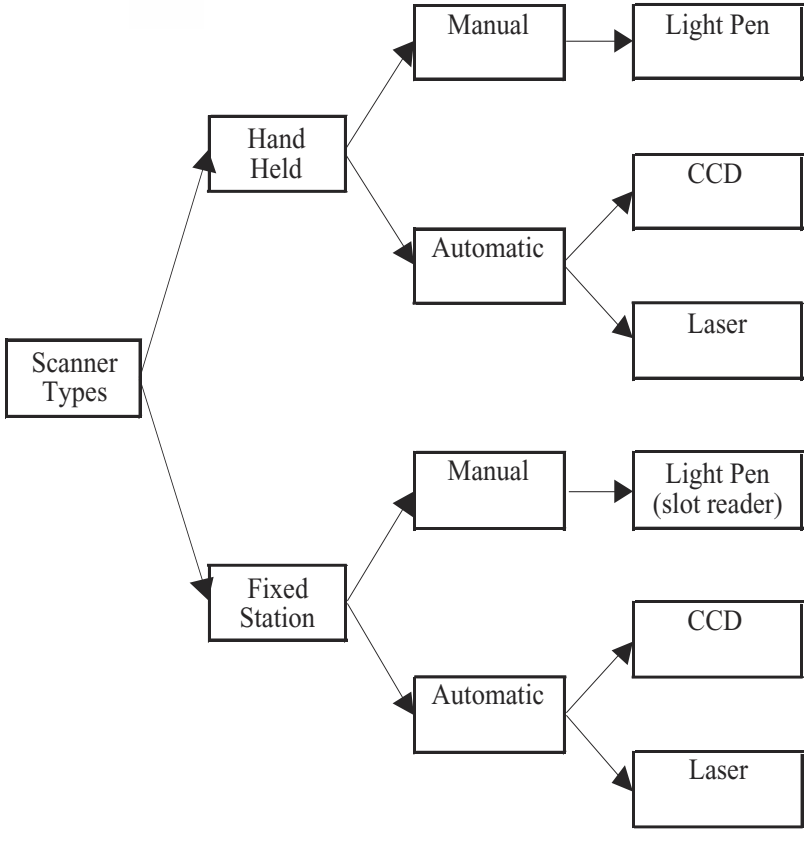
The spot of light must not be larger than the "X" dimension being used for that label or you will get misreads.



Scanners must be purchased so that they match the "X" dimension that will be used for printing labels or for printing directly onto a surface.

Scanners can either be manual (where the user supplies the scanning motion) or automatic (where the device provides the scanning motion). See Exhibit 4–5.

Exhibit 4–5 Scanner Types



Cont. on page 104

Printing Basics

Bar code printing can be done by the user on-site or by an off-site third party vendor.

On-site printing generally occurs close to where product is either being received or shipped—it's point-of-use.

There are five basic on-site bar code print technologies: direct thermal, thermal transfer, dot matrix impact, ink jet, and laser (Xerographic). See Exhibit 4–6.

Cont. from page 103

- Light pen (wand scanner)
  —Makes contact with the label or surface on which pattern is printed
  —Inexpensive
  —Durable
  —Can be tied into various decoder types of equipment
- Charge Coupled Device (CCD)
  —Has a depth of field of several inches so you do not have to make contact with the label or other surface. Therefore, you can read through shrink wrap, which is common in warehousing operations.
  —Floods symbol with light and reflectance illuminates photodetectors in the CCD scanner. Can read very high bar code densities
  —Moderate cost
- Lasers
  —Project a beam of energy off of a rotating prism or oscillating mirror
  —Depth of field of several feet
  —Expensive but versatile

Off-site, commercial printers use a wide variety of printing techniques.

See Chapter 3, Exhibit 3–13 for a discussion of methods to affix bar code labels.

Exhibit 4–6 Common Bar Code Print Technologies

- **Direct Thermal**—Overlapping dots are formed on a heat-sensitive substrate (label or other foundation) by selectively heating elements in a printhead.
- **Thermal Transfer**—Same concept as direct thermal except the image is transferred to the substrate from a ribbon that is heated by the elements in the printhead.
- **Dot Matrix Impact**—A moving printhead with rows of hammers that creates images through multiple passes over a ribbon.
- **Ink Jet**—A fixed printhead sprays tiny droplets of ink onto a substrate.
- **Laser (Xerographic)**—A controlled laser beam creates an image on an electrostatically charged, photoconductive drum. The charged areas attract toner particles that are transferred and fused onto the substrate.

Bar Code Applications

It is far more important that you understand what you want to accomplish with bar codes than for you to understand all of the technical aspects of them.

Think of all of the bits and pieces of information you need to know in order to control inventory in a distribution environment. For example:

- Manufacturer
- Supplier
- SKU number
- Description

- Pack size
- Ship to address
- Bill To address
- Credit terms
- Identification of receiving clerk, stock replenishment worker, order filler, shipping clerk
- Shipper
- Carrier
- Quantity
- Throughput rates, e.g., pieces per hour
- Time, date
- Location
- Purchase order identification

Think of all the information you need to control material in a manufacturing environment. For example:

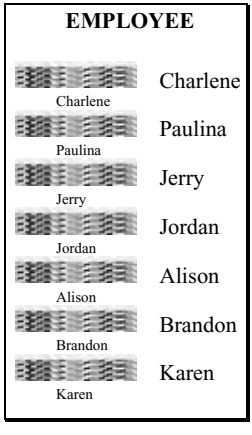
- Particular bill of materials
- SKU number
- Quantity
- Work in process (WIP)
- Individual tasks
- Throughput rates
- Scrap
- Time, date
- Which machine
- Which process
- Location
- Machine instructions
- Job number

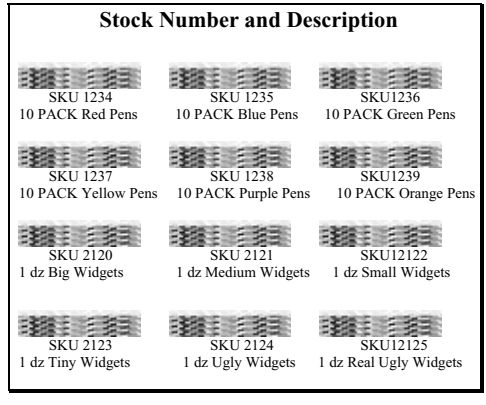
All of the above can be given a bar code identifier.

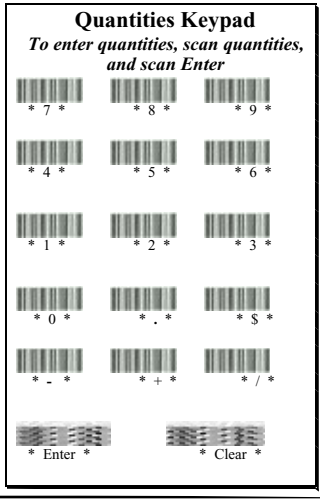
Bar code labels and markings can be printed directly on forms, boxes, the product itself, or on labels that are then affixed to forms, boxes, items themselves, individual parts of items, and so on.

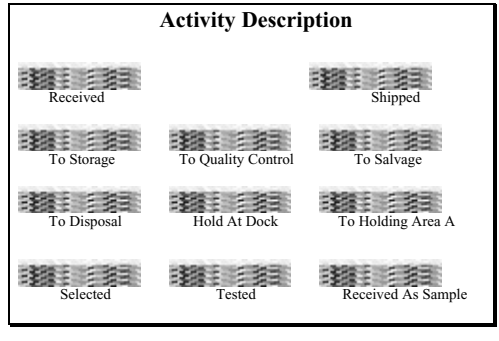
A quick and easy way to begin using bar codes is through the use of scan boards or menu cards. A scan board or menu card is merely a sheet of paper or heavier card stock that contains on it information in both machine readable (bar code) and human readable (plain alpha-numeric text). See Exhibit 4–7 for examples of common scan boards/menu cards.

Exhibit 4–7 Common Types of Bar Code Scan Boards/ Menu Cards





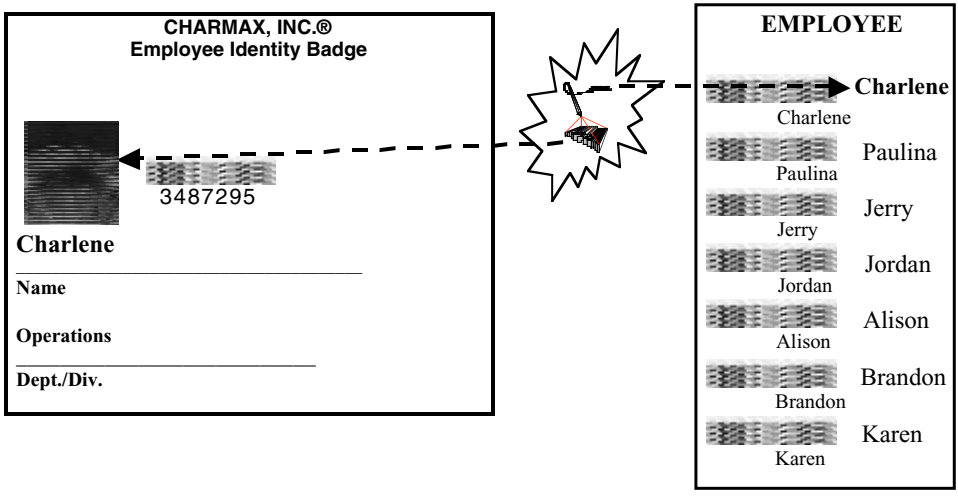




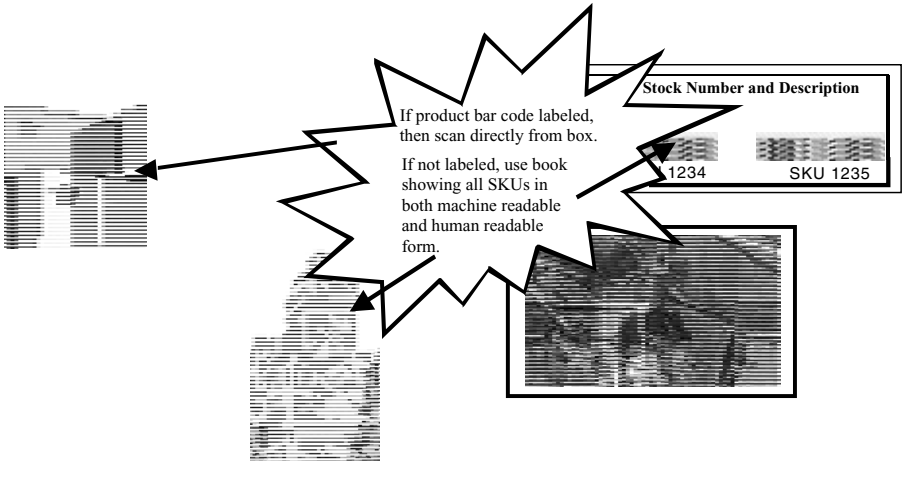
Examples of Using Bar Codes

- Receiving—Shipping

1. Employee scans in their own identity off of scan board or identification badge.



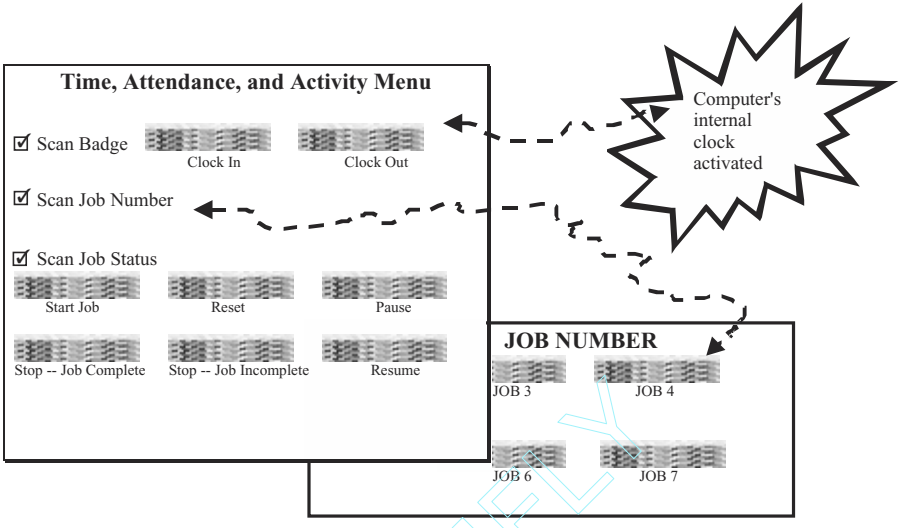
2. Employee scans product code from either items themselves or from scan board.



3. Employee scans in quantity.

4. Employee scans in activity (received, shipped, etc.).

- Tracking Multiple Activities at the Same Time in a Manufacturing Setting



1. Employee scans in their identity.

2. Employee scans in either "Clock In" or "Clock Out." This starting/stopping time can be noted by the computer's internal clock. In addition, the computer's internal calendar notes the date.

(a) This information could be automatically routed to accounting for payroll purposes.

(b) This information will be captured for the particular job in question. That information can then be used as a part of various variance reports such as projected starting time versus actual starting time, projected ending time versus actual ending time, and so on. See Chapter 6, page 162 for a discussion of variance reports.

3. Employee scans in Job Number.

4. Employee scans in Job Status.

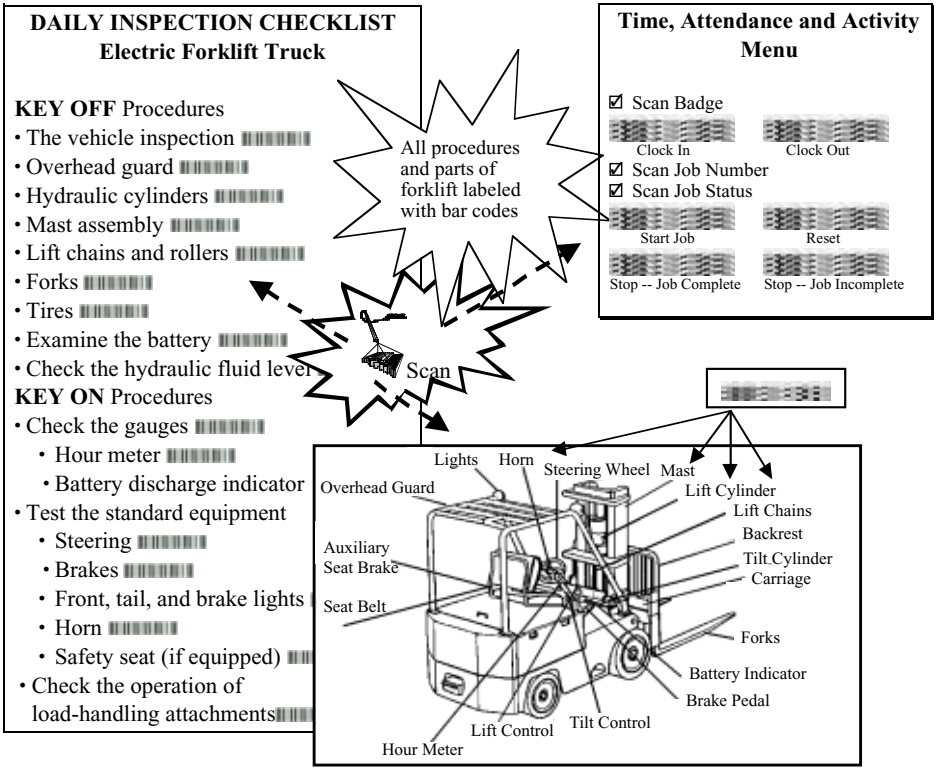
5. When employee scans in "Stop—Job Complete," system could begin, for example, a backflush of all raw materials used

as part of the job just completed. See Exhibit 6–1 on p. 172 for more information on backflushing.

- Using Bar Coding as Part of a Maintenance Program

1. Bar codes are assigned to each part of the maintenance procedure and to various parts (engines, for example) of the piece of equipment in question.

2. Employee then uses a Time, Attendance, and Activity Menu to track the maintenance tasks.



- Bar Coding and Physical Inventory and Cycle Counting

1. Bar code markings in both machine readable and human readable form are placed on both the storage locations (shelves, racks, drawers, bins) and on the product itself.
2. A counter equipped with a portable scanner:
   a. Scans in the identity of the SKU.
   b. Enters the quantity through a keypad on the scanner. The record count and shelf count can be compared in a variety of ways:

(1) The shelf count as captured by the scanner and counter can be transmitted into the system by way of radio frequency at the time of information capture, or it can be uploaded from the scanner at a later time. The computer system would then generate an exception report of those items where the record and shelf counts did not match.

(2) Scanners are small computers. Because of that they can contain software allowing them to have the record count stored within them. As the scanner reads the bar code and the counter enters the quantity information, the scanner could immediately compare the record count and shelf count. If there was a discrepancy, the scanner could alert the counter either through audible tones, flashing lights, or LED displays. The counter could then immediately initiate a recount.

recap The objective of this chapter was to provide you with an overview of bar coding, various popular symbologies, and basic bar code applications.

The set of rules for how the bars and spaces of a bar code language, its symbology, are arranged dictates how much and what type of data can be displayed within a particular symbol. The language that is most appropriate to your industry will be determined by how much data and in what form that information must be displayed on your goods, inventory, or other materials.

Many industry segments such as automotive and retail sales have selected the symbology felt to be most appropriate for their respective needs. Often it is more economical and efficient to adopt the symbology commonly found within your own industry segment.

In applying bar coding to your system, you are only limited by your imagination—and your wallet. Applications can be simple ones involving scan boards or can be complex, utilizing laser scanners, radio frequency, and sophisticated sharing of information throughout the system at the time of information capture.

? REVIEW QUESTIONS

1. What appears on both sides of a bar code symbol to give the scanner a starting point from which to start its measurements?

1. (c)

(a) "X" Dimension
(b) A 3 of 9 interleave
(c) Quiet zones
(d) An aperture

2. **True or False**
   There are only five types of bar code languages. 2. (b)
   (a) True
   (b) False

3. **True or False**
   The most widely used bar code symbology for nonretail applications is Code 39. 3. (a)
   (a) True
   (b) False

4. **True or False**
   A discrete symbology starts with a bar and ends with a bar.
   4. (a)
   (a) True
   (b) False

5. Which symbology is the most widely used for retail point of sale transactions? 5. (a)
   (a) Universal Product Code
   (b) Code 39
   (c) Code 128
   (d) Codabar

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CHAPTER 5

Planning and Replenishment Concepts

Introduction

The objective of this chapter is to provide basic approaches to forecasting inventory levels and to undertaking stock replenishment. With the proper techniques, you will have the right item, in the right quantity, at the right time, and in the right place.

Replenishment Costs

As discussed in Chapter 2, Inventory as Money, every day that an item remains in your stockroom it costs you money in the form of a carrying cost (K Factor). If you take that concept to its ultimate extreme, it would make sense to only buy items exactly when you need them. Multiple smaller quantity purchases of the same item certainly hold down your carrying costs. However, it hurts your cost of replenishment—the expenses associated with buying things.

It costs money to buy things. That sounds absurdly simple when you first read it. However, the cost of purchasing product exceeds the actual price paid for it. Expenses related to purchasing include the salaries of the purchasing staff, rent, and other overhead expenses attributable to the purchasing department. See Exhibit 5-1.

In fact, the more often you buy, the greater your internal costs. For example, if you purchased one million widgets all at the same time, your purchasing or replenishment cost (R Factor) would be the cost per line item, per purchase order (PO). See Exhibit 5–1.

- If the per line, per PO cost is $5.00, then your cost to buy all one million widgets at one time would be $5.00.
- If you were to buy the same one million widgets 250,000 at a time, then your R Factor would be $5.00 times four (four POs with one line item each) or $20.00.
- If you purchased the widgets one at a time, the cost would be one million times $5.00 or five million dollars.

Order size versus frequency of purchase shifts the cost burden from the K Factor to the R Factor and vice versa. In other words:

- If you buy smaller quantities more often, your purchasing costs go up—or your R Factor increases.
- If you buy larger quantities less often, you have a higher inventory level for a longer period of time, so your carrying costs go up—or your K Factor increases.

In a perfect world the K Factor and the R Factor would be equal. Although this is difficult to achieve, an organization attempting to have the correct amount of product at the overall lowest cost will strive for that balance.

Exhibit 5–1 Calculating the R Factor

The cost of replenishment is calculated on a per item, per order basis. This is because it takes the same amount of internal effort to determine how much of each item you desire, from which supplier, at what pricing, terms, and so on, no matter which item is being considered and no matter how many items there are on any given PO. Therefore, if the R Factor is $5.00 per item, per order, and there is a single line item on an order, the replenishment cost is $5.00. If there are two items, it's $10.00. If there are three items, it's $15.00, and so on.[1]

To calculate the cost of replenishment, include:

Annual cost of purchasing department labor	220,000
Annual cost of purchasing department overhead (rent, utilities, equipment allocation, etc.)	$179,000
Annual cost of expediting stock items	$ 25,000
Total annual costs	$424,000
Number of purchase orders created per year for stock (assume):	10,000
Average number of different stock items per order (assume):	x 8
Total number of times stock items were ordered:	80,000

$$\frac{\text{Total Annual Costs}}{\text{Total Times Stock Items Were Ordered}} = \text{R Factor} \rightarrow = \frac{\$424{,}000}{80{,}000} = \boxed{\$5.30 = \text{R Factor}}$$

Case Study: Balancing Carrying and Replenishment Costs

A dispute has arisen at the Charmax Co. between the purchasing and warehouse managers.

Charmax's receiving ends at 5:00 PM. At 4:45 PM, a 40-foot trailer is backed up to the dock. The doors are opened to reveal three levels of floor-stacked boxes extending from floor to ceiling, back to front.

Joe, the warehouse manager, realizes that it will take four workers at least two hours to hand unload the trailer. Virtually all of that time will be on an overtime basis.

Joe reviews the truck's manifest and determines what items on the trailer are needed for delivery tomorrow morning. He discovers that there are only three boxes on the trailer that are truly required for tomorrow's business. He asks Tracy, the truck driver, if he helped to load the trailer. Tracy replies that he did. Joe asks if Tracy remembers where those three boxes are. With a smile, Tracy replies that they are located in the nose of the trailer.

Joe decides not to incur the overtime. He will have the trailer unloaded in the morning.

Betty, the sales manager, hears that the three items will not be shipped to Acme, a large and important customer. She storms into the warehouse and demands that the trailer be unloaded.

Joe explains the overtime situation. Betty replies that Joe should have scheduled the trailer to arrive earlier in the day. Joe replies that the buyer, Bill, handles traffic management as part of the purchase of the product. Betty angrily says she doesn't much care. Joe had told her that the product would be here today for delivery tomorrow. "You promised me," Betty says, "so that's what I prom-

ised the customer. Now unload the trailer." Joe reluctantly does so.

Later, Joe confronts Bill and demands that product be brought in palletized or unitized or in some other manner so it can be unloaded quickly. Joe argues that since internal handling is a major component in computing the cost of carrying inventory, unitization will help cut Charmax's costs.

Bill responds that he has to buy the product as he is buying it now. He argues that to palletize the product would increase the costs per unit of product. He also points out that since the product already extends to the top of the trailer, that the added height of three levels of pallets at approximately four inches each, would force him to buy less per order so that it will all fit on a trailer. Therefore, he will have to buy less and buy it more often driving up his replenishment costs. Ill-will and stalemate result.

Suggested Solutions:

1. Joe and Bill should coordinate traffic management so that loads match the labor, equipment, time resources, and constraints of the organization. By lowering handling costs the company will reduce overall carrying costs.

2. Both Joe and Bill need to specifically determine their respective costs.

   (a) Joe can determine the handling portion of the K Factor by :
   (1) Determining the average time it takes to hand unload a trailer.
   (2) Multiplying the average hand unloading time times the number of trailers during the year.

Cont. on page 120

Cont. from page 119

(3) Multiplying the total hand unloading time times the average hourly labor rate being paid the warehouse personnel.
(4) Determining the average time it would take to unload unitized loads.
(5) Multiplying the average unitized unloading time times the number of trailers during the year.
(6) Multiplying the total unitized unloading time times the average hourly labor rate being paid the warehouse personnel.
(7) Comparing the annual labor costs involved for hand unloading to the annual labor costs of unitized unloading to determine the total dollar savings.

(b) Bill can determine his added replenishment costs associated with smaller loads purchased more often.

(c) A fair comparison can then be made as to which route is the most advantageous for the overall organization.

3. Alternatives meeting the needs of both parties might be developed. For example, if slip-sheets (thin cardboard or plywood sheets the same length and width as a pallet) were used, Bill might be able to overcome the size of load and volume problem, while Joe could automate the unloading process.

Inventory Types

In the worlds of distribution, retailing, and replacement parts, an organization deals with finished goods. In the manufacturing world an organization deals with raw materials and subassemblies. Considerations of what to buy, when to buy it, in what quantities, and so on are dramatically different in these two worlds.

In distribution you are concerned with having the right item, in the right quantity. Issues relating to having the item at the right time and place are often dealt with by simply increasing safety stock on-hand. That is not a good solution because it leads to wasted money and space. However, traditional formulae used in computing inventory requirements in a distribution environment focus on item and quantity rather than place and time. In manufacturing, you are concerned with having the right item, in the right quantity, at the right time, in the right place.

Demand for finished goods and spare parts for replacements are said to be "independent," while demand for items in the manufacturing world are said to be "dependent." Understanding these distinctions will assist you in forecasting your procurement needs.

Independent demand is influenced by market conditions outside the control of your organization's operations. The demand for the widgets your organization sells will be independent of the demand for your gadgets, doodads, and whatchamacallits. Your products are independent of one another. In this environment you must have the right item in the right quantity.

Dependent demand is related to another item. The demand for products built up or created from raw materials, parts, and assemblies is dependent on the demand for the final product. You would not need one item if you did not also require another,

both of which would go into an assembly or finished product. In this environment you must have the right items in the right quantities at the time in order to complete a finished product.

A chair can be used as an example of the above. The demand for the number of chairs you need is independent from the number of tables that you need because quantity required is influenced by the demand in the market for each item. The demand for chair legs, or seats, or rails is mathematically dependent on the demand for *finished* chairs. Four legs and one seat are required for each chair.

Dependent and independent demands demonstrate very different usage and demand patterns.

Independent demand calls for a *replenishment* approach to inventory management. This approach assumes that market forces will exhibit a somewhat fixed pattern. Therefore, stock is replenished as it is used in order to have items on hand for customers.

Dependent demand calls for a *requirements* approach. When an assembly or finished item is needed, then the materials needed to create it are ordered. There is no fixed pattern because an assembly created in the past may never be produced again.

The nature of demand, therefore, leads to different concepts, formulae, and methods of inventory management.

Independent Demand Inventory

Order-Point Formulae

Order point formulae are used to determine how much of a given item needs to be ordered where there is independent demand. In these formulae a reorder point (ROP) is set for each item. The ROP is the lowest amount of an item you will have on hand and on order before you reorder.

A Simple Min-Max Inventory System

Order point formulae are based on some relatively simple concepts.

Imagine that all of a particular SKU are kept in a single bin. If no reorder point was set, then the entire batch would be used up without any order being placed. The organization would then be unable to sell or use that item during whatever time frame was required to order and bring the SKU in—the lead time. It would therefore make sense to adopt a two-bin system with Bin 1 containing working stock and Bin 2 containing working reserve. The amount of product in Bin 2 would be equal to your usage rate during that item's lead time.

In a two-bin system, if all goes as it should, then immediately upon using the first item from Bin 2, you would reorder a quantity equal to both Bins 1 and 2. As you use the last item in Bin 2, the order arrives and you refill both bins. This assumes that lead time is exact, there are no vendor stockouts or backorders, and that there are never any defects. That assumption is, of course, often false. Therefore, a true order-point system is a three-bin system, with the Bin 3 containing safety stock.

Bin 3, safety stock, relates to Bin 2 since Bin 3 is to make up for uncertainties in lead time and defects. Mathematically safety stock is 50 percent of working reserve. (The average between having nothing in Bin 2 and having it at 100 percent full is 50 percent.) However, companies adjust safety stock levels to coincide with their actual experience.

Bins can be mathematically created or can reflect actual physical separation of items in the stockroom.

A simple formula for determining the ROP reflects the above concepts.

(Usage x Lead Time) + Safety Stock = ROP

In the above formula lead time is shown as a percentage of a month, as follows:

1 week	= 0.25	= 25%	4 weeks	= 1.00	= 100%
2 weeks	= 0.50	= 50%	5 weeks	= 1.25	= 125%
3 weeks	= 0.75	= 75%	6 weeks	= 1.50	= 150%

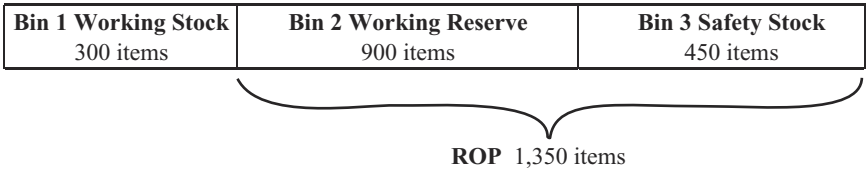
Example 1:

Assume:

- Usage rate of 1,200 items per month
- Lead time of 3 weeks

Step-by-Step Calculation:

- Calculate weekly usage. Assume a 4-week month. 1,200 items ÷ 4 weeks = 300 items per week ➜ therefore Bin 1 or working stock should contain at least 300 items
- Calculate working reserve: Given 3 weeks of lead time, working reserve should be 1,200 items x 0.75 = 900 items
- Calculate safety stock, use 50 percent of working reserve as a guideline (900 items x 50% = 450 items)
- Calculate ROP: (1,200 items x 0.75) + 450 items = ROP 1,350 items



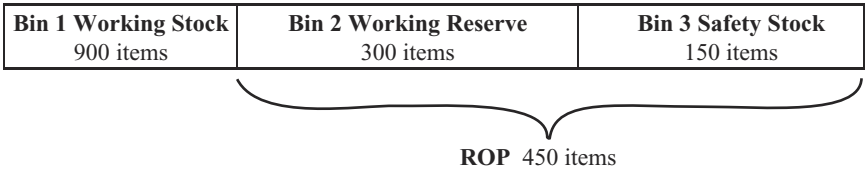
Example 2:

Assume:

- Usage rate of 1,200 items per month
- Lead time of 1 week

Step-by-Step Calculation:

- Calculate weekly usage. Assume a 4-week month. 1,200 items ÷ 4 weeks = 300 items per week ➜ therefore Bin 1 or working stock should contain at least 300 items
- Calculate working reserve: Given 1 week of lead time, working reserve should be 1,200 items x 0.25 = 300 items
- Calculate safety stock, use 50 percent of working reserve as a guideline (300 items x 50% = 150 items)
- Calculate ROP: (1,200 items x 0.25) + 150 items = ROP 450 items



The ROP is the "minimum" (min) in a "minimum-maximum" (min-max) inventory control system. In these systems there is a minimum below which you will not let your stock level fall; and there is a maximum above which you will not have items on hand or on order.

In order to compute the maximum in these systems, you must first determine how often you will place orders. This time period is called the *review cycle*.

The review cycle is the length of time between reviews of when you wish to order product. The formula to determine the review cycle is:

$$\frac{\text{Total Purchases from Vendor for a Year}}{\text{Discount Quantity}} = \text{Review Cycle}$$

The unit of measure reflecting total purchases from a vendor can be dollars, pieces, pounds, units, or whatever your organization uses. The discount quantity is the minimum amount you have to order of that unit of measure in order to be granted a discount.

Review cycle example:

$$\frac{200{,}000}{5{,}000} = 40 \text{ reviews per year}$$

And, by dividing 40 reviews by 52 weeks equals a review roughly every 1.3 weeks. When the review actually occurs will also depend on factors such as seasonality.

The maximum in these systems is also represented by a simple formula.

ROP + Usage During the Review Cycle = Maximum

Maximum Point Example 1:
Assume:

- **Usage rate of 1,200 items per month**
- **Review cycle every 1.3 weeks**
- **ROP equals 1,350 items**

$$\frac{\text{1,200 items}}{\text{4 wks}} = \text{300 items used per week}$$

300 items x 1.3 weeks = 390 items used during review cycle

1,350 items + 390 items = 1,740 items max

Maximum Point Example 2:
Assume:

- **Usage rate of 1,200 items per month**
- **Review cycle every 1.3 weeks**
- **ROP equals 450 items**

$$\frac{\text{1,200 items}}{\text{4 wks}} = \text{300 used per week}$$

300 items x 1.3 weeks = 390 used during review cycle

450 items + 390 items = 840 items max

By setting a min-max for each item in your inventory, you can create a simple method of ordering products having independent demand.

Economic Order Quantity (EOQ) Formula

In 1915, F. W. Harris of General Electric developed the Economic Order Quantity formula (EOQ) to help stockkeepers in determining how much product to buy.

To calculate EOQ, assume:

A = Total Value of SKU Per Year
K = Carrying Cost (The K Factor)
R = Replenishment Cost (The R Factor)
P = Price Per Unit

Basic Formula:

$$EOQ = \sqrt{\frac{2AR}{P^2K}}$$

This formula and its variations allow you to determine the following:

- the optimal quantity to order
- when it should be ordered
- the total cost
- the average inventory level
- how much should be ordered each time
- the maximum inventory level

The EOQ model is based on several assumptions:

- the demand rate is constant (no variations), recurring, and known.
- the carrying cost and ordering cost are independent of the quantity ordered (no discounts).
- the lead time is constant and known. Therefore, the ordering times given result in new orders arriving exactly when the inventory level reaches zero.

- formula can handle only one type of item at a time.
- orders arrive in a single batch (no vendor stockouts or backorders).

A simple example of the basic formula is:

A = $36,000
K = 15%
R = $75
P = $25

$$EOQ = \sqrt{\frac{2AR}{P^2K}} = \sqrt{\frac{2(\$36{,}000)(\$75)}{(\$25)^2(0.15)}} = \sqrt{\frac{5{,}475{,}000}{93.75}} = \sqrt{58{,}400}$$
$$= 242 \text{ units per order}$$

Since the above assumptions do not reflect the real world, mathematicians have developed variations of the basic formula. See Exhibit 5–2.

Exhibit 5–2 Variations of the Basic EOQ Formula

Inventory Variable Formulae and Examples

For the below formulae and examples, assume:

A = Total Value of SKU Per Year = $36,000
K = Carrying Cost (The K Factor) = 15%
R = Replenishment Cost (The R Factor) = $75
P = Price Per Unit = $25

Optimum Number of Orders Per Year =

$$\sqrt{\frac{AK}{2R}} = \sqrt{\frac{(\$36{,}000)(0.15)}{2(\$75)}} = \sqrt{\frac{5{,}475}{150}} = \sqrt{36.5} = 6.4 \cong 6 \text{ per order}$$

Optimum Number of Dollars Per Order =

$$\sqrt{\frac{2AR}{K}} = \sqrt{\frac{2(\$36{,}000)(\$75)}{0.15}} = \sqrt{\frac{5{,}475{,}000}{0.15}} = \sqrt{36{,}500{,}000} \cong \$6{,}041.52$$

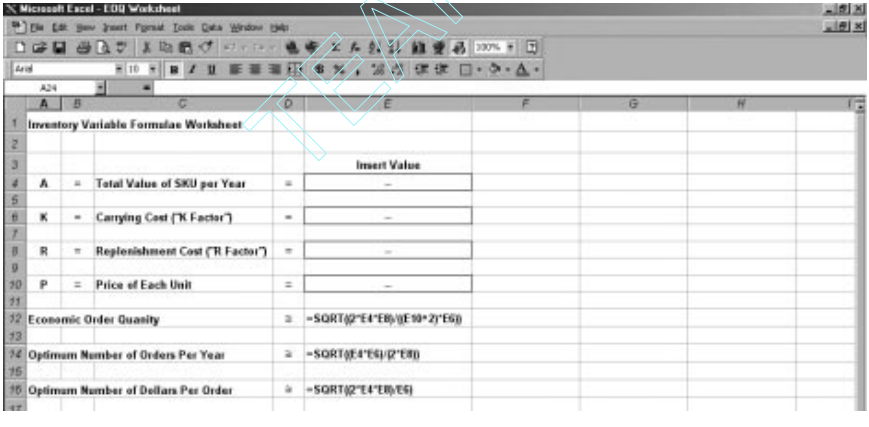
How to Set Up an EOQ Worksheet in Microsoft® Excel®

Here's a tip . . . by setting up a permanent worksheet in Microsoft® Excel® or similar spreadsheet program, you will be able to quickly calculate important EOQ information simply by entering variable values for A, K, R, and P under the "Insert Value" column.

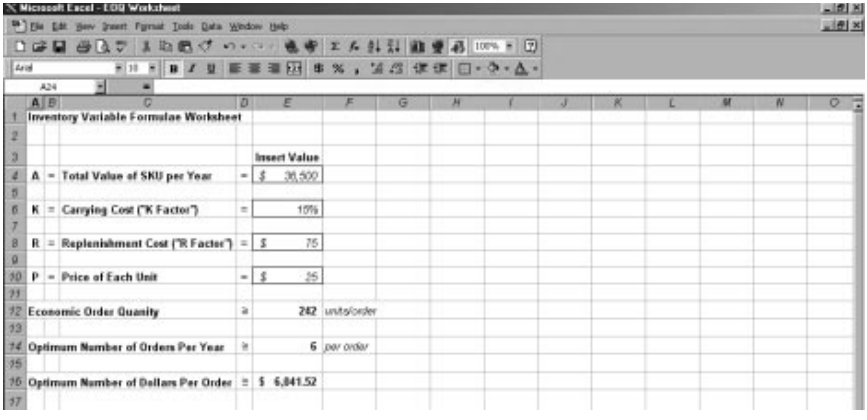
Based on the cell placement as noted below, you can calculate each quantity by entering the following formulae:

Economic Order Quantity ➜ type: = SQRT((2*E4*E8)/((E10 ^ 2)*E6))
Optimum Number of Orders Per Year ➜ type: = SQRT((E4*E6)/(2*E8))
Optimum Number of Dollars Per Order ➜ type: = SQRT((2*E4*E8)/E6)

Screen Shot I Illustrates worksheet set up including formulae input



Screen Shot II Illustrates example of completed worksheet. Values were entered for the variables A, K, R, and P. The worksheet then updated itself as the formulae were already input:



1	Inventory Variable Formulae Worksheet															
2																
3					Insert Value											
4	A	=	Total Value of SKU per Year	=	$ 36,500											
5																
6	K	=	Carrying Cost ("K Factor")	=	15%											
7																
8	R	=	Replenishment Cost ("R Factor")	=	$ 75											
9																
10	P	=	Price of Each Unit	=	$ 25											
11																
12	Economic Order Quanity			=	242	units/order										
13																
14	Optimum Number of Orders Per Year			=	6	per order										
15																
16	Optimum Number of Dollars Per Order			=	$ 6,841.52											
17																

Dependent Demand Inventory

Materials Requirements Planning

Controlling not only what item is purchased and in what quantities, but also the timing of its arrival through computerized systems is called *materials requirements planning* (MRP). This concept of the right item, in the right quantity, and at the right time was first introduced by Joseph Orlicky in 1975.

Independent demand inventory management is customer oriented. The objective of ROP rules and formulae is high customer service levels and low operating costs. Dependent demand systems, however, are manufacturing oriented. The objective of dependent demand inventory control is to support the master production schedule. Even if you have a low stock level of an item, it won't be ordered unless and until it is needed to produce something for the master schedule—a true requirements philosophy of inventory control. MRP dependent demand inventory control is directed inward rather than outward like ROP inventory control. See Exhibit 5–3.

Exhibit 5–3 Contrasting Order Point with MRP Systems

	ORDER POINT	MRP
Demand	**Independent**	**Dependent**
Order Philosophy	**Replenishment**	**Requirements**
Forecasting	**Based on past demand**	**Based on master schedule**
Control Concept	**ABC categorization**	**All items are equally important**
Objectives	**Meet customer needs**	**Meet manufacturing needs**
Lot Sizing	**EOQ**	**Individual item requirements**
Demand Pattern	**Consistent**	**Random but predictable**
Inventory Type	**Finished goods/ spare parts**	**Work in progress/ raw materials**

MRP Elements

Key concepts in understanding MRP are the *master production schedule* and the *bill of materials*.

The *master production schedule* sets out what will be built, when, and in what quantities. It can either cover short or long time horizons.

- Short horizon—planning of initial requirements sets out:
  —final product requirements
  —schedule for production of components
  —purchase order priorities
  —short term capacity requirements

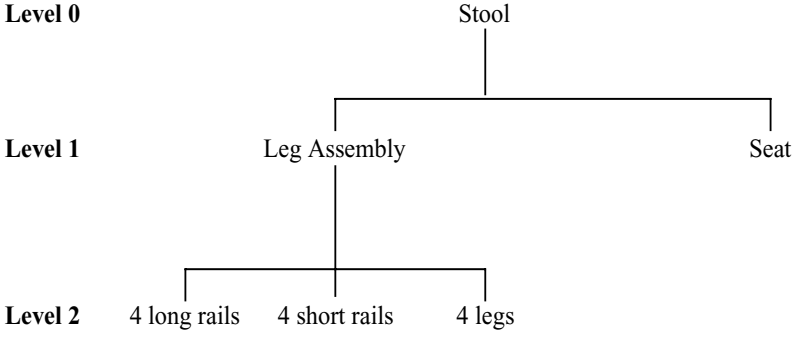
- Long horizon—estimating long term requirements sets out:

—long term production capacity required
—long term warehouse capacity required
—long term staffing required
—long term money required

The *bill of materials* (BOM) is the recipe of raw materials, parts, subassemblies, and so on required to build or make something.

There are levels to each BOM. See Exhibit 5–4 and Exhibit 6–1 on page 165 for a discussion of how inventory is relieved from stock after each level of the BOM is completed. This is a technique called "backflushing."

Exhibit 5-4 Bill of Materials Levels



MRP's chief advantage over the ROP approach is that it lets you customize your ordering strategy for raw materials, parts, and so on with different demand characteristics such as lead times. The ROP approach answers the questions of *what* and *how much*:

On Hand	60	or	60
On Order	100		50
Required	130		130
Available	30		–20

ROP does not answer the question of *when*:

On Hand	60	or	60
On Order	100 due in on Nov. 15th		50 due on Nov. 1st
Required	*130 needed by Nov. 5th*		100 needed by Nov. 5th *30 needed by Nov. 15th*
Available when needed	–70		10 on Nov. 5th –20 on Nov. 15th

MRP allows purchases to be made as and when needed to ensure that items will arrive when needed. It accomplishes this by setting up time phasing charts within the computer system. See Exhibit 5–5.

Exhibit 5-5 Time Phasing Chart for a Single Item Within a MRP System

Assumptions:

- 12-week production schedule
- 10 units of this item are required each week for production
- Starting balance of 70 units
- One week lead time

As evidenced by the first chart, you do not need to buy and hold any of the items in question until Week 7. Week 7's production will bring our balance of inventory on hand to zero.

Time Phasing Chart Without Release of Purchase Order

0	1	2	3	4	5	6	7	8	9	10	11	12	Week Number
	10	10	10	10	10	10	10	10	10	10	10	10	Gross Requirements
													Scheduled Receipt
70	60	50	40	30	20	10	0	–10	–20	–30	–40	–50	Inventory on Hand
													Planned Order Release

Time Phasing Chart With Release of Purchase Order

0	1	2	3	4	5	6	7	8	9	10	11	12	Week Number
	10	10	10	10	10	10	10	10	10	10	10	10	Gross Requirements
							100						Scheduled Receipt
70	60	50	40	30	20	10	100	90	80	70	60	50	Inventory On Hand
						100							Planned Order Release

In the second chart, a purchase order is released during Week 6. The product arrives during Week 7, and you are ready for production as Week 8 begins.

The above charts demonstrate that by timing the release of the PO for a specific item, that item can be brought in only when needed. This holds our inventory levels down.

MRP has evolved into three somewhat distinct systems:

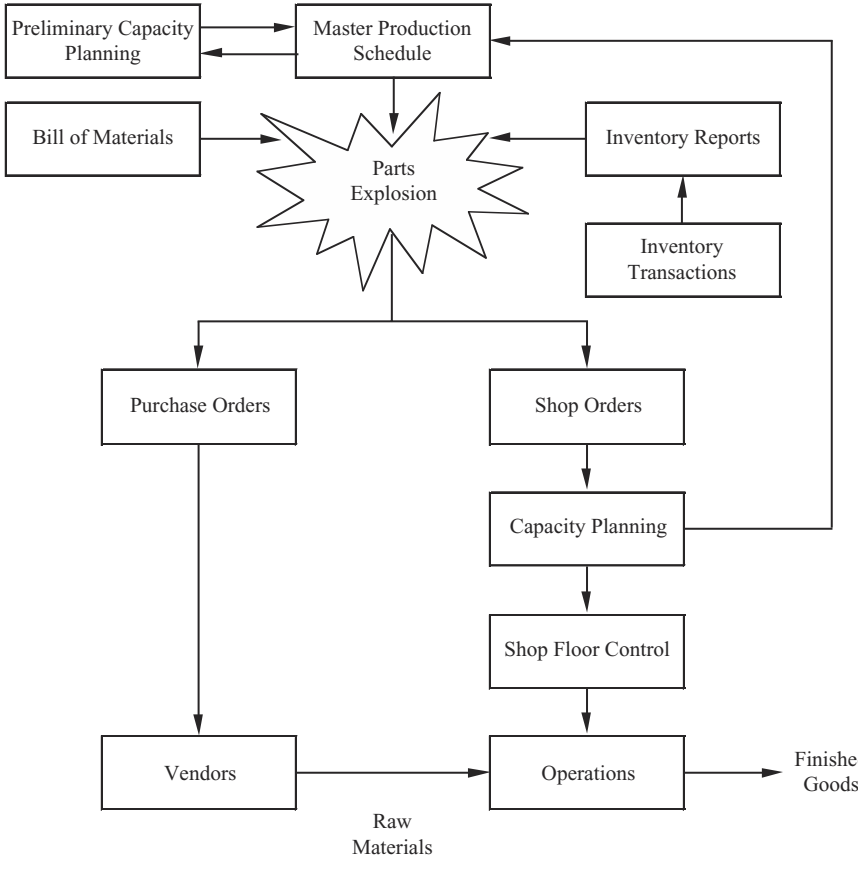
• **MRP—an inventory control system**	**Overall characteristics:** **—Master Production Scheduling** **—Master Requirements Planning** **—Capacity Requirements Planning** **—Executing Capacity Plans** **—Executing Material Plans** **These systems are sometimes called closed-loop systems. See Exhibit 5–6.** **Overall characteristics:** **—Business Plan** **—Sales and Operations Planning** **—Simulation**
• **Enterprise Resource Planning (ERP) And Other Just-In-Time (JIT) Inventory Systems—manufacturing resource-planning systems**	**ERP and other JIT systems are used to plan and control all resources: cash, labor, inventory, facilities, and capital equipment.** **Overall Characteristics:** **—Investment Management** **—Plant Maintenance** **—Quality Management** **—Personnel Planning & Development** **—Materials Management** **—Sales and Distribution** **—Financial Accounting** **—Controlling**

An example of MRP would be a decision to build one bar stool in your garage on Saturday.

The decision to build a single unit of something on a given day is the master schedule.

Included in your thinking was the fact that if you had all of

Exhibit 5–6 MRP—The Closed Loop



the pieces, parts, and tools necessary, you could actually accomplish the task. That is rough-cut capacity planning.

You then draw-up and define what parts are required for the task. See Exhibit 5–4. This is your bill of materials.

The next step is a parts explosion where you review your on-hand inventory levels to initially determine if any POs must be prepared and released.

You then engage in detailed capacity planning to decide if you can proceed or if the master schedule, capacity, or the planned release of POs must be changed.

Ultimately, all parts, equipment, and so on come together and the stool is built.

MRP works well because it is a forward-looking system. The predictability of events allows for careful planning and a reduction in unnecessary inventory.

A major drawback of MRP and JIT systems is that they are highly data dependent. Not only do you have to have *all* of the data easily available on an ongoing basis, but in addition, the information must be accurate and timely. Organizations lacking a strong software/hardware infrastructure will have difficulty in fully implementing an MRP system.

Just-In-Time (JIT) Inventory Systems

JIT was first developed within Toyota's manufacturing operations by Taiichi Ohno in the 1970s as a means of meeting customer demands with minimum delay. In its original form, it referred to the production of goods, assemblies, and subassemblies to meet exactly the customer's demand in terms of time, quality, and quantity. With a JIT system, the "buyer" can be the actual end user or another process along the production line.

JIT goes further than MRP, because you control not only the right item, in the right quantity, at the right time, but you also bring that SKU to the right place. Under this time-based concept, an item appears exactly when it is needed—not before, not after.

The American Production and Inventory Control Society (APICS) has the following definition of JIT:

> . . . a philosophy of manufacturing based on planned elimination of all waste and continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery

> and including all stages of conversion from raw material onward. The primary elements include having only the required inventory when needed; to improve quality to zero defects; to reduce lead time by reducing setup times, queue lengths and lot sizes; to incrementally revise the operations themselves; and to accomplish these things at minimum cost.

There are many benefits to a JIT system, including:

- Reduction of stockouts
- Reduction of inventory levels
- Reduction of need for material handling equipment
- Reduction of time frames between delivery and production
- Significant quality improvement
- Employee inclusion in continuous quality improvement

JIT is a management philosophy rather than a technique.

The fact that certain words and acronyms have come to be used somewhat interchangeably can be confusing to anyone not in the manufacturing world. Do those terms/acronyms have individual, stand alone characteristics differentiating one from another? Most certainly they do, however, grappling with the details of what separates one particular type of manufacturing philosophy from another closely related theory won't further your understanding of the basic concepts of inventory management and control.

The terms/acronyms *MRP III, Computer Integrated Manufacturing, Lean Manufacturing, Short Cycle Manufacturing, Just-in-Time, JIT, Enterprise Resource Planning, ERP,* and so on all relate to the fundamental notions that:

- manufacturing activities should be integrated.
- the actions and decisions of each department should complement all other departments.
- information should flow both internally throughout the organization and externally to/from suppliers/customers electronically rather than through:

  —the movement of hard paper copies, or

  —through individual software (accounting) modules whose data do not flow into one another both automatically and in real time.
- suppliers are reliable and raw materials are without defect.
- all employees follow the philosophy of continuous quality improvement in all aspects of the operation.

Let's concentrate on how these concepts—by whatever name—relate to inventory. They all regard inventory as *waste*.

Today JIT has come to mean producing with a minimum of waste. "Waste" is used in the broadest sense and includes any nonvalue adding activities. For example, storing, inspecting, and counting materials doesn't change the items; therefore, those actions add no value. There are seven types of waste JIT systems strive to eliminate:

- Overproduction—producing more than needed. Wasted money, effort, space, etc.
- Waiting time—decreases productivity and efficiency.
- Transportation—double and even triple handling of an item from one storage position to another.
- Processing— what are the interfaces between parties, de-

partments, you, and your suppliers? The fewer and faster the better.

- Inventory—stock simply sitting around does no one any good.
- Motion—reduce motions such as those involved in looking for materials.
- Defects—defective goods not only cost money directly, but they also cause stops and delays.

Implementing JIT

Take the following steps to introduce a JIT type system into your manufacturing facility:

1. Stabilize and level the production schedule.
- All work centers should have a uniform load through constant daily production.
- Prevent changes in the production plan for some period of time.
- Produce roughly the same mix of products each day, using a repeating sequence if several products are produced on the same line. This is often called "mixed model assembly."
- Change the quantity of end-item inventory to meet demand fluctuations rather than through fluctuations in production levels.

2. Reduce or eliminate setup times.
- Strive to create single digit setup times (less than 10 minutes).

3. Reduce lot sizes (manufacturing and purchase).

- Reducing setup times allows economical production of smaller lots.
- Close cooperation with suppliers is necessary to achieve reductions in order lot sizes since more frequent deliveries will be called for. In JIT systems, the old, adversarial methods of purchasing will not work. In traditional approaches buyers buy an item here and another item there through a series of disconnected negotiations over price, delivery quality, and terms. In JIT systems, larger quantities and types of items are purchased from fewer vendors. The larger purchases give the buyer more economic leverage while providing the supplier with enough financial incentive to become the buyer's business partner. Both parties recognize the critical needs, costing, pricing, quality concerns, and so on of the other.

4. Reduce lead times (production and delivery)

- Production lead times can be reduced by:
  —moving work stations closer together.
  —applying group technology and cellular manufacturing concepts.
  —reducing the number of jobs waiting to be processed at a given machine ("queue" length).
  —improving the coordination and cooperation between successive processes, such as, reducing delivery times by inducing suppliers to have distribution centers/warehouses closer to your operation.

5. Engage in strong preventive maintenance

- Machine and worker idle time should be used to maintain equipment and prevent breakdowns.

6. Cross-train to create a flexible work force

- Workers should be trained to:
  —operate several machines.
  —perform maintenance tasks.
  —perform quality inspections.

7. Require supplier quality assurance and implement a zero-defects quality program.

- Since there are no buffers of safety stock, errors leading to defective items must be eliminated.

8. Use a control system such as a kanban (card) system to convey parts between work stations in small quantities (ideally, one unit at a time).

Inventory Objectives

Inventory in and of itself is not waste. *Unnecessary* inventory is waste. A key question is: What is unnecessary in the context of your organization?

In manufacturing operations, inventory in excess of that needed to support current operations or research and development efforts would certainly be waste. However, is the inventory of a distributor that uses immediate availability of a large cross-section of items as an effective, profitable marketing tool, "unnecessary?"

Your company should have a "zero-tolerance" inventory policy. That is, it will not accept any inventory over a stated target. But what is the target? Is it zero-tolerance from a days supply of inventory on-hand? Is it a zero-tolerance from a dollars invested standpoint (turns per year)? Is it zero-tolerance from an order fill rate of 97 percent?

For an organization to actually have useful inventory, it must understand its own objectives for the product it will have

on-hand, on-order, or in-transit at any one time. What inventory level is required for your organization to profitably and effectively operate?

Until the answers to these questions are determined, it will be difficult to get everyone within the organization to work toward the common, shared goal of eliminating inventory waste.

recap Organizations establish techniques for forecasting their product level needs based on the nature of the demand characteristics of those items.

Formulae for ensuring that you have the right item, in the right quantity, in the right place, at the right time can range from relatively simple min-max models to highly sophisticated computer-dependent systems.

For individuals not directly involved in purchasing, successful inventory control doesn't so much flow from actually using the various formulae, but rather from understanding what outcomes are supposed to result from their use.

? REVIEW QUESTIONS

1. Independent demand is best described as: 1. (c)

(a) erratic purchasing of inventory.

(b) one item is needed because of its relationship to another item.

(c) items are impacted by market conditions outside the control of your organization's operations, and they are therefore independent of operations.

(d) demand for items outside of their normal review cycle.

2. Just-in-time manufacturing results in: 2. (a)
   (a) right item, right quantity, right place, right time.
   (b) right item, right quantity, right place.
   (c) right item, right quantity.
   (d) larger inventory levels.

3. Independent demand calls for a(n) _____ approach to inventory management.

3. *replenishment*

4. Dependent demand calls for a(n) _____ approach to inventory management.

4. *requirements*

5. The reorder point is the 5. (c)
   (a) point in time when a product review is undertaken.
   (b) largest quantity of an item you will have on hand or on order.
   (c) lowest quantity of an item you will have on hand or on order before you reorder
   (d) lowest quantity at which you can obtain a discount from a vendor

6. The bill of materials is: 6. (b)
   (a) another name for a purchase order.
   (b) the recipe of raw materials and subassemblies that make up a finished product.
   (c) the schedule of what will be built, when, and in what quantities.
   (d) an accounts payable concept.

7. JIT systems regard inventory in excess of current production and R & D needs to be: 7. (c)

(a) safety stock.
(b) FIFO inventory.
(c) waste.
(d) part of the kanban system.

Note

1. This method of calculating the R Factor takes a straight average. It implies that every PO requires the same time and effort. Companies that calculate items using activity based costing would probably develop the R Factor using a blended average.

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CHAPTER 6

Why Inventory Systems Fail and How to Fix Them

Introduction

The objective of this chapter is to provide you with an understanding of the nature of inventory accuracy and the working tools to "fix" your inventory system. If all items are moving through a properly operating system, then it doesn't matter what the characteristics of an SKU are—expensive item, inexpensive item, fast mover, slow mover, long lead time, critical—the *shelf count* of the item (actual balance on-hand stock levels) and *record count* (how many your records say are supposed to be here) will match.

The traditional method of determining if actual balance on-hand stock levels match book/record levels is to take an annual physical inventory. As a method of correcting inventory accuracy problems, this costly and time consuming effort is riddled with deficiencies. Why? Consider the following:

• Accuracy is often defined in dollars rather than in actual physical units. As discussed in Chapter 1, the dollar value of product does not reflect exactly what items are in house. For example, imagine you sent out a thousand cases of peaches to a customer rather than the thousand cases of pears actually requested. An annual inventory would reflect an overall dollar value roughly equal to whatever it would have been even if the correct item had been shipped. Therefore, our shelf count is off a thousand over for one SKU and a thousand under for another with no discrepancy in accuracy—if accuracy is measured in dollars.

• Misidentification of product. As discussed in Chapter 3, product within a facility is misidentified for a variety of reasons. During annual inventories, misidentification often occurs because inexperienced counters assisting with the effort do not recognize items, misunderstand package descriptions, and so on.

• Misidentification of units of measure. Incorrect quantities are often written down during annual inventories because counters simply do not understand an SKU's pack size, pack size descriptions, or abbreviations on packaging.

• Discrepancies "adjusted away." Perhaps the greatest problem with using the annual inventory as a method for establishing accuracy is that it provides no method for backtracking through physical and paper transactions to determine why an item's shelf count and its record count do not agree—a twelve month time period is simply too long of an audit trail. Consequently, if the reason for a discrepancy cannot be immediately found during the inventory, an adjustment is made with the underlying cause of the error never being corrected.

At the end of an annual inventory, after all of the adjustments have been made and after the lights have been turned off,

you have an inventory shelf and record count that agree. At least they agree until the next morning when the same system that spawned the discrepancies found during the effort reasserts itself and a new group of errors is born.

Albert Einstein, the famous physicist, once said, "A problem stated is a problem half-solved." Modern business writers like Peter Drucker have expressed a similar view, "A problem analyzed is a problem half-solved." The sentiment expressed in these sayings, that reviewing the nature of inventory problems is a key step in solving them, provides you with a good starting point in resolving your own inventory-related issues. Consider the following:

Inventory System Failures—Example Case

The following paragraph events have been numbered for ease of reference.

1. Big Hammer, Inc. manufactures and distributes widgets. Manufacturing occurs at its Los Angeles, CA, plant. It distributes from two separate locations. One of these locations is in Kansas City, MO, and has been part of Big Hammer for many years. The other location is in New York, NY, and is the surviving portion of Paulex Co., a distribution company just purchased by Big Hammer.

2. Marc, Big Hammer's president, has just reviewed operating reports from all three locations and is upset. It seems that the inventory accuracy level at all three locations is off. The end result is delayed production, too much inventory, and poor customer service. In addition, various department heads in all three locations clash with one another. In order to get everything straightened out, he hires the consulting firm of Alana, Eric, and Shawn.

3. Alana goes to KC. Eric goes to NY. Shawn goes to LA.

4. The trio immediately discovers that NY is using a different software system than LA and KC. In addition, the LA/KC software was designed for distribution, not manufacturing. However, some modifications have been made to the LA/KC software to help with manufacturing applications.

5. The NY system allocates inventory on a real-time basis. In other words, as a pick ticket is generated for an item, the quantity in question is allocated to a specific order and is not available for any other customer—its paper life ceases.

6. The LA/KC system is a batch system. Items are relieved from stock at the time the system is updated. This usually occurs once per day when billing is done. A modification to the system backflushes[1] some items out of stock during the manufacturing cycle.

7. Eric wanders around the NY location and observes the following:

8. Sales people, customer service personnel, clerical staff, and others freely roam through all stockrooms. Eric notices that some nonstockroom personnel fill their own orders, grab samples for customers, and put things back into the facility that they have previously removed.

9. Eric observes that some of these individuals document their actions immediately, while others document nothing, and others turn in necessary paperwork—later.

10. Eric observes Sally, a sales person, peering intently into her computer screen. He hears her utter an oath and declare out loud, "I just saw a whole bunch of SKU #1234 out there a little while ago." She then creates a manual invoice within the software system, prints it, walks out into the stockroom, fills the order she has just created, delivers it to customer Acme Widgets of

the World, and later drops the signed delivery copy on the desk of her accounts receivables clerk.

11. Eric observes an angry exchange between the warehouse manager and the accounting manager of the NY location. They were arguing over a negative stock balance for SKU #1234.

12. Eric also observes Sally angrily telling the warehouse manager that one of her customers, Widgets, Gidgets, Gadgets and Such, was shorted 10 widgets on an order it received "just a little while ago."

13. Alana has also observed some interesting things in KC.

14. Alana has observed two different order fillers attempting to fill orders for the same item—from the same empty shelf.

15. At 5 P.M. one evening, Alana was standing behind Carmen, the company's billing clerk. Carmen's inbox contained several inches of delivery slips ready for processing. Carmen got up and began to make preparations to go home. Alana asked her what she was doing. Carmen replied, "It's 5 P.M. I'm going home."

Alana said, "But you still have a lot of work in your inbox."

"So what? I'll work on it tomorrow," Carmen indignantly responded.

"But you'll mess up the warehouse if you don't get those slips processed tonight," Alana stated.

Angrily, Carmen stated, "I work in accounting. I don't work in the warehouse."

Alana asked, "How long would it take you to do those?"

Carmen glanced at her inbox and replied, "About 30 minutes."

"Please stay and get them done," Alana cajoled.

"I can't even if I wanted to," Carmen said. "I'm not allowed any overtime."

Bill, one of Carmen's co-workers chimes in and says, "Why can't you get your work done during the day?"

Furious, Carmen turns on Bill and says, "Hey, you sort and distribute the mail every morning, run photocopies of all incoming checks while fighting with people over our one copy machine, and prepare and go out to make the daily deposit like I do; and, then let's see if you can get your stuff done."

16. Hanging around the warehouse, Alana observed that receiving was done on a manual basis; and there wasn't always a copy of a PO in the warehouse to support incoming loads.

Alana noticed on several occasions that when the receiving staff did not have all appropriate paperwork for an item, they would simply put it away or move it off to the side. Then later, or the next day, they would hunt down all of the appropriate documentation and turn everything in to the data entry people for entry into the system.

Like Eric, Alana also observed nonstockroom individuals filling their own orders.

17. Alana also observed a curious exchange between Franklin, the accounting manager, and Carmen, the billing clerk.

While attempting to create an invoice for an item, Carmen's computer screen flashed an error message indicating that she was trying to bill for something that had a zero stock balance in the system. The software would not let her bill for an item it did not reflect as being available for the subject sale.

Carmen called Franklin over. She showed him the signed delivery slip indicating that the item had, in fact, been delivered.

Franklin stated, "Those people in the warehouse can't get anything right." He then proceeded to manually override the system and entered the SKU (SKU #4567) and quantity in question (10). Franklin then directed Carmen to try again. The invoice was created without any further problems.

Mid-morning of the next day the stock records began to show that there were 10 of SKU #4567 in the facility. A telemarketing sales person sold 10 SKU #4567s that afternoon. A pick ticket was generated for the order. The order filler could not find any of SKU #4567 in the warehouse. A stock adjustment form is processed to take these ten items out of stock.

18. Alana overhears a telephone conversation between Carmen and a customer. The customer wants to return five SKU #9876s and wants to ensure that it is not charged for them. Carmen notes the information, prepares a pickup slip, and issues a credit to the customer's account.

Later that day, a salesperson sells five SKU #9876's. A pick ticket was generated for the order. The order filler could not find any of SKU #9876s in the warehouse. A stock adjustment form is processed to take these five items out of stock.

19. Meanwhile, Shawn has been talking to Ichiro, the inventory control clerk in LA. Ichiro is frustrated. He works hard at his job but can't seem to track work in process.[2] Consequently, he is never sure how much of any particular item the company has available for production purposes.

20. Shawn observes a worker disassembling a sub-assembly. He asks the worker what he is doing. The worker replies that there is a rush order they lack all of the raw materials for, so they are disassembling some less important assemblies to cannibalize the required parts.

Shawn asks if the products being disassembled are from other orders. The worker replies that they are. Shawn asks about any paperwork that was generated to support whatever it is the worker is doing. The worker replies that he doesn't know.

Discussion of Example Case

After events, note problem identification and discussion.

Event #1. Big Hammer, Inc. manufactures and distributes widgets. Manufacturing occurs at its Los Angeles, CA, plant. It distributes from two separate locations. One of these locations is in Kansas City, MO, and has been part of Big Hammer for many years. The other location is in New York, NY, and is the surviving portion of Paulex Co., a distribution company just purchased by Big Hammer.

Any organization that has several locations must clearly identify the answers to the "who, what, when, where, why, and how" questions: Who is doing what? When are they doing it? Where are they doing it? Why are they doing it? and How are they doing it? If these questions are not answered materials and information will not flow smoothly between and among the organization's separate departments. See pages 169–172.

Event #2. Marc, Big Hammer's president, has just reviewed operating reports from all three locations and is upset. It seems that the inventory accuracy level at all three locations is off. The end result is delayed production, too much inventory, and poor customer service. In addition, various department heads in all three locations clash with one another. In order to get everything straightened out, he hires the consulting firm of Alana, Eric, and Shawn.

Although consultants are helpful in most instances, by applying the concepts contained within this chapter, you should be able to resolve many system problems your organization may be currently experiencing.

Event #3. Alana goes to KC. Eric goes to NY. Shawn goes to LA.

Event #4. The trio immediately discovers that NY is using a different software system than LA and KC. In addition, the LA/KC software was designed for distribution, not manufacturing. However, some modifications have been made to the LA/KC software to help with manufacturing applications.

Trying to integrate different software systems is always difficult. Once again, any organization hoping to achieve that result must clearly lay out the timing and sequencing of the information flow within the system.

In addition, the demand patterns for items in a distribution world and those in a manufacturing environment are radically different. See the discussion of inventory types on pages 119–20. Purchasing patterns for finished goods and spare parts in a distribution are based on past usage patterns. See the discussion of independent demand inventory on pages 120–24. Purchasing patterns for the raw materials and sub-assemblies used in manufacturing are based on the master production schedule. See the discussion of dependent demand inventory on pages 128–40. Different concepts and formulae are used for each type of inventory and, therefore, software designed for one or the other or specifically written for a combination environment should be used whenever possible.

Event #5. The NY system relieves inventory on a real-time basis. In other words, as a pick ticket is generated for an item, the quantity in question is allocated to a specific order and is not available for any other customer—its paper life ceases.

The central problem often encountered in real time systems is that there is often a time lapse between the creation of a pick ticket and the actual removal of the product from the shelves.

Since the items on the pick ticket were immediately allocated[3] to that order, with their paper life ceasing (see pages 9–15), those SKUs will actually be sitting on the shelves but won't appear in the then current record count.

Somewhere in the software files is the information: total items on hand, items allocated, and items actually available for sale or use. The problem is that *not everyone in the organization has access to this information!* If (a) staff members are allowed to fill their own orders, and (b) do not understand how it is possible to check the then current stock records and see a lower number of items than are actually sitting in plain view, then (c) they will stop believing in the record count, will only believe their eyes, and will raid product allocated for other orders.

Event #6. The LA/KC system is a batch system. Items are relieved from stock at the time the system is updated. This usually occurs once per day when billing is done. A modification to the system backflushes some items out of stock during the manufacturing cycle.

The most significant issue created by batch software systems is that items are physically gone from the shelves/building but still appear in the record count until the system is updated. The longer the length of time between updates, the more out of balance the shelf count and the record count are.

Backflushing works well *if* the backflush occurs at each level of the bill of materials. See the discussion of Event 19 on pages 163–64.

Event #7. Eric wanders around the NY location and observes the following:

Event #8. Sales people, customer service personnel, clerical staff, and others freely roam through all stockrooms. Eric notices that some non-stockroom personnel fill their own orders, grab samples for cus-

tomers, and put things back into the facility that they have previously removed.

Any organization hoping to continuously have its shelf count match its record count simply must stop all unauthorized personnel from touching anything in a stockroom or warehouse. And, authorized personnel must have a paper- or computer-based document before placing anything into or removing anything from storage areas. These points cannot be overstated. They are imperative to inventory accuracy.

Event #9. Eric observes that some of these individuals document their actions immediately, while others document nothing, and others turn in necessary paperwork—later.

Documentation created after something has been placed into or removed from a facility creates all sorts of problems. For example:

a. If an item is physically removed without a document deleting it from inventory, then sales people, production schedulers, and others will believe that the item is still available for sale or use. They will then generate pick tickets for its selection. Order fillers will then waste their time looking for items that do not exist. The order fillers will generate adjustment forms leading to the items being deleted from inventory. Eventually, when the original documentation goes through the system, it causes these same items to be deleted from inventory—again. Your shelf count and record count are now almost hopelessly out of balance.

b. If an item is placed into the stockroom without accompanying paperwork, then the subject SKU is unavailable for sale or use—since no one knows its there.

Event #10. Eric observes Sally, a sales person, peering intently into her computer screen. He hears her utter an oath and declare out

loud, "I just saw a whole bunch of SKU #1234 out there a little while ago." She then creates a manual invoice within the software system, prints it, walks out into the stockroom, fills the order she has just created, delivers it to customer Acme Widgets of the World, and later drops the signed delivery copy on the desk of her accounts receivables clerk.

Event #10 is an example of someone in a real time software scenario that does not understand how it is possible to have a stock record (in the computer or hard paper copy) that reflects a stock balance lower than the actual number of items on the shelves. Recall that the discrepancy is due to the time period between the creation of a pick ticket with its allocation of product to an order and the physical removal of the SKUs from the stockroom.

Event #11. Eric observes an angry exchange between the warehouse manager and the accounting manager of the NY location. They were arguing over a negative stock balance for SKU #1234.

Since this is a real time system, when Sally created a manual pick ticket she caused the system to allocate and delete the subject SKU. If the stock balance was zero when Sally did this, her actions have caused the balance to go into a negative.

As discussed in Event #17 of this section, Sally's actions have also created the potential for a much different problem in an entirely different department of the organization. By forcing a manual invoice through the system and dropping off a delivery slip for billing, Sally has created the potential for a billing clerk to try to create an invoice for product that the system has never received into itself. Many accounting programs will not let an invoice be created for product that has never been received.

Event #12. Eric also observes Sally angrily telling the warehouse manager that one of her customers, Widgets, Gidgets, Gadgets

and Such, was shorted 10 widgets on an order it received "just a little while ago."

In Event #10 it should be obvious that the product Sally took had already been allocated to a different customer (Customer #1) than the one she was taking care of at that time (Customer #2). Sally's actions caused her to raid Customer 1's order, causing a stockout for one of her own customers—Customer 1.

Event #13. Alana has also observed some interesting things in KC.

Event #14. Alana has observed two different order fillers attempting to fill orders for the same item—from the same empty shelf.

It is common in batch systems that are only updated once per day and in which there is no way to easily check (without going to look) the availability of an item, for multiple orders to be written against the same "phantom" items. This also creates the danger of multiple adjustments adding to the overall confusion.

Event #15. At 5 P.M. one evening, Alana was standing behind Carmen, the company's billing clerk. Carmen's inbox contained several inches of delivery slips ready for processing. Carmen got up and began to make preparations to go home. Alana asked her what she was doing. Carmen replied, "It's 5 P.M., I'm going home."

Alana said, "But you still have a lot of work in your inbox."

"So what? I'll work on it tomorrow," Carmen indignantly responded.

"But you'll mess up the warehouse if you don't get those slips processed tonight," Alana stated.

Angrily, Carmen stated, "I work in accounting. I don't work in the warehouse."

Alana asked, "How long would it take you to do those?"

Carmen glanced at her inbox and replied, "About 30 minutes."

"Please stay and get them done," Alana cajoled.

"I can't even if I wanted to," Carmen said. "I'm not allowed any overtime."

Bill, one of Carmen's co-workers chimes in and says, "Why can't you get your work done during the day?"

Furious, Carmen turns on Bill and says, "Hey, you sort and distribute the mail every morning, run photocopies of all incoming checks while fighting with people over our one copy machine, and prepare and go out to make the daily deposit like I do; and, then let's see if you can get your stuff done."

A number of issues are raised by the Event #15 scenario, such as:

a. The morning following an incident like the one described will find everyone who deals with inventory—sales, accounting, production scheduling, customer service, and purchasing—making decisions on information they believe is as current as the night before when the system was updated. The reality is that the information is no more current than the last time Carmen made it to the bottom of the in-basket. If she hasn't made it to the bottom of her basket in several days, then the records and operations are really suffering.

The problem is made worse by the fact that roughly 20 percent of our inventory will represent 80 percent of our most important items. (See also pages 63–65 in Chapter 3.) Therefore, not only does our shelf count not match our record count, but they don't match regarding some of our most important items.

b. Another problem revealed by the incident is that the organization does not recognize the importance of getting all receiving and shipping into and out of the building on both a real life and paper life basis every day. This is indicated by those du-

ties assigned to Carmen that cause her not to complete her inventory related tasks on a daily basis. Although these duties are important, they should be performed by someone whose actions do not have the ripple effect that Carmen's actions have throughout the entire organization.

Event #16. Hanging around the warehouse, Alana observed that receiving was done on a manual basis; and there wasn't always a copy of a PO in the warehouse to support incoming loads.

Alana noticed on several occasions that when the receiving staff did not have all appropriate paperwork for an item, they would simply put it away or move it off to the side. Then later, or the next day, they would hunt down all of the appropriate documentation and turn everything in to the data entry people for entry into the system.

Like Eric, Alana also observed nonstockroom individuals filling their own orders.

Virtually every organization has a purchase order system. And, in virtually every organization anyone with the authority to buy something is repeatedly told to have a PO for everything. In spite of those facts, in many organizations product comes in daily without any supporting documentation. This causes confusion, inefficient receiving operations, and separates an item's real life from its paper life. (See also Chapter 1.) There should be either a hard copy or a record of the PO in the computer system available to receiving for all items that arrive at the stockroom.

When an item's real life becomes separated from its paper life, people begin to ship or use product that has not been received; to put away product that has not been received so that no one knows it is available for sale or use, creates an environment where inventory clerks and accounting personnel are making adjustment after adjustment to the record count.

Event #17. Alana also observed a curious exchange between Franklin, the accounting manager, and Carmen, the billing clerk.

While attempting to create an invoice for an item, Carmen's computer screen flashed an error message indicating that she was trying to bill for something that had a zero stock balance in the system. The software would not let her bill for an item it did not reflect as being available for the subject sale.

Carmen called Franklin over. She showed him the signed delivery slip indicating that the item had, in fact, been delivered.

Franklin stated, "Those people in the warehouse can't get anything right." He then proceeded to manually override the system and entered the SKU (SKU #4567) and quantity in question (10). Franklin then directed Carmen to try again. The invoice was created without any further problems.

Mid-morning of the next day the stock records began to show that there were 10 of SKU #4567 in the facility. A telemarketing sales person sold 10 SKU #4567s that afternoon. A pick ticket was generated for the order. The order filler could not find any of SKU #4567 in the warehouse. A stock adjustment form is processed to take these ten items out of stock.

From Event #16, it appears here that someone delivered an item that had not yet gone through the paperwork receiving cycle. Then when Carmen tried to bill for it, the software would not let her.

Instead of researching what had actually happened, Franklin overrode the system and put in a quantity of 10. Carmen's billing then deleted the 10 items.

When the receiving paperwork finally made it through the system it created a quantity of 10 items that were no longer in the building. These 10 phantom items were then sold—maybe more than once.

When the 10 items could not be found, additional paperwork had to be initiated to delete the SKUs from the system.

All of the above issues are caused, in part, by a lack of understanding on the part of various staff members of how the timing and sequencing of the system works.

Event #18. Alana overhears a telephone conversation between Carmen and a customer. The customer wants to return five SKU #9876s and wants to ensure that it is not charged for them. Carmen notes the information, prepares a pickup slip, and issues a credit to the customer's account.

Later that day, a salesperson sells five SKU #9876's. A pick ticket was generated for the order. The order filler could not find any of SKU #9876s in the warehouse. A stock adjustment form is processed to take these five items out of stock.

Although application software systems vary widely in how items are accounted for, many systems place an item back into stock (in the data base) when a credit is issued against that item. By issuing a credit, Carmen caused the software system to place the five SKUs back into stock—even though they had not yet been returned to the building.

Again, a lack of understanding regarding timing and sequencing of software and events causes terrible dysfunctions to stockroom operations.

Event #19. Meanwhile, Shawn has been talking to Ichiro, the inventory control clerk in LA. Ichiro is frustrated. He works hard at his job but can't seem to track work in process. Consequently, he is never sure how much of any particular item the company has available for production purposes.

As indicated in Event #4, a key problem Ichiro faces is that the company is using two separate methods of relieving items from stock. One method is batch, while the other is a backflush of some items. Recall that *backflushing* refers to a software technique where raw materials and other components going into a

particular sub-assembly or final product are relieved from stock when that sub-assembly/product is completed.

As indicated in the discussion of Event #6, if a batch system is not updated with some degree of frequency, it is difficult to understand what is available without actually looking. This problem can be overcome through software modules that advise the stockkeeper of those SKUs that have gone into completed orders. This report shows a running total for each SKU that has been drawn down that day. Once the system is updated, then a new report begins.

The key issue regarding backflushing is, does the backflush occur at every level of the bill of materials? See Exhibit 6–1. (A similar example is also used in Exhibit 5–4.) If the backflush only goes down one level, but no backflush occurred at that next lower level, then all materials below that level will still appear to be in stock. In reality they have been used up.

Event #20. Shawn observes a worker disassembling a sub-assembly. He asks the worker what he is doing. The worker replies that there is a rush order they lack all of the raw materials for, so they are disassembling some less important assemblies to cannibalize the required parts.

Shawn asks if the products being disassembled are from other orders. The worker replies that they are. Shawn asks about any paperwork that was generated to support whatever it is the worker is doing. The worker replies that he doesn't know.

Exhibit 6–1 Backflushing

Although perpetual computer systems backflush more than one level down on the bill of materials, for the purposes of this example, assume a backflush of only a single level down. If the backflush does not occur until Level 1 is completed, then only SKUs 0021 and 9876 are deleted from the stock record. SKUs 3435, 3436, and 3474 would still remain "in stock" even though they were consumed in producing SKU 1234.

Level 0 Stool [SKU#1234]

Level 1 Leg Assembly [SKU 0021] Seat [SKU 9876]

Backflush

Level 2 4 long rails [SKU #3435] 4 short rails [SKU #3436] 4 legs [SKU #3474]

Level 0 Stool [SKU #1234]

Level 1 Leg Assembly [SKU 0021] Seat [SKU 9876]

Backflush

Level 2 4 long rails [SKU 33435] 4 short rails [SKU #3436] 4 legs [SKU #3474]

If the backflush occurs both at Level 2 and and Level 1, then SKUs 3435, 3436, and 3474 will be deleted after the first backflush (Level 2); and, SKUs 0021 and 9876 will be taken out after Level 1 is completed. Our records would then properly reflect what actually occurred.

Metrics

"You can't control what you don't measure." Peter Drucker

Before doing *anything* toward establishing methods to discover, analyze, and fix any discrepancies between actual on-hand stock lev-

els and database record levels, you should take a snapshot of where you are *now*. There are two sets of numbers you should develop that relate to (a) inventory record accuracy (IRA) and (b) fill rate.

IRA is a reflection of how well your shelf count and record count match. In other words, do your stock records accurately reflect what is actually in the stockroom?

Fill rate is a reflection of how effective your inventory is. Did you have what you needed when you needed it?

Inventory Record Accuracy

Test Counting

A quick, accurate method of establishing your current IRA is to perform a test count:

- Select 100 SKUs that represent a cross-section of all items. In other words, select all sorts of items—fast movers, slow movers, expensive items, inexpensive items, and those with both long and short lead times to acquire.
- Count all 100 in all locations where they are located. Measure accuracy by considering actual units on the floor—not dollar value.
- Divide the number of accurate counts by the total number of counts. Accurate counts mean where the record count and the shelf count exactly match.
- Quotient is your inventory record accuracy. See Exhibit 6–2.

Tolerances

How accurate does accuracy have to be? You may think, at first, that *accurate* means that 100 percent of the time your stock records match your shelf counts. Consider, however, your feelings about counting a large container of nails.

Exhibit 6–2 Test Counting To Establish Inventory Record Accuracy

$$\frac{\text{Accurate Counts}}{\text{Total Counts}} = \text{Inventory Record Accuracy} \quad \frac{87}{100} = .87 = 87\% \text{ IRA}$$

In counting a large container of nails, would you actually count each nail individually? It is more probable that you will (a) weigh out one pound of nails, (b) count the number of nails in a pound, (c) weigh all of the nails, and (d) then compute the total number of nails by comparing the number of nails in a pound to the number of pounds of nails in the container. Will your computation capture the exact number of nails in the container? Probably not. Do you really care? Probably not. Why? Because of the nature of the SKU in question, in this case nails, is low cost, easy to acquire, and hard to count individually (if there is a large quantity of them). Therefore, you would probably be willing to accept some percentage of tolerance in your numbers. If you were within ±5 percent of a perfect match between the record count and the shelf count, would you be satisfied? Probably so. Would you be equally satisfied applying the same approach to a large container of diamonds? Of course not.

Many organizations allow a variance or tolerance in considering IRA. That is, they allow a plus-minus percentage of accuracy they find acceptable. These tolerances can be set using dollars, actual units, or some combination of the two. Most accountants use dollars. Stockkeepers should use actual units: It's either here or it isn't.

Few organizations accept a tolerance of greater than ±5 percent on any item. In other words, a 95 percent tolerance should

be the lowest variance from a 100 percent accuracy level you will accept for any item no matter what its characteristics.

If you will accept tolerances, they must be set for each item or category of item with great care. Consider the following factors:

- Dollar value: The higher the dollar value, the more accuracy you will demand.
- Usage rate: Usage rate can actually be argued in two ways:

  —The Higher-the-Usage-Rate-the-Lower-the-Tolerance-Level Argument: If you are using a large quantity of an item you will want to always know how much is available so there is never a stockout.

  —The Lower-the-Usage-Rate-Lower-the-Tolerance-Level Argument: If an item is not moving very quickly, then why should there be any discrepancy between shelf and record count? A low variance percentage for a slow moving item will alert everyone to a problem quickly as opposed to waiting for a crisis. This argument assumes that if there are stockouts on higher moving products, then the situation will alert everyone anyway.
- Lead time: The longer the lead time, the lower the tolerance level. A long lead time requires more working reserve and safety stock. See also Chapter 5.
- Level on bill of materials: The higher something is on the bill of materials, the more overall value it has. Therefore, the higher on the bill of materials an SKU is, the lower the tolerance.
- Criticality: Some items are critical for reasons other than dollar value, usage rate, or lead time. A safety equipment company may only sell a few biohazard cleanup suits

per year, but when they are needed they are needed immediately.

- Combination of the above

Example: Considering Tolerances

Read the following scenario:

Melvin, President of Megawatts, Inc., doesn't believe in allowing any tolerances in his inventory levels. His friend, Sarah, President of Bright Lights Co., does.

A cross-section of 100 items was counted in each of these companies' facilities.

The actual stock count on 87 SKUs in each facility matched the respective companies' stock records.

Bright Lights allowed a variance of ±2 percent on 5 of the 13 items that were not 100 percent accurate. The count of these 5 fell within their respective tolerances.

$$\text{Megawatts: } \frac{87}{100} = 87\% \text{ accuracy}$$

$$\text{Bright Lights: } \frac{92}{100} = 92\% \text{ accuracy}$$

Melvin argues that Sarah's higher IRA level is artificial and doesn't really reflect accuracy.

Sarah's approach does reflect an acceptable level of accuracy if the tolerances were carefully set. As in the container of nails example, if we (1) weighed a large container of nails and determined there were 14,003 nails, (2) entered that total into our

records, (3) reweighed the nails and determined there were 14,010 nails, would we change our records? Probably not. The second total would fall within an acceptable tolerance.

Impact of Tolerances on Adjustments

Once you have set tolerances, you should not make adjustments to your records when a discrepancy between shelf and record counts falls within the variance allowed. If an item does fall outside of the tolerance range, you would hunt down the reason for the discrepancy and adjust the record if necessary. See Exhibit 6–3.

Fill Rates

Although matching shelf count to record count is one way of measuring inventory, it does not indicate if you have the items you need when you need them. Simple fill rate calculations achieve that objective. The fill rate looks at the qualitative nature of your inventory efforts.

Fill Rate Formulae

Simple Fill Rate:

$$\text{Fill Rate} = \frac{\text{Items Shipped on a Given Day}}{\text{Items Ordered for Shipment on a Given Day}} \quad \frac{\text{417 Items Shipped}}{\text{447 Items Ordered}} = 0.93 = 93\% \text{ Fill Rate}$$

The above indicates that you had 93 percent of the items you needed on the day they were required.

The fill rate can reflect the availability of a single item or a grouping of items.

Exhibit 6–3 Tolerances and Adjustments

Assume that a count was made of ten SKUs, with the results being as follows:

SKU #	RECORD COUNT	ACTUAL COUNT	% DEVIATION	% TOLERANCE ±	HIT/MISS
1	1,200	1,128	–6%	2%	M
2	2,217	2,106	–5%	5%	H
3	317	304	–4%	5%	H
4	8,947	8,679	–3%	2%	M
5	100	98	–2%	5%	H
6	567	561	–1%	2%	H
7	100	100	0%	0%	H
8	1,367	1,381	+1%	0%	M
9	1,432	1,461	+2%	2%	H
10	185	191	+3%	5%	H

SKUs 1, 4, and 8 fell outside of their tolerances. For example, if the count for SKU 1 would have fallen within the range of 1,176 to 1,224, a ±2 percent of the record count, then it would have been a hit. It was not. Therefore, you would research why the discrepancies exist and adjust your records if necessary.

All of the other SKUs fell within their tolerances. However, only SKU 7 was exactly correct. You would still not make any adjustments to any SKUs where there was a hit. The variance percentages you set should allow you a comfortable range in which you can tolerate some up or down differences. Often pluses and minuses cancel one another out over time.

Stockouts Per Year:

$$\text{Stockout \%} = \frac{\text{Number of Days Where all Orders Were Not Shipped Complete}}{\text{Total Number of Shipping Days During the Year}} \quad \frac{34}{200[4]} = 0.17 = 17\%$$

This indicates that you were unable to send all orders out complete 17 percent of the time. Stated more positively, you were able to send orders out complete 83 percent of the time.

Tools with Which to Uncover System Dysfunctions

To solve problems you need to engage in:

- Fact finding—what is happening now?
- Problem finding—what is wrong with what is going on?
- Solution finding—how can we fix what is wrong?

So far this chapter has focused on (a) beginning to analyze inventory problems in an intellectual, intuitive, "gut feel" manner, and (b) developing some measurements with which to understand your current level of inventory accuracy and availability. This is part of fact finding.

Another way of determining what is actually happening at your facility is to create a number of charts.

Charts, by their very nature, allow you to analyze things. However, you need to guard against "paralysis by analysis." If

everything is equally important, then nothing is important. In other words, you should only chart things that are really important to controlling inventory items, trends, operational undertakings, and so on.

Run Charts

Run charts allow you to measure a variable that changes over time.

A run chart is an x–y axis chart with the unit of measure appearing on the vertical y-axis, and the timeframe running along the horizontal x-axis. The unit of measure can be anything you wish to track such as stockouts, errors, labor hours, pieces, pounds, or gallons. The timeframe can also be whatever you desire it to be such as seconds, minutes, hours, days, weeks, months, or years. See Exhibit 6–4.

Flow Charts

Flow charts allow you to analyze the sequence of a set of events. A flow chart does not necessarily show the interdependence of events or which events are going on at the same time as others.

Flow charts are easier to understand than written procedures.

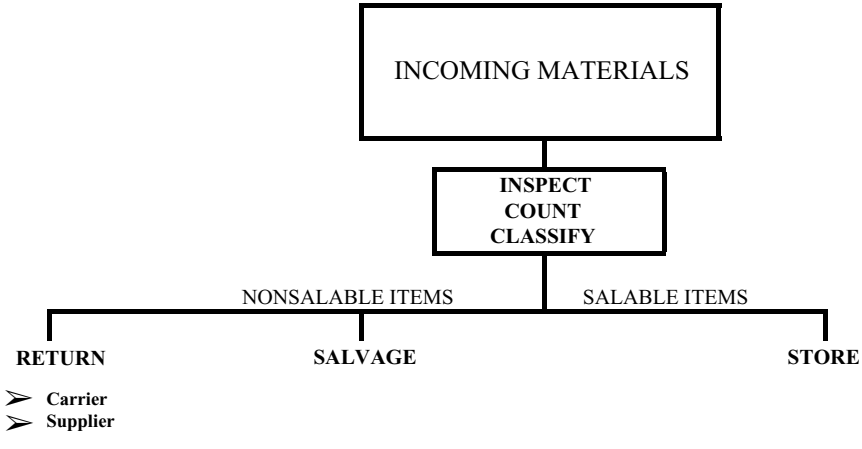
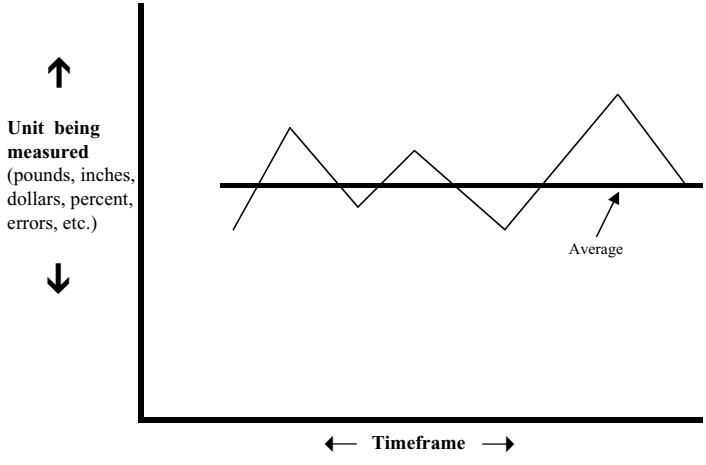
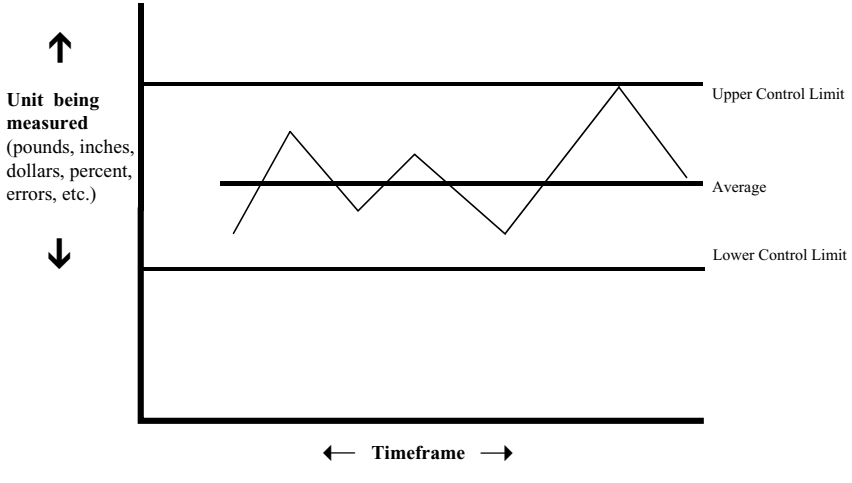


Exhibit 6–4 Run Charts

The first chart shows trend analysis.



The second chart indicates that you can set an upper and lower control limit on the chart that will alert you to a pending crisis before it occurs.

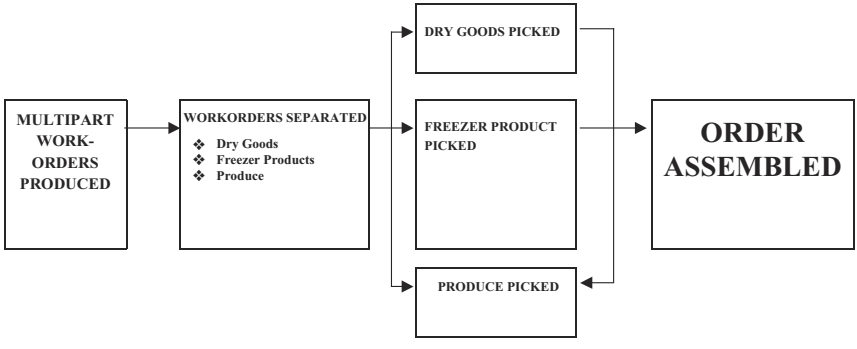


Caution:

- You do not have to use traditional flow chart symbols. Be consistent however, with the symbols you do use or you will confuse yourself and others. Provide a key to symbols.
- Have version control. If flow charts are not revised as procedures change, they are worthless.

Logic Charts

Logic charts are flow charts that show the interrelationships of events.



Variance Reports

Variance reports compare an expectation with what actually occurred.

Variance reports can be based on any factor necessary for tracking an expectation. Some factors are dollars, labor, consumption rates, lines/pieces per hour, or trucks per day.

VARIANCE REPORT

			VARIANCE	
DESCRIPTION	PROJECTED	ACTUAL	AMOUNT	PERCENT
TOTAL				

Cycle Counting

After becoming familiar with your system through utilization of the techniques described in this chapter, you should be ready to systematically approach "fixing" whatever might be causing discrepancies between your shelf and record counts.

The most systematic method of solving inventory problems and enjoying a consistently high IRA is cycle counting. Cycle counting is simply counting a statistically significant cross-section of your inventory frequently.[5]

This continuous counting leads to the discovery of discrepancies soon after they arise. By catching an error quickly, you can backtrack through both the paperwork and the stock movement of the item(s) to determine why that SKU's paper life became separated from its real life. Once the cause of the error is identified, it can be eliminated.

Since this is a continuous process, as one cause of error after another is eliminated the system begins to operate more and more smoothly. Eventually all items move through a series of procedures that work.

Cycle counting is different than an annual inventory in several ways:

Annual Inventories

- Objectives

  —The objective of the annual physical inventory is to produce a financial valuation of the inventory on a given day.

  —Every item must be counted as part of the annual inventory.

  —The 12-month long audit trail of the annual physical is too long for any serious effort made at uncovering why

an error occurred or even when—did it happen yesterday, last month, ten months ago?

Cycle Counting

- Objectives:

  —Discover discrepancies soon after they occur

  —Identify causes of errors

  —Correct conditions causing errors

  —Continuous process improvement

  —Minimum of 95 percent accuracy on ALL items

  —Correct statement of inventory assets

  —Eliminate annual inventory. Most accounting firms will allow an organization to stop taking annual physical inventories once the company has established a mature cycle counting program. Generally, a company will cycle count for at least twelve months. Then, an annual physical inventory is taken and the numbers from the annual are compared with the cycle count figures. If they match, then in the future the accounting firm will merely test count once per year for valuation purposes.
- Not every item in the building has to be counted as part of a cycle count, only a statistically significant cross-section of all items.

Cycle Count Methodologies

There are a number of cycle count methodologies.

- Control Group
- Location Audit

- Random Selection
- Diminishing Population
- Product Categories
- A-B-C Categorization

A key point to remember is that no matter what cycle count methodology you eventually choose to follow, when you first begin and your inventory record accuracy is low, you *will not* count a large number of items per day. This is because it will take time to recount, review paperwork, talk to people, and do all of the other things necessary to determine why an item's record count and shelf count do not match. Why count fifty items a day if you can only count and reconcile ten of them? As your record accuracy increases, and more and more items match their record counts, you can comfortably count more items each day.

Any cycle count methodology will assist you in achieving high levels of IRA. However, not every method works in every company setting. For example:

Assumptions:

- You wish to cycle count each item 4 times per year
- Cycle count 200 days per year (4 days/wk x 50 wks = 200 count days)
- 10,000 SKUs
- 3 cycle counters working 7 hours per day
- Company A has 10,000 items that are unitized and in single locations within the stockroom
- It takes Company A an average of 2 minutes to count an item
- Company B has 10,000 items that are not unitized, would

have to be counted in "onesy-twosy," and each item is found in multiple locations throughout the facility

- It takes Company B an average of 5 minutes to count an item

Company A	Company B
10,000 SKUs x 4 counts/yr = 40,000 counts	10,000 SKUs x 4 counts/yr = 40,000 counts
40,000 counts ÷ 200 days = 200 counts/day	40,000 counts ÷ 200 days = 200 counts/day
200 counts/day x 2 minutes = 400 minutes	200 counts/day x 5 minutes = 1,000 minutes
400 minutes ÷ 60 minutes = 7 hours/day	1,000 minutes ÷ 60 minutes = 17 hours/day
7 hrs/day ÷ 3 counters = 2.33 hours/day each	17 hrs/day ÷ 3 counters = 6 hrs/day each

Treating all items equally and counting them four times per year may work for Company A; however, it seems like an unreasonable burden for Company B.[6]

You should select a method that fits your own organization's resources and inventory types.

Control Group Cycle Counting Method

No matter which method you eventually decide to use, always start with a small scale counting test run. By using a control group approach you will be able to:

1. Immediately identify significant system problems such as unrestricted access to the stockroom, major timing problems

related to when product is moved, and when records of the move are updated.

2. Develop an understanding of the who, what, when, where, why, and how of the way your system actually works.

3. When you first begin cycle counting you will probably make adjustments only to find that you made a mistake. It is much simpler to correct errors related to only a few SKUs rather than hundreds of them.

Control Group Procedure

- Select 100 items as a control group. **IMPORTANT:** The SKUs selected must be a true cross-section of the entire population of items they represent such as some expensive items, some inexpensive, some fast movers, some slow, or some with a long lead time, etc.
- Count only ten items per day. Use a Control Group Count Tracking Sheet. See Exhibit 6–5.
- Count for 100 days.
- Stats: 10 x 100 = 1,000 counts
- "Cycle" is 10 days
- Each item counted 10 times during test

Because you have tracked the same items over and over again, at the conclusion of your control group cycle count you should be able to eliminate major systems problems and have a good understanding of how your overall inventory system is working.

The control group approach should only be used as a starting point and not as an ongoing cycle count method. The reason for this is that the control group is not statistically large enough to actually represent your entire inventory.

Exhibit 6–5 Control Group Count Tracking Sheet

	SKU #	DESCRIPTION	1	2	3	4	5	6	7	8	9	10
1	BD79	Widget	✓	✓								
2	QD455	Gidget	✓	✓								
3	XD110	Gadget	✓	✓								
4	PD418	Thig-a-ma-jig	✓	✓								
5	AC123	Doohickey	✓	✓								
6	ZG23	Receiver	✓	✓								
97	HG786	Receiver Mount	✓									
98	LK951	Miniplexer	✓									
99	LK236	Multiplexer	✓									
100	DK47	Radome	✓									

Now you are ready to select a cycle count method that bests suits your own organization's needs.

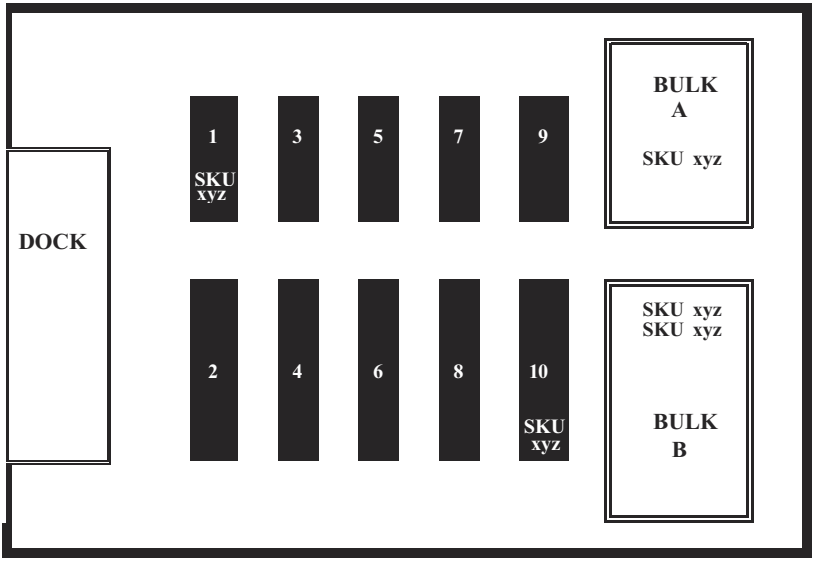
Location Audit Cycle Counting Method

In this approach you divide the stockroom(s) up in some logical method—rooms, racks, bins, and so on. See Exhibit 6-6. Then on each counting day you count the SKUs found in those areas.

All items are treated equally. In other words, selection of those items included on that day's count is based solely on the item being located in the area counted. No other characteristics such as cost, usage rate, and so on are considered.

The length of the cycle depends on how many areas are to be counted. For example, if you were counting by rack, one rack per day, and there were 45 racks, then the entire cycle would be 45 days. You would then start over again.

Exhibit 6–6 Example of Dividing a Stock into Geographic Areas for a Location Audit Cycle Count



The location audit approach has two significant benefits:

1. This approach does not require detailed recordkeeping of whether or not you have counted a specific item or the exact number of times you have counted it. It is administratively simple to follow.

2. This approach serves as a double audit because you are checking the quantity of an item at the same time that you are checking to make sure it is in the right location in your facility. Product that has been misplaced can be "discovered" sooner than the annual inventory through the use of this method.

Two separate approaches are possible regarding how much of any selected SKU gets counted:

1. Only count the SKU in the location being cycle counted that day.

Example: Count only the quantity of SKU xyz in Rack 1. (See Exhibit 6–6) Item xyz located in Rack 10 and in both bulk storage areas ignored.

This first approach requires a higher level of sophistication within your own inventory control system. Your system must allow you to identify not only how much of an item you have, but also each location it is located in and how much of it is in each location. See also Chapter 3, Physical Location and Control of Inventory.

This first approach forces you to keep your shelf count and record count accurate on an ongoing basis.

2. Count the selected SKU in all locations where it may be located throughout the facility.

Example: Quantities of SKU xyz counted in Racks 1 and 10 and in both bulk areas.

With either locational audit approach, the warehouse will be counted wall-to-wall during the cycle. However, this does not mean that *all* items in the stockroom during that cycle will actually be counted.

Not all items in the stockroom during the cycle will be counted because items will arrive into and leave from areas already counted or to be counted during the cycle. In other words, SKUs will be coming in behind you and moving away from in front of you as you go through the count.

Does it matter if every item in the stockroom is counted during a location audit cycle? It does not matter that all items are not counted during any particular cycle because of the large

number of items that are counted during that cycle. Remember that in cycle counting you are interested in looking at the *system* not individual SKUs within the system. Whether or not a SKU's shelf and record counts match is merely a way of determining if the system is actually working. Therefore, as long as you count a statistically significant number of the total items in the stockroom, you will accomplish the cycle count objective.

Random Selection Cycle Counting Method

This is probably the easiest form of cycle counting. The items selected for counting are totally random. However, the SKUs selected must be a true cross-section of the entire population of items they represent: some expensive items, some inexpensive, some fast movers, some slow movers, some with a long lead time.

The cycle is generally one year with a statistically significant number of SKUs being counted during that time frame. For example,

- 10,000 total SKUs
- 200 counting days
- Therefore, 50 items/day counted (10,000 ÷ 200 = 50)
- 10,000 total counts during the year—a statistically significant number!

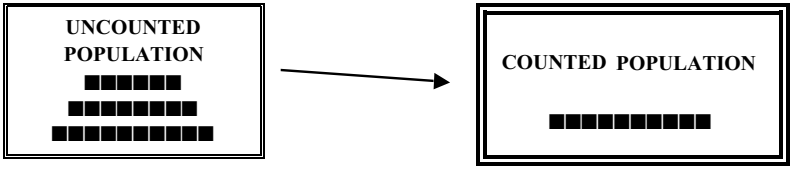
All items are treated equally. Product characteristics like dollar value and usage rate are ignored.

Diminishing Population Cycle Counting Method

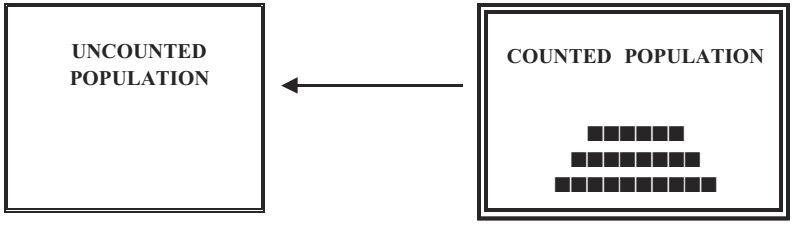
This is a versatile approach. It can be used as a stand-alone procedure or used as part of the product category approach or the A-B-C approach, which are both explained later in this chapter.

The basic concept is to:

1. Count each item in a defined population before counting any item over again.



2. Then you begin the count all over again



The diminishing population technique ensures all items in the population are counted at least once per cycle.

The number of times the total population is counted during a year depends on the size of the total number of items there are and how many days you are willing to count. See Exhibit 6–7.

The larger the number of items counted per day the more cycles can be completed during the year.

Product Categories Cycle Counting Method

To this point in our cycle count discussion we have ignored an item's characteristics. In the product categories approach, the organization decides on what categories it wishes to place SKUs into based on some characteristics, such as by manufacturer or by type of use (the "criteria").

Exhibit 6–7 Diminishing Population Cycle Counting

EXAMPLE:	EXAMPLE:	EXAMPLE:
• 900 total SKUs	• 900 total SKUs	• 900 total SKUs
• 200 counting days in cycle	• 100 counting days in cycle	• 50 counting days in cycle
• 900 ÷ 200 = 4.5 > 5 items/day	• 2 cycles per year	• 4 cycles per year
• 1,000 total counts/yr	• 900 ÷ 100 = 9 items/day	• 900 ÷ 50 = 18 items/day
	• 1,800 total counts/yr	• 3,600 total counts/yr

Items matching the criteria are counted either on the basis of:

(a) a single event, e.g., only items whose balance-on-hand equals zero, or

(b) using the diminishing population technique for each separate category: all of the widgets this week, all of the gadgets next week, all of the gidgets the week after, and so on.

The number of items to be counted can vary or be set by the number of items in the group divided by the number of days in the cycle. See Exhibit 6–7.

Cycle can be a single day or a defined number of times per year.

Single Criteria

You should be careful of using single event characteristics in defining categories. For example:

Criteria: Only cycle count items on that day's purchase orders.

Benefits:

1. Ensures that correct quantity is being ordered.

2. Allows for count when stock level at a low point. Makes it easier to count.

Problems:

a. Only the fastest moving items receive attention. Expensive but slower use items might be ignored until there is a crisis.

b. A true cross section of all types of SKUs won't be represented until a large part of the year will have past and when POs for most items will have been written and released.

c. Ignores completely items that are not ordered during a given year such as where the quantity on hand exceeds your use for that entire year.

Criteria: Only cycle count items at zero or negative balance

Benefits:

1. Negative balances should always trigger a count

2. Items at zero should be easy to verify.

Problems:

a. Neither of these is statistically significant and both fail to represent a cross-section of all items.

Using the Diminishing Population Technique with Product Categories

- Define the criteria by which each SKU will be placed into a category.

- Decide sequence in which categories will be counted: all manufacturer X's products this week, all of manufacturer Y's products next week.
- Divide the number of SKUs in the category by the number of days to determine how many must be counted per day. See Exhibit 6–7.
- Move to the next category.

The product categories method of cycle counting involves a great deal of administration but provides you with more detailed information and audit trails as to what you have actually done during a cycle count.

A-B-C Analysis Cycle Counting Method

The most sophisticated method of cycle counting, and the one preferred by most accountants, is to break your inventory up into A-B-C classifications. Items **are not** treated equally. Based on classification, the A items will be counted more frequently than the B items, and the B items will be counted more frequently than the C.

The classifications are based on "Pareto's Law"—the 80–20 Rule. See Chapter 3, pages 66–75 for a discussion of Pareto's Law and of how to determine which SKUs go into which categories.

For cycle counting purposes, classifications are determined by "value." Value could be based on money, usage rate, or a combination of the two.

Step-By-Step Implementation of the A-B-C Cycle Count Method

- Perform Pareto analysis of SKUs utilizing desired criteria. See Chapter 3.
- Assign SKUs into A-B-C categories

- Decide count frequency of each category. See Determining A-B-C Count Frequency below.
- Multiply respective number of SKUs per category by desired frequency to establish total counts. Cycle is assumed to be one year. See Exhibit 6–8.
- Divide total counts by the number of count days, (for example, 200 days per year,) to determine number of items to be counted each day. See Exhibit 6–8.
- Ask yourself, Is this a reasonable number of daily items? If "Yes," proceed. If "No," then change the frequencies and recalculate until a reasonable daily total is established.
- Determine how many items from each category will be counted each day: (See Exhibit 6–9)

  —Divide the number of annual counts within each category by the total (annual) number of counts. This establishes the percentage of counts represented by the respective categories when compared to the total counts.

  —Multiply the A, B, and C percent of total by the number of items to be counted daily. This establishes the quantity of each category to be counted each day.
- Count each category the desired number of times using the diminishing population technique.

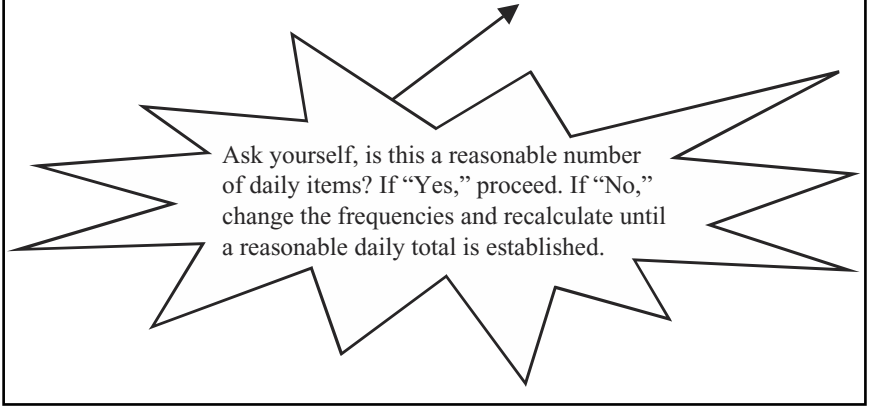
Determining A-B-C Count Frequency

Determine count frequency by:

- Decide count frequency of each category. You can count the respective categories the number of times you desire. There is no rule-of-thumb. You may want to count "A"

Exhibit 6–8 Determining Count Frequency and Number of Items To Count Per Day

Class	No. of Items	Count Frequency	Total Counts
A	275	x 12	3,300
B	525	x 4	2,100
C	1,700	x 2	3,400
		Total Counts for the year	8,800
		Count Days ÷	200
		Items to count per day	44



items 12 times per year, "B" items 4 times per year, and "C" items 2 times per year. See Appendix A.

- Multiply the respective number of SKUs per category by the desired frequency to establish total counts. Cycle is assumed to be one year.
- Divide the total counts by the number of count days, (for example, 200 days per year) to determine the number of items to be counted each day.

Exhibit 6–9 Determining How Many Items from Each Category Will Be Counted Each Day

Number of counts per year taken from Exhibit 6–8.

Category	Annual Counts		Total Annual Counts		Percent of All Counts
A	3,300	÷	8,800	=	.375 > 38%
B	2,100	÷	8,800	=	.238 > 24%
C	3,400	÷	8,800	=	.386 > 39%

Category	Total Daily Counts		Percent of All Counts		Number of SKUs To Be Counted Daily
A	3,300	x	38%	=	16.72 > 17 A SKUs per day
B	2,100	x	24%	=	10.56 > 11 B SKUs per day
C	3,400	x	39%	=	17 C SKUs per day

Count each category the desired number of times using the diminishing population technique.

Determine How Many Items from Each Category Will Be Counted Each Day

- Divide the number of annual counts within each category by the total (annual) number of counts. This establishes the percentage of counts represented by the

respective categories when compared to the total counts. See Exhibit 6–9.

- Multiply the A, B, and C percent of total by the number of items to be counted daily. This establishes the quantity of each category to be counted each day. See Exhibit 6–9.

When To Count

The ideal time during the day to cycle count would be when there is no movement of paper or product. You may, therefore, want to count:

- at end of business day
- prior to start of day
- over the weekend
- during slowest shift

Another alternative is to creating a cycle counting cut-off during a regular business day by using time-of-day.

To use this approach you would:

1. Create a list of items to be cycle counted the next day.

2. Distribute the list to Shipping, Receiving, the stock put-away workers, order fillers, and data entry clerks.

3. Have Receiving, Shipping, the stock put-away workers, order fillers, and data entry clerks all note the time of day they interacted and actually dealt with any of the items on your list.

4. You now have the ability to audit back into any time frame during the day. For example:

- You cycle count widgets at 1:00 P.M. using a stock status report generated by data entry at 11:30 A.M.

- You find that there are 10 less widgets on the shelves than the stock status shows.
- You review all of the paper work from these different departments.
- The receiving paperwork shows that 10 widgets were received at 10:30 A.M.
- There is no paperwork from the stock put-away workers indicating that the widgets were ever moved into stock.
- The missing widgets are sitting out in the dock area. Your record count matches what you have in house.

Who Should Count

If there are 4 hours of counting involved in cycle counting all items on any given day, should you have a single person count for four hours and then begin any necessary reconciliations—or—does it make more sense to have 4 people count for one hour each and then let the inventory control clerk have the rest of the day to correct any problems? It makes sense to spread the raw counting portion of the cycle count among a group of people. This will allow the inventory control clerk to devote more hours of each day to actually fixing the system as opposed to spending each day counting boxes.

recap

The objective of this chapter was to provide you with insights as to why many inventory control systems fail.

Often failure is due to individuals in different departments simply not understanding the unintended consequences of their own actions.

A review of who is supposed to write something down, what they are supposed to write down, who they are to give the information to, what that person is supposed to do with the information, and the sequencing and overall timing of these events often reveals that respective departments are using different units of measure to define inventory. Some use dollars, while others use actual physical units. In addition, seemingly simple issues like the timing of when an item is entered into the computer system or who is allowed to actually see various items of information can cause severe misunderstandings and inventory inaccuracies.

In analyzing "what is going on," metrics should be used, with the old management phrase, "you can't control what you don't measure," being a constant guiding principle.

By documenting the who, what, when, where, why, and how of how the system is actually working you can demonstrate to yourself and others where changes might be necessary.

? REVIEW QUESTIONS

1. Cycle counting is: 1. (a)

(a) counting a statistically significant cross-section of your inventory frequently.

(b) counting everything in your facility at least twice per calendar or fiscal year.

(c) determining a fair valuation of your inventory value at least once per fiscal year.

(d) counting all of the bicycle parts in your facility.

2. Flow charts allow you to: 2. (a)

(a) analyze the sequential sequence of a set of events.

(b) determine trends.

(c) compare a projected value against an actual one.

(d) create a report that identifies the number of items per level and number of tiers of product on a flow-through rack.

3. Run charts allow you to: 3. (b)

(a) analyze the sequential sequence of a set of events.

(b) determine trends.

(c) compare a projected value against an actual one.

(d) create a report that identifies the number of items per level and number of tiers of product on a flow-through rack.

4. True or False 4. (b)

The diminishing population method of cycle counting involves counting items when that SKU'S stock level reaches zero.

(a) True

(b) False

5. Fill rates indicate: 5. (c)

(a) how much of a particular SKU you have in stock at the end of a calendar month.

(b) the quantitative nature of your inventory.

(c) if you had what you needed when you needed it.

(d) the ratio of accurate shelf counts to record counts.

Notes

1. *Backflushing* refers to a software technique where raw materials and other components going into a particular sub-assembly or final product are relieved from stock when that sub-assembly/product is completed. If there were a seat and a leg assembly that goes into making up a stool, then upon completion of the stool these items would be deleted from inventory.

Until the backflush occurs the respective parts, sub-assemblies, and so on remain in the record count. Contrast this to having each item relieved from stock as it is removed from the shelf for production purposes. Backflushing reduces the time and effort involved in tracking individual inventory transactions.

2. *Work in process* is used to describe raw materials, parts, and sub-assemblies as they are being used to produce the next higher level component or finished item in a bill of materials (the recipe of materials going into an assembly of some type).

3. *Allocation* refers to an item being tied to a specific order. "Relieving" an item refers to it actually being removed from stock in terms of both its paper life and its real life.

4. Based on four days per week, fifty weeks per year.

5. It is a rule-of-thumb that cycle counting should be done four days per week, fifty weeks per year, 200 days per year.

6. Issues like who will count, when should they count, how many people should count, and so on will be covered as part of the cycle count discussion.

CHAPTER 7

Protecting Inventory

Introduction

The objective of this chapter is to provide you with a basic understanding of how to approach emergency/disaster and business continuation planning for the storekeeping portion of your operation. You must decide what an "emergency" is for your organization. An event that would be viewed as an irritant by one company, for example, a 48-hour power outage, might be a disaster to a different organization.

What would the department managers, supervisors, and team leaders of your organization actually do within the first thirty minutes of any of the following emergencies?

- Area wide power outage
- Significant workplace violence incident
- Major theft incident
- Earthquake
- Tornado
- Major fire within your space

What *would* everyone do? What incremental steps, policies, procedures, and internal training presently exist within your organization to prevent or mitigate these types of major disruptions?

Many organizations aren't sure what the answer would be. In fact, many companies are not fully prepared to react to a *natural*, *technological* or *incited* emergency. Consider these recent Federal Emergency Management Agency statistics:

- Most businesses do not have an emergency or recovery plan.
- Forty-seven percent of businesses that experience fire or major theft go out of business within two years.
- Forty-four percent of companies that lose records in a disaster never resume business.
- Ninety-three percent of companies that experience a significant data loss are out of business within five years.
- Most businesses spend less than three percent of their total budget on business recovery planning.

Organizations that do have some form of plan unfortunately only concentrate on protecting data files with no consideration being given to other aspects of the business. A disaster plan is more than having daily data file backups taken offsite. Offsite data doesn't do much good if there is no recovery site from which to operate and no equipment or application software to run it on.

Another example of the broad range of topic areas you must consider when assessing the impact of a crisis is: Assume that other than serial number and descriptive information contained in its data files, your company has no offsite records related to powered industrial trucks or other equipment used in

your stock keeping operations. There is an area wide disaster, a tornado, and your building and its contents are lost. Your insurance carrier states that it cannot process a claim on the equipment unless you can provide not only descriptions and serial numbers of lost equipment but also copies of the relevant purchase orders. It's simply too late to think about critical records retention after a tornado has destroyed the building.

Legal Duties

Under the Uniform Commercial Code, as well as the common law (effective in all states except Louisiana), if you are storing goods for a third party the degree of care you must show toward the items is that of a reasonably prudent owner. In other words, how would you care for the items if you owned them? Basically, then, if you don't take reasonable precautions to protect items, your organization becomes legally liable for their loss.

If you are storing items for your own organization, you must legally act in the best interests of the company's shareholders. Once again the question will be: Did you act in a reasonable manner?

Emergency planning helps you fulfil your legal obligations of care.

The Plan

There are three sections that make up an emergency/disaster and business continuation plan (the Plan): **preparation**—including steps toward disaster avoidance and mitigation; **execution**—including handling the crisis as it unfolds; and **recovery**—initiating business continuation.

Preparation

The first step toward protecting the product is assessing your vulnerability to *natural*, *technological*, or *incited* emergencies.

Natural Emergencies

- Earthquakes
- Coastal Erosion
- Tornadoes
- Droughts
- Hailstorms
- Extreme Heat
- Severe Winter Storms
- Volcanoes
- Tsunamis
- Hurricanes
- Storm Surges
- Wildfires
- Landslides
- Windstorms
- Freezing
- Severe Thunder and Lightning
- Flooding
- Hailstorms

A good deal of information regarding specific measures to prepare for specific natural disasters may be obtained from the Federal Emergency Management Agency (FEMA).

Technological Emergencies

- Power Outage
- Power Surge or Spike
- Hardware Error
- Software Error
- Software Virus
- Loss of Natural Gas
- Loss of Water
- Loss of Hydraulics
- Loss of Elevators
- Loss of Communications Equipment
- Loss of Compressed Air
- Loss of Municipal and Internal Sewage Systems
- Loss of Waste Water Treatment Services
- Fire Alarms
- Security Alarms
- HVAC Systems (Heating, Ventilating, and Air Conditioning Systems)
- Manufacturing Equipment Failure

Incited Emergencies

- Workplace Violence
- Arson
- Internal Theft
- Mass Theft
- Bomb Threat
- Sabotage
- Area-wide Terrorism Incident
- Labor Stoppage (strike)

Planning Team

Although the objective of this chapter is to focus on that portion of the organization charged with protecting inventory, any planning team formed to assess vulnerabilities should include individuals from several departments. Contingency planning is a business issue and not just an inventory or information technology or accounting issue. Each department is dependent on the others: operations supports sales, the computer department supports many functions, the facility manager supports the computer department, and so forth.

A multi-functional contingency planning team allows:

- a comprehensive understanding of the total company effort required;
- broad-based commitment to the effort;
- a definition of recovery requirements from the perspective of the business units being impacted;
- a definition of each department's "pain threshold." One department may be devastated by a 24-hour event, while another department may only be inconvenienced; and,
- for a plan comprehensible to each impacted group.

The Assessment

The team should assess each type of risk—natural, technological, and incited—and determine the probability of each event occurring and its potential impact on each department if it did happen.

Potential threats should be broken down into two groupings:

1. Threats likely to occur within the facility
2. Threats likely to occur in the surrounding area

Probability should be based on such factors as:

- **Historical**—What types of emergencies have occurred at this facility, this community, this region?
- **Geographical**—Is the facility close to a flood plain; seismic faults; dams; controversial organizations such as research institutions or abortion clinics; or nuclear power plants?
- **Technological**—What could result from a process or systems failure caused by fire, explosion, release of toxic fumes, loss of communications, or power failure?
- **Human Error**—What could result from poor training, poor maintenance, poor safety practices, misconduct, substance abuse, or fatigue?
- **Physical**—What is the building made of? What and how much is stored in the facility?
- **Regulatory**—What emergencies or hazards (such as hazardous material spills) are you regulated to deal with?

Exhibit 7–1 Self-Assessment Worksheet

Business component or function _____

Assessment prepared by: _____ Date: _____

1. List all business processes performed by this business unit.
   a. Check ☑ processes required to maintain business functions.
   b. Rank, as follows:

C for Critical	This ranking denotes operations we cannot do without or a function that is vital to the operation and/or poses the risk of serious injury or death (life safety risk).
E for Essential	This ranking denotes operations that are difficult to operate without, but the organization could function for a period of time without them.
NE for Nonessential	Disruption would be an inconvenience.

   c. Prioritize as to maximum allowable recovery or down time, as follows:

Imm for Immediate	0 to 24 hours
Del for delayed	24 hours to 7 days
Def for deferred	Beyond 7 days

   d. Categorize as to vulnerability, as follows:

H for Highly Vulnerable	Business functions with a great risk of experiencing a threat or hazard
V for Vulnerable	May experience a threat or hazard
NV for Not Vulnerable	Threat or hazard not likely to occur

Business Process	**Required to maintain business function ☑**	**Ranking C, E, or NE**	**Priority Imm, Del, or Def**	**Vulnerability H, V, or NV**

Cont. on page 204

Cont. from page 203

2. Prioritize all critical processes.
   a. List plans for process recovery.
   b. List resources required to maintain the business function.

Priority	Critical Processes	Recovery Plan(s)	Required Resources
1			
2			
3			
4			

3. List duties and tasks needed to recover the critical process.
   a. If an alternate site is required
      (1) List needed resources.
      (2) Explain what must be accomplished at that location.
         A. _____
         B. _____
         C. _____

4. Where will recovery resources be obtained?
   a. List resources from within business unit.
   b. List resources from other business units.
   c. List resources required from contractors, vendors, or other outside sources.
         A. _____
         B. _____
         C. _____

5. Identification of persons responsible for the above recovery process:

Employee	Home Phone	Work Phone	Pager

6. Identify customers, suppliers, and other operations affected by the disruption.
         A. _____
         B. _____
         C. _____

Break down your assessment of impact in the following areas:

- **Human Impact**—death or injury
- **Property Impact**—cost to replace, cost of temporary arrangements, cost to repair
- **Business Impact**—interruption, loss of customers, employees unable to report to work, violations of contractual arrangements, fines and penalties.

Whenever possible, the team should be assisted in its efforts through the use of worksheets, checklists, and other job aids. An example of an assessment worksheet is contained in Exhibit 7–1.

The assessment should allow you to (a) develop plans for preventing or mitigating the threat, (b) assign duties to be carried out during and immediately after an emergency, and (c) plan for business continuity.

Theft

A particular danger of inventory loss comes from theft. All too often a stockkeeper almost invites the problem. Consider the situations in Exhibits 7–2 and 7–3.

Types of Theft Threats

Generally stockroom or warehouse thefts fall into the categories of mass theft and pilferage.

Mass theft would involve a major break-in and removal of significant amounts of product or the hijacking of a truck or trailer. Pilferage covers a wide range of activities from the removal of small amounts of merchandise on a continuous basis

resulting in significant losses to collusion between employees or between employees and shippers or customers involving either shipping or receiving.

Assessing the Threat

Just as you did in preparing to counter a natural or technological emergency, to prevent or mitigate a theft you must first assess the probability of a loss occurring and its expected impact if it did happen. To accomplish this, do a crime pattern analysis:

1. Write down each activity engaged in as part of your direct stockkeeping operation. For example:

Receiving Activities

- Check-in loads against bills-of-lading, purchase orders, or packing slips
  - —Inspect goods
  - —Count items
  - —Check count against paperwork
  - —If items are damaged
    - Stop unpacking
    - Alert driver
    - Make appropriate notations on paperwork
    - Photograph
    - Notify shipper's claims department
    - Refuse load or isolate damaged product for inspection by shipper's representatives

2. Write down the sequential steps involved in each activity.
3. Review the physical layout of your facility.

4. Using the information gained through steps 1 through 3, apply the following crime pattern analysis:

- *Type of crime*—What type of crime could occur during any of the activities or sequential steps you listed? What type of crime could occur because of your physical layout?
- *Attack methods*—Given the type of crime identified, what methods would an attacker use to "pull it off"?
- *Times of Attack*—Given the type of crime identified and attack methods likely to be used, what time periods (seasons of the year, particular days of the week, particular hours of the day) seem the most logical for the attack to occur?
- *Suspect Characteristics*—Who is most likely to engage in the particular crime you have identified? Is a worker acting alone the danger? Are two workers acting in concert the danger?
- *Typical Types and Amounts of Loss or Injuries Suffered*—The amount of money, time, and effort you will use to deter one type of loss will certainly be different from the resources devoted to a different, lesser danger.

Countering the Threats

Countering theft threats involves developing physical barriers and deterrents such as lighting, fences, security cameras, intrusion sensors and alarms, as well as thoroughly checking the background of people you hire.

Crime Prevention Through Environmental Design (CPTED)

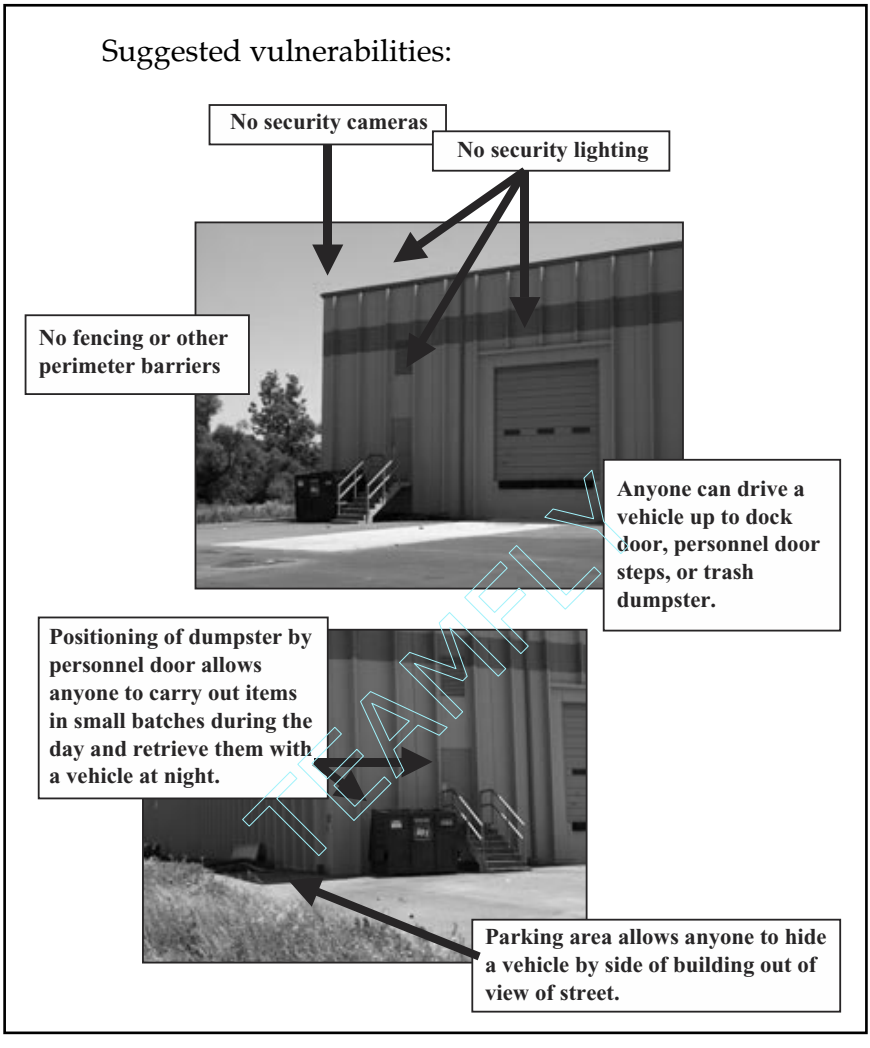
CPTED is a modern approach to crime prevention that seeks to balance a facility's layout (design) with the processes (human

Exhibit 7–2 Assessing Vulnerabilities—Invitations to Theft

INSTRUCTIONS: Review the photographs below. What vulnerabilities do you see?

circulation, product flow, and information flow) taking place within it. This concept employes strategies of access control, natural surveillance, territoriality ("Why are you in this part of the building?"), management, and maintenance to support legitimate activity. It strives to create an environment where:

- suspicious behavior will be observed, caught, and punished.
- it takes a lot of extra effort to commit a crime.
- there is a reduction in the reward for attempting the crime: target items are sheltered, distanced, reduced in quantity.
- there is a removal of excuses for improper behavior through clear work rules and policies, signage, and border definition.



CPTED uses three strategies:

1. Organizational—staff and perhaps outside security personnel both overt and covert.

2. Mechanical—technology and hardware.

3. Natural—architectural and circulation flow patterns

Use CPTED to plan an overall approach to preventing or at least lessening the opportunity for crime to occur. Exhibit

Exhibit 7–3 Assessing Vulnerabilities—Invitations to Assault

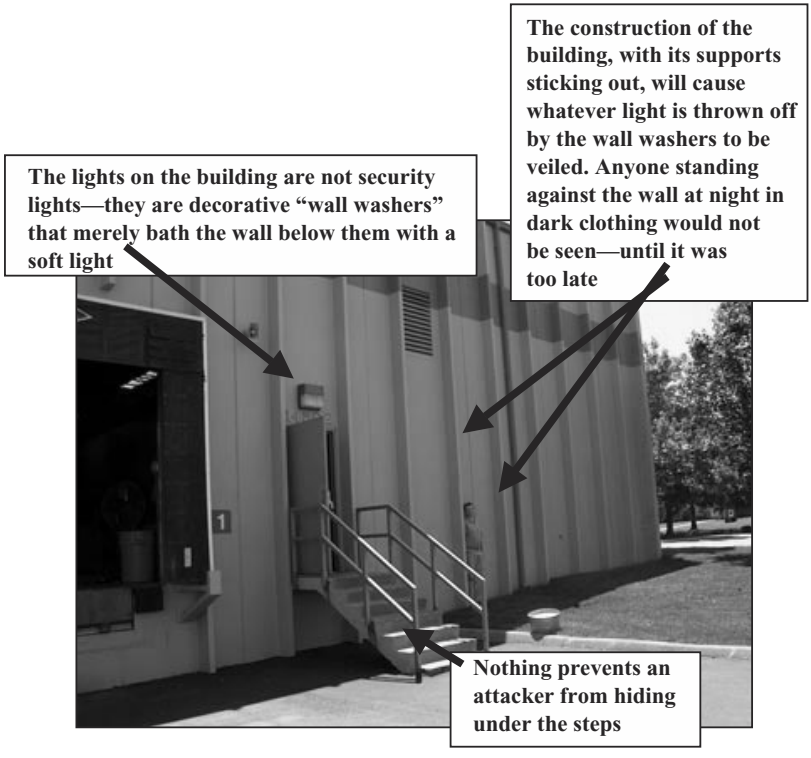
INSTRUCTIONS: Review the photograph below. What major vulnerabilities to assault are identifiable in the picture?

7–4 contains a list of CPTED-related action items you should consider.

Collusion Theft

Collusion theft occurring through the partnership of a truck driver and a warehouse worker is difficult to actually "catch." However, there are effective techniques aimed toward prevention through increasing the possibility of detection. Consider the following:

Suggested vulnerabilities:



- Random, detailed checking of loads on outbound trucks at the dock.
- At least twice each month, call a driver back in after she has left the facility. Thoroughly check the load. Check drivers on a random basis.
- Receiving by appointment coupled with random detailed checking of incoming loads.
- Using cycle counting. See pages 176–193 in chapter 6. Once employees understand that there is an ongoing effort to discover and hunt down the causes of inventory discrep-

ancies, they will also understand that management is watching.

Background Checks

No discussion of deterring crime would be complete without considering that the most effective method of avoiding both pilferage and collusion theft is to hire honest people. Since many people misrepresent their history, a background check is a must.

A reasonable background check will help you hire qualified workers, avoid hiring the dishonest, and assist you in avoiding claims for negligent hiring if a worker commits a crime against a customer, the public, or another employee.

It is not the objective of this text to serve as a guide to all human resource procedures that need to be followed in the hiring process. Therefore, no attempt is made to address issues such as discrimination, immigration, equal employment recordkeeping, and so on. However, since you may personally be involved in reference checking, it is important to use techniques calculated to encourage former employers and others to actually provide you with useful information.

An unfortunate fact of life is that many employers will either provide you with no information or will limit it to the following:

- They will confirm or deny that an individual worked for them.
- They will confirm or deny a length of employment.
- They will confirm or deny a job title or brief job description of their former employee.
- They will confirm or deny what you tell them the former employee says she was compensated.

Exhibit 7–4 CPTED-Related Action Items

- Control facility parking
  —Fencing
  —Gates
  —Card activated gates or barrier arms
  —Signage
- Control adjacent parking
- Provide a waiting area for outside supplier truck drivers. These areas may include vending machines, pay telephones, and restrooms. Remove reasons for a driver to leave the waiting area. Restrict access. Do not let outside drivers wander around.
- 24-hour CCTV surveillance and recording of all desired locations
  —Parking lots
  —Doorways
  —Valuable stock areas
  —Docks
  —Infrared LED lighting with low light cameras to observe dark areas either within or outside of the facility
- Lighting with emergency backup
  —Security lighting should be overlapping with tamperproof housings

Cont. on page 214

When you follow-up with questions such as, "Would you rehire the worker?" a former employer's response could well be, "Sorry, I've given you all of the information I can. Don't take my lack of information as either a positive or negative recommendation. I hope I've helped. Good bye."

Cont. from page 213

- Extend the physical perimeter with barriers
- Receiving and shipping procedures should be thoroughly examined for vulnerabilities to theft
  —Employees responsible for ordering items should not be the same individuals responsible for receiving them or paying for them
- Trash removal containers and procedures should be reviewed for vulnerabilities to theft
- Determine security guard requirements
- Consider undercover detectives periodically working within the workforce
- Install intrusion detection equipment and monitoring
- Provide employee and visitor identification systems
- Display employee identification at all times
- Prevent unauthorized access to utility areas
- Install mylar film on all exterior windows for shatter protection
- Control keys
  —Issue as few keys as possible
  —Establish specific rules regarding "loaning out" keys
  —Have keys stamped "Do Not Duplicate"
  —Control who can make duplicate keys
  —Periodically inventory keys
  —Institute an electronic access card system

To overcome the fear of liability and litigation that many organizations have in providing background information regarding a job applicant, you should use release forms. An example of a reference/background release form is contained in Exhibit 7–5.

Exhibit 7–5 Background Check Release Form

Use this in conjunction with your application form

RELEASE FORM

I understand that, in connection with my application for employment with _____ , investigative inquiries are to be made on myself including, but not limited to, consumer credit, criminal convictions, motor vehicle history, educational transcripts, and other reports of any nature and type. These reports will include information as to my character, work, habits, performance, and experience together with reasons for termination of past employment.

Further, I understand that you will be requesting information from various federal, state, and other agencies that maintain records concerning my past activities related to my driving, credit, criminal, education, and other experiences.

I authorize without reservation all corporations, companies, credit agencies, persons, educational institutions, law enforcement agencies, and former employers to release information they may have about me, and I release them from any liability and responsibility for doing so; further, I authorize the procurement of an investigative consumer report related to me and acknowledge my understanding that such report may contain information as to my background, mode of living, character, and personal reputation.

This authorization, in original and copy form, shall be valid for this and any future reports that may be requested.

I hereby authorize investigation of all statements made by me either in writing or verbally with no liability arising therefrom.

I willingly provide the following personal information as an aid in the proper identification of my file or records.

PRINT NAME: _____

SOCIAL SECURITY NUMBER: _____

CURRENT ADDRESS: _____

FORMER ADDRESS: _____

APPLICANT SIGNATURE: _____ DATE: _____

The form in Exhibit 7–5 releases both the provider of information and your organization from liability.

It is important that you follow your organization's guidelines regarding what you may or may not ask during reference checking or interviews. Generally, prospective employers are allowed to check criminal conviction records when the type of position being filled justifies the inquiry. Some state laws only allow you to deny someone a job if they were convicted of a crime reasonably related to the position for which you are considering the applicant for.

Do not ask about arrest records. Many state laws (a) do not permit inquiry into or (b) at least restrict information regarding arrests. An arrest record does not prove that the applicant committed any crime.

recap Business emergencies are a question of "when," not "if." Therefore, to fulfill your legal obligations of care you must assess any reasonably foreseeable circumstances that might cause harm to or loss of the inventory you are storing and handling.

Each organization should methodically assess its vulnerability to natural, technological, and incited emergencies. That assessment must involve a determination of not only how likely an event is, but also what impact it might have on the inventory or the business as a whole.

The vulnerability assessment should lead to an action plan that includes specific procedures, responsibilities, and resources to be used to (a) prevent or mitigate a crisis, (b) to handle the crisis as it unfolds, and (c) to allow for business continuation.

? REVIEW QUESTIONS

1. Which of the following is not an incited crisis? 1. (c)
   (a) Terrorism
   (b) Arson fire
   (c) Work stoppage due to an employee refusing to use a piece of equipment
   (d) Work stoppage during a labor dispute

2. List three potential technological threats.

   (a) _____

   (b) _____

   (c) _____

   - Power Outage
   - Power Surge or Spike
   - Hardware Error
   - Software Error
   - Software Virus
   - Loss of Natural Gas
   - Loss of Water
   - Loss of Hydraulics
   - Loss of Elevators

3. Duty of care you owe under the Uniform Commercial Code is: 3. (d)
   (a) each item you store must be fully insured at its replacement value.
   (b) each item you store must be fully insured at its depreciated value.
   (c) you may not store items without a written contract.
   (d) you must act as a reasonably prudent owner.

4. When can you inquire into an applicant's criminal history? 4. (b)
   (a) Always
   (b) Convictions for offenses related to the job applied for
   (c) After an arrest for an offense related to the job applied for
   (d) Never

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APPENDIX A— INVENTORY

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
1	Part 79	Product A	8,673	8,673	6.3%	0.3%
2	Part 133	Product B	6,970	15,643	11.3%	0.7%
3	Part 290	Product C	5,788	21,431	15.5%	1.0%
4	Part 65	Product D	5,690	27,121	19.6%	1.3%
5	Part 111	Product E	4,899	32,020	23.2%	1.7%
6	Part 195	Product F	3,669	35,689	25.8%	2.0%
7	Part 139	Product G	3,364	39,053	28.3%	2.3%
8	Part 131	Product H	3,250	42,303	30.6%	2.7%
9	Part 132	Product I	3,022	45,325	32.8%	3.0%
10	Part 175	Product J	2,864	48,189	34.9%	3.3%
11	Part 255	Product K	2,844	51,033	36.9%	3.7%
12	Part 101	Product L	2,670	53,703	38.9%	4.0%
13	Part 265	Product M	2,665	56,368	40.8%	4.3%
14	Part 48	Product N	2,453	58,821	42.6%	4.7%
15	Part 2	Product O	2,222	61,043	44.2%	5.0%
16	Part 14	Product P	1,976	63,019	45.6%	5.3%
17	Part 70	Product Q	1,896	64,915	47.0%	5.7%
18	Part 117	Product R	1,888	66,803	48.4%	6.0%
19	Part 134	Product S	1,872	68,675	49.7%	6.3%
20	Part 170	Product T	1,687	70,362	50.9%	6.7%
21	Part 182	Product U	1,666	72,028	52.1%	7.0%
22	Part 28	Product V	1,646	73,674	53.3%	7.3%
23	Part 138	Product W	1,566	75,240	54.5%	7.7%
24	Part 23	Product X	1,530	76,770	55.6%	8.0%
25	Part 300	Product Y	1,057	77,827	56.3%	8.3%
26	Part 9	Product Z	1,050	78,877	57.1%	8.7%
27	Part 241	Product AA	1,022	79,899	57.8%	9.0%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
28	Part 219	Product AB	1,022	80,921	58.6%	9.3%
29	Part 51	Product AC	1,001	81,922	59.3%	9.7%
30	Part 278	Product AD	997	82,919	60.0%	10.0%
31	Part 222	Product AE	991	83,910	60.7%	10.3%
32	Part 154	Product AF	986	84,896	61.5%	10.7%
33	Part 184	Product AG	972	85,868	62.2%	11.0%
34	Part 190	Product AH	968	86,836	62.9%	11.3%
35	Part 87	Product AI	964	87,800	63.6%	11.7%
36	Part 95	Product AJ	943	88,743	64.2%	12.0%
37	Part 6	Product AK	894	89,637	64.9%	12.3%
38	Part 142	Product AL	889	90,526	65.5%	12.7%
39	Part 210	Product AM	889	91,415	66.2%	13.0%
40	Part 13	Product AN	888	92,303	66.8%	13.3%
41	Part 121	Product AO	888	93,191	67.5%	13.7%
42	Part 3	Product AP	875	94,066	68.1%	14.0%
43	Part 235	Product AQ	867	94,933	68.7%	14.3%
44	Part 297	Product AR	861	95,794	69.3%	14.7%
45	Part 266	Product AS	856	96,650	70.0%	15.0%
46	Part 239	Product AT	846	97,496	70.6%	15.3%
47	Part 233	Product AU	843	98,339	71.2%	15.7%
48	Part 77	Product AV	800	99,139	71.8%	16.0%
49	Part 188	Product AW	795	99,934	72.3%	16.3%
50	Part 240	Product AX	788	100,722	72.9%	16.7%
51	Part 103	Product AY	779	101,501	73.5%	17.0%
52	Part 160	Product AZ	766	102,267	74.0%	17.3%
53	Part 211	Product BA	764	103,031	74.6%	17.7%
54	Part 243	Product BB	761	103,792	75.1%	18.0%
55	Part 201	Product BC	754	104,546	75.7%	18.3%
56	Part 202	Product BD	712	105,258	76.2%	18.7%
57	Part 75	Product BE	698	105,956	76.7%	19.0%
58	Part 206	Product BF	697	106,653	77.2%	19.3%
59	Part 200	Product BG	697	107,350	77.7%	19.7%
60	Part 124	Product BH	689	108,039	78.2%	20.0%
61	Part 208	Product BI	662	108,701	78.7%	20.3%
62	Part 253	Product BJ	644	109,345	79.2%	20.7%
63	Part 264	Product BK	640	109,985	79.6%	21.0%
64	Part 230	Product BL	614	110,599	80.1%	21.3%
65	Part 53	Product BM	590	111,189	80.5%	21.7%
66	Part 33	Product BN	587	111,776	80.9%	22.0%
67	Part 104	Product BO	566	112,342	81.3%	22.3%
68	Part 207	Product BK	564	112,906	81.7%	22.7%
69	Part 63	Product BL	544	113,450	82.1%	23.0%
70	Part 275	Product BM	533	113,983	82.5%	23.3%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
71	Part 155	Product BN	530	114,513	82.9%	23.7%
72	Part 7	Product BO	512	115,025	83.3%	24.0%
73	Part 90	Product BP	499	115,524	83.6%	24.3%
74	Part 59	Product BQ	468	115,992	84.0%	24.7%
75	Part 122	Product BR	467	116,459	84.3%	25.0%
76	Part 35	Product BS	456	116,915	84.6%	25.3%
77	Part 67	Product BT	450	117,365	85.0%	25.7%
78	Part 92	Product BU	444	117,809	85.3%	26.0%
79	Part 83	Product BV	443	118,252	85.6%	26.3%
80	Part 287	Product BW	433	118,685	85.9%	26.7%
81	Part 162	Product BX	420	119,105	86.2%	27.0%
82	Part 189	Product BY	420	119,525	86.5%	27.3%
83	Part 245	Product BZ	398	119,923	86.8%	27.7%
84	Part 274	Product CA	382	120,305	87.1%	28.0%
85	Part 242	Product CB	355	120,660	87.3%	28.3%
86	Part 258	Product CC	354	121,014	87.6%	28.7%
87	Part 136	Product CD	353	121,367	87.9%	29.0%
88	Part 238	Product CE	334	121,701	88.1%	29.3%
89	Part 115	Product CF	333	122,034	88.3%	29.7%
90	Part 94	Product CG	333	122,367	88.6%	30.0%
91	Part 64	Product CH	332	122,699	88.8%	30.3%
92	Part 298	Product CI	326	123,025	89.1%	30.7%
93	Part 295	Product CJ	325	123,350	89.3%	31.0%
94	Part 30	Product CK	325	123,675	89.5%	31.3%
95	Part 11	Product CL	323	123,998	89.8%	31.7%
96	Part 192	Product CM	321	124,319	90.0%	32.0%
97	Part 96	Product CN	321	124,640	90.2%	32.3%
98	Part 40	Product CO	298	124,938	90.4%	32.7%
99	Part 47	Product CP	285	125,223	90.7%	33.0%
100	Part 125	Product CQ	269	125,492	90.8%	33.3%
101	Part 198	Product CR	260	125,752	91.0%	33.7%
102	Part 135	Product CS	258	126,010	91.2%	34.0%
103	Part 130	Product CT	256	126,266	91.4%	34.3%
104	Part 85	Product CU	255	126,521	91.6%	34.7%
105	Part 216	Product CV	223	126,744	91.8%	35.0%
106	Part 193	Product CW	222	126,966	91.9%	35.3%
107	Part 285	Product CX	220	127,186	92.1%	35.7%
108	Part 288	Product CY	200	127,386	92.2%	36.0%
109	Part 26	Product CZ	199	127,585	92.4%	36.3%
110	Part 176	Product DA	199	127,784	92.5%	36.7%
111	Part 186	Product DB	194	127,978	92.6%	37.0%
112	Part 173	Product DC	189	128,167	92.8%	37.3%
113	Part 81	Product DD	188	128,355	92.9%	37.7%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
114	Part 172	Product DE	188	128,543	93.1%	38.0%
115	Part 144	Product DF	186	128,729	93.2%	38.3%
116	Part 12	Product DG	186	128,915	93.3%	38.7%
117	Part 141	Product DH	186	129,101	93.5%	39.0%
118	Part 15	Product DI	185	129,286	93.6%	39.3%
119	Part 227	Product DJ	185	129,471	93.7%	39.7%
120	Part 191	Product DK	184	129,655	93.9%	40.0%
121	Part 272	Product DL	178	129,833	94.0%	40.3%
122	Part 279	Product DM	156	129,989	94.1%	40.7%
123	Part 247	Product DN	150	130,139	94.2%	41.0%
124	Part 89	Product DO	144	130,283	94.3%	41.3%
125	Part 174	Product DP	143	130,426	94.4%	41.7%
126	Part 118	Product DQ	133	130,559	94.5%	42.0%
127	Part 27	Product DR	116	130,675	94.6%	42.3%
128	Part 34	Product DS	116	130,791	94.7%	42.7%
129	Part 169	Product DT	116	130,907	94.8%	43.0%
130	Part 178	Product DU	113	131,020	94.8%	43.3%
131	Part 84	Product DV	105	131,125	94.9%	43.7%
132	Part 204	Product DW	103	131,228	95.0%	44.0%
133	Part 273	Product DX	102	131,330	95.1%	44.3%
134	Part 24	Product DY	101	131,431	95.1%	44.7%
135	Part 114	Product DZ	100	131,531	95.2%	45.0%
136	Part 57	Product EA	100	131,631	95.3%	45.3%
137	Part 168	Product EB	99	131,730	95.4%	45.7%
138	Part 187	Product EC	99	131,829	95.4%	46.0%
139	Part 214	Product ED	99	131,928	95.5%	46.3%
140	Part 220	Product EE	98	132,026	95.6%	46.7%
141	Part 29	Product EF	98	132,124	95.6%	47.0%
142	Part 98	Product EG	98	132,222	95.7%	47.3%
143	Part 261	Product EH	97	132,319	95.8%	47.7%
144	Part 180	Product EI	97	132,416	95.9%	48.0%
145	Part 289	Product EJ	96	132,512	95.9%	48.3%
146	Part 146	Product EK	96	132,608	96.0%	48.7%
147	Part 299	Product EL	94	132,702	96.1%	49.0%
148	Part 68	Product EM	92	132,794	96.1%	49.3%
149	Part 41	Product EN	91	132,885	96.2%	49.7%
150	Part 38	Product EO	90	132,975	96.3%	50.0%
151	Part 140	Product EP	89	133,064	96.3%	50.3%
152	Part 16	Product EQ	89	133,153	96.4%	50.7%
153	Part 128	Product ER	88	133,241	96.5%	51.0%
154	Part 25	Product ES	88	133,329	96.5%	51.3%
155	Part 45	Product ET	87	133,416	96.6%	51.7%
156	Part 1	Product EU	86	133,502	96.6%	52.0%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
157	Part 246	Product EV	85	133,587	96.7%	52.3%
158	Part 108	Product EW	85	133,672	96.8%	52.7%
159	Part 231	Product EX	85	133,757	96.8%	53.0%
160	Part 21	Product EY	84	133,841	96.9%	53.3%
161	Part 183	Product EZ	84	133,925	97.0%	53.7%
162	Part 248	Product FA	84	134,009	97.0%	54.0%
163	Part 199	Product FB	84	134,093	97.1%	54.3%
164	Part 120	Product FC	80	134,173	97.1%	54.7%
165	Part 224	Product FD	80	134,253	97.2%	55.0%
166	Part 256	Product FE	76	134,329	97.2%	55.3%
167	Part 281	Product FF	76	134,405	97.3%	55.7%
168	Part 157	Product FG	76	134,481	97.4%	56.0%
169	Part 5	Product FH	75	134,556	97.4%	56.3%
170	Part 56	Product FI	75	134,631	97.5%	56.7%
171	Part 44	Product FJ	74	134,705	97.5%	57.0%
172	Part 76	Product FK	74	134,779	97.6%	57.3%
173	Part 267	Product FL	74	134,853	97.6%	57.7%
174	Part 262	Product FM	72	134,925	97.7%	58.0%
175	Part 225	Product FN	68	134,993	97.7%	58.3%
176	Part 276	Product FO	67	135,060	97.8%	58.7%
177	Part 43	Product FP	66	135,126	97.8%	59.0%
178	Part 10	Product FQ	66	135,192	97.9%	59.3%
179	Part 126	Product FR	65	135,257	97.9%	59.7%
180	Part 296	Product FS	64	135,321	98.0%	60.0%
181	Part 277	Product FT	63	135,384	98.0%	60.3%
182	Part 42	Product FU	63	135,447	98.1%	60.7%
183	Part 197	Product FV	62	135,509	98.1%	61.0%
184	Part 284	Product FW	61	135,570	98.1%	61.3%
185	Part 22	Product FX	61	135,631	98.2%	61.7%
186	Part 39	Product FY	61	135,692	98.2%	62.0%
187	Part 82	Product FZ	58	135,750	98.3%	62.3%
188	Part 237	Product GA	56	135,806	98.3%	62.7%
189	Part 69	Product GB	56	135,862	98.4%	63.0%
190	Part 62	Product GC	56	135,918	98.4%	63.3%
191	Part 213	Product GD	56	135,974	98.4%	63.7%
192	Part 109	Product GE	55	136,029	98.5%	64.0%
193	Part 149	Product GF	55	136,084	98.5%	64.3%
194	Part 159	Product GG	55	136,139	98.6%	64.7%
195	Part 113	Product GH	54	136,193	98.6%	65.0%
196	Part 110	Product GI	54	136,247	98.6%	65.3%
197	Part 218	Product GJ	54	136,301	98.7%	65.7%
198	Part 46	Product GK	53	136,354	98.7%	66.0%
199	Part 112	Product GL	52	136,406	98.7%	66.3%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
200	Part 179	Product GM	52	136,458	98.8%	66.7%
201	Part 100	Product GN	52	136,510	98.8%	67.0%
202	Part 37	Product GO	52	136,562	98.9%	67.3%
203	Part 282	Product GP	50	136,612	98.9%	67.7%
204	Part 116	Product GQ	48	136,660	98.9%	68.0%
205	Part 8	Product GR	46	136,706	99.0%	68.3%
206	Part 254	Product GS	45	136,751	99.0%	68.7%
207	Part 148	Product GT	45	136,796	99.0%	69.0%
208	Part 66	Product GU	44	136,840	99.1%	69.3%
209	Part 18	Product GV	43	136,883	99.1%	69.7%
210	Part 119	Product GW	43	136,926	99.1%	70.0%
211	Part 52	Product GX	42	136,968	99.2%	70.3%
212	Part 123	Product GY	41	137,009	99.2%	70.7%
213	Part 55	Product GZ	41	137,050	99.2%	71.0%
214	Part 147	Product HA	37	137,087	99.2%	71.3%
215	Part 161	Product HB	36	137,123	99.3%	71.7%
216	Part 127	Product HC	34	137,157	99.3%	72.0%
217	Part 74	Product HD	34	137,191	99.3%	72.3%
218	Part 250	Product HE	33	137,224	99.3%	72.7%
219	Part 260	Product HF	32	137,256	99.4%	73.0%
220	Part 263	Product HG	32	137,288	99.4%	73.3%
221	Part 20	Product HH	28	137,316	99.4%	73.7%
222	Part 229	Product HI	26	137,342	99.4%	74.0%
223	Part 58	Product HJ	25	137,367	99.4%	74.3%
224	Part 31	Product HK	25	137,392	99.5%	74.7%
225	Part 50	Product HL	24	137,416	99.5%	75.0%
226	Part 217	Product HM	24	137,440	99.5%	75.3%
227	Part 232	Product HN	23	137,463	99.5%	75.7%
228	Part 234	Product HO	23	137,486	99.5%	76.0%
229	Part 257	Product HP	22	137,508	99.5%	76.3%
230	Part 280	Product HQ	21	137,529	99.6%	76.7%
231	Part 80	Product HR	21	137,550	99.6%	77.0%
232	Part 88	Product HS	20	137,570	99.6%	77.3%
233	Part 49	Product HT	19	137,589	99.6%	77.7%
234	Part 212	Product HU	18	137,607	99.6%	78.0%
235	Part 226	Product HV	18	137,625	99.6%	78.3%
236	Part 97	Product HW	18	137,643	99.6%	78.7%
237	Part 166	Product HX	18	137,661	99.7%	79.0%
238	Part 293	Product HY	18	137,679	99.7%	79.3%
239	Part 36	Product HZ	18	137,697	99.7%	79.7%
240	Part 249	Product IA	17	137,714	99.7%	80.0%
241	Part 143	Product IB	16	137,730	99.7%	80.3%
242	Part 145	Product IC	16	137,746	99.7%	80.7%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
243	Part 167	Product ID	15	137,761	99.7%	81.0%
244	Part 268	Product IE	15	137,776	99.7%	81.3%
245	Part 181	Product IF	14	137,790	99.8%	81.7%
246	Part 292	Product IG	14	137,804	99.8%	82.0%
247	Part 19	Product IH	14	137,818	99.8%	82.3%
248	Part 185	Product II	14	137,832	99.8%	82.7%
249	Part 102	Product IJ	13	137,845	99.8%	83.0%
250	Part 269	Product IK	12	137,857	99.8%	83.3%
251	Part 270	Product IL	12	137,869	99.8%	83.7%
252	Part 158	Product IM	12	137,881	99.8%	84.0%
253	Part 228	Product IN	12	137,893	99.8%	84.3%
254	Part 205	Product IO	11	137,904	99.8%	84.7%
255	Part 223	Product IP	11	137,915	99.8%	85.0%
256	Part 17	Product IQ	10	137,925	99.8%	85.3%
257	Part 156	Product IR	10	137,935	99.9%	85.7%
258	Part 171	Product IS	10	137,945	99.9%	86.0%
259	Part 137	Product IT	9	137,954	99.9%	86.3%
260	Part 203	Product IU	9	137,963	99.9%	86.7%
261	Part 106	Product IV	9	137,972	99.9%	87.0%
262	Part 209	Product IW	8	137,980	99.9%	87.3%
263	Part 244	Product IX	8	137,988	99.9%	87.7%
264	Part 99	Product IY	8	137,996	99.9%	88.0%
265	Part 60	Product IZ	8	138,004	99.9%	88.3%
266	Part 71	Product JA	8	138,012	99.9%	88.7%
267	Part 93	Product JB	8	138,020	99.9%	89.0%
268	Part 150	Product JC	7	138,027	99.9%	89.3%
269	Part 215	Product JD	7	138,034	99.9%	89.7%
270	Part 294	Product JE	7	138,041	99.9%	90.0%
271	Part 236	Product JF	6	138,047	99.9%	90.3%
272	Part 86	Product JG	6	138,053	99.9%	90.7%
273	Part 32	Product JH	6	138,059	99.9%	91.0%
274	Part 129	Product JI	5	138,064	99.9%	91.3%
275	Part 164	Product JJ	5	138,069	100.0%	91.7%
276	Part 283	Product JK	5	138,074	100.0%	92.0%
277	Part 252	Product JL	5	138,079	100.0%	92.3%
278	Part 259	Product JM	5	138,084	100.0%	92.7%
279	Part 152	Product JN	5	138,089	100.0%	93.0%
280	Part 78	Product JO	4	138,093	100.0%	93.3%
281	Part 251	Product JP	4	138,097	100.0%	93.7%
282	Part 73	Product JQ	4	138,101	100.0%	94.0%
283	Part 194	Product JR	4	138,105	100.0%	94.3%
284	Part 107	Product JS	3	138,108	100.0%	94.7%
285	Part 196	Product JT	3	138,111	100.0%	95.0%

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
286	Part 177	Product JU	3	138,114	100.0%	95.3%
287	Part 221	Product JV	3	138,117	100.0%	95.7%
288	Part 105	Product JW	3	138,120	100.0%	96.0%
289	Part 72	Product JX	2	138,122	100.0%	96.3%
290	Part 286	Product JY	2	138,124	100.0%	96.7%
291	Part 291	Product JZ	2	138,126	100.0%	97.0%
292	Part 54	Product KA	2	138,128	100.0%	97.3%
293	Part 163	Product KB	2	138,130	100.0%	97.7%
294	Part 271	Product KC	1	138,131	100.0%	98.0%
295	Part 4	Product KD	1	138,132	100.0%	98.3%
296	Part 153	Product KE	1	138,133	100.0%	98.7%
297	Part 91	Product KF	1	138,134	100.0%	99.0%
298	Part 151	Product KG	—	138,134	100.0%	99.3%
299	Part 61	Product KH	—	138,134	100.0%	99.7%
300	Part 165	Product KI	—	138,134	100.0%	100.0%

APPENDIX B—FORMULAE

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
1	79	Product A	8673	=0+D1	=E1/$E$300	=A1/$A$300
2	133	Product B	6970	=E1+D2	=E2/$E$300	=A2/$A$300
3	290	Product C	5788	=E2+D3	=E3/$E$300	=A3/$A$300
4	65	Product D	5690	=E3+D4	=E4/$E$300	=A4/$A$300
5	111	Product E	4899	=E4+D5	=E5/$E$300	=A5/$A$300
6	195	Product F	3669	=E5+D6	=E6/$E$300	=A6/$A$300
7	139	Product G	3364	=E6+D7	=E7/$E$300	=A7/$A$300
8	131	Product H	3250	=E7+D8	=E8/$E$300	=A8/$A$300
9	132	Product I	3022	=E8+D9	=E9/$E$300	=A9/$A$300
10	175	Product J	2864	=E9+D10	=E10/$E$300	=A10/$A$300
11	255	Product K	2844	=E10+D11	=E11/$E$300	=A11/$A$300
12	101	Product L	2670	=E11+D12	=E12/$E$300	=A12/$A$300
13	265	Product M	2665	=E12+D13	=E13/$E$300	=A13/$A$300
14	48	Product N	2453	=E13+D14	=E14/$E$300	=A14/$A$300
15	2	Product O	2222	=E14+D15	=E15/$E$300	=A15/$A$300
16	14	Product P	1976	=E15+D16	=E16/$E$300	=A16/$A$300
17	70	Product Q	1896	=E16+D17	=E17/$E$300	=A17/$A$300
18	117	Product R	1888	=E17+D18	=E18/$E$300	=A18/$A$300
19	134	Product S	1872	=E18+D19	=E19/$E$300	=A19/$A$300
20	170	Product T	1687	=E19+D20	=E20/$E$300	=A20/$A$300
21	182	Product U	1666	=E20+D21	=E21/$E$300	=A21/$A$300
22	28	Product V	1646	=E21+D22	=E22/$E$300	=A22/$A$300
23	138	Product W	1566	=E22+D23	=E23/$E$300	=A23/$A$300
24	23	Product X	1530	=E23+D24	=E24/$E$300	=A24/$A$300
25	300	Product Y	1057	=E24+D25	=E25/$E$300	=A25/$A$300
26	9	Product Z	1050	=E25+D26	=E26/$E$300	=A26/$A$300
27	241	Product AA	1022	=E26+D27	=E27/$E$300	=A27/$A$300
28	219	Product AB	1022	=E27+D28	=E28/$E$300	=A28/$A$300
29	51	Product AC	1001	=E28+D29	=E29/$E$300	=A29/$A$300
30	278	Product AD	997	=E29+D30	=E30/$E$300	=A30/$A$300
31	222	Product AE	991	=E30+D31	=E31/$E$300	=A31/$A$300
32	154	Product AF	986	=E31+D32	=E32/$E$300	=A32/$A$300
33	184	Product AG	972	=E32+D33	=E33/$E$300	=A33/$A$300
34	190	Product AH	968	=E33+D34	=E34/$E$300	=A34/$A$300
35	87	Product AI	964	=E34+D35	=E35/$E$300	=A35/$A$300
36	95	Product AJ	943	=E35+D36	=E36/$E$300	=A36/$A$300
37	6	Product AK	894	=E36+D37	=E37/$E$300	=A37/$A$300

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
38	142	Product AL	889	=E37+D38	=E38/$E$300	=A38/$A$300
39	210	Product AM	889	=E38+D39	=E39/$E$300	=A39/$A$300
40	13	Product AN	888	=E39+D40	=E40/$E$300	=A40/$A$300
41	121	Product AO	888	=E40+D41	=E41/$E$300	=A41/$A$300
42	3	Product AP	875	=E41+D42	=E42/$E$300	=A42/$A$300
43	235	Product AQ	867	=E42+D43	=E43/$E$300	=A43/$A$300
44	297	Product AR	861	=E43+D44	=E44/$E$300	=A44/$A$300
45	266	Product AS	856	=E44+D45	=E45/$E$300	=A45/$A$300
46	239	Product AT	846	=E45+D46	=E46/$E$300	=A46/$A$300
47	233	Product AU	843	=E46+D47	=E47/$E$300	=A47/$A$300
48	77	Product AV	800	=E47+D48	=E48/$E$300	=A48/$A$300
49	188	Product AW	795	=E48+D49	=E49/$E$300	=A49/$A$300
50	240	Product AX	788	=E49+D50	=E50/$E$300	=A50/$A$300
51	103	Product AY	779	=E50+D51	=E51/$E$300	=A51/$A$300
52	160	Product AZ	766	=E51+D52	=E52/$E$300	=A52/$A$300
53	211	Product BA	764	=E52+D53	=E53/$E$300	=A53/$A$300
54	243	Product BB	761	=E53+D54	=E54/$E$300	=A54/$A$300
55	201	Product BC	754	=E54+D55	=E55/$E$300	=A55/$A$300
56	202	Product BD	712	=E55+D56	=E56/$E$300	=A56/$A$300
57	75	Product BE	698	=E56+D57	=E57/$E$300	=A57/$A$300
58	206	Product BF	697	=E57+D58	=E58/$E$300	=A58/$A$300
59	200	Product BG	697	=E58+D59	=E59/$E$300	=A59/$A$300
60	124	Product BH	689	=E59+D60	=E60/$E$300	=A60/$A$300
61	208	Product BI	662	=E60+D61	=E61/$E$300	=A61/$A$300
62	253	Product BJ	644	=E61+D62	=E62/$E$300	=A62/$A$300
63	264	Product BK	640	=E62+D63	=E63/$E$300	=A63/$A$300
64	230	Product BL	614	=E63+D64	=E64/$E$300	=A64/$A$300
65	53	Product BM	590	=E64+D65	=E65/$E$300	=A65/$A$300
66	33	Product BN	587	=E65+D66	=E66/$E$300	=A66/$A$300
67	104	Product BO	566	=E66+D67	=E67/$E$300	=A67/$A$300
68	207	Product BK	564	=E67+D68	=E68/$E$300	=A68/$A$300
69	63	Product BL	544	=E68+D69	=E69/$E$300	=A69/$A$300
70	275	Product BM	533	=E69+D70	=E70/$E$300	=A70/$A$300
71	155	Product BN	530	=E70+D71	=E71/$E$300	=A71/$A$300
72	7	Product BO	512	=E71+D72	=E72/$E$300	=A72/$A$300
73	90	Product BP	499	=E72+D73	=E73/$E$300	=A73/$A$300
74	59	Product BQ	468	=E73+D74	=E74/$E$300	=A74/$A$300
75	122	Product BR	467	=E74+D75	=E75/$E$300	=A75/$A$300
76	35	Product BS	456	=E75+D76	=E76/$E$300	=A76/$A$300
77	67	Product BT	450	=E76+D77	=E77/$E$300	=A77/$A$300
78	92	Product BU	444	=E77+D78	=E78/$E$300	=A78/$A$300
79	83	Product BV	443	=E78+D79	=E79/$E$300	=A79/$A$300
80	287	Product BW	433	=E79+D80	=E80/$E$300	=A80/$A$300

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
81	162	Product BX	420	=E80+D81	=E81/$E$300	=A81/$A$300
82	189	Product BY	420	=E81+D82	=E82/$E$300	=A82/$A$300
83	245	Product BZ	398	=E82+D83	=E83/$E$300	=A83/$A$300
84	274	Product CA	382	=E83+D84	=E84/$E$300	=A84/$A$300
85	242	Product CB	355	=E84+D85	=E85/$E$300	=A85/$A$300
86	258	Product CC	354	=E85+D86	=E86/$E$300	=A86/$A$300
87	136	Product CD	353	=E86+D87	=E87/$E$300	=A87/$A$300
88	238	Product CE	334	=E87+D88	=E88/$E$300	=A88/$A$300
89	115	Product CF	333	=E88+D89	=E89/$E$300	=A89/$A$300
90	94	Product CG	333	=E89+D90	=E90/$E$300	=A90/$A$300
91	64	Product CH	332	=E90+D91	=E91/$E$300	=A91/$A$300
92	298	Product CI	326	=E91+D92	=E92/$E$300	=A92/$A$300
93	295	Product CJ	325	=E92+D93	=E93/$E$300	=A93/$A$300
94	30	Product CK	325	=E93+D94	=E94/$E$300	=A94/$A$300
95	11	Product CL	323	=E94+D95	=E95/$E$300	=A95/$A$300
96	192	Product CM	321	=E95+D96	=E96/$E$300	=A96/$A$300
97	96	Product CN	321	=E96+D97	=E97/$E$300	=A97/$A$300
98	40	Product CO	298	=E97+D98	=E98/$E$300	=A98/$A$300
99	47	Product CP	285	=E98+D99	=E99/$E$300	=A99/$A$300
100	125	Product CQ	269	=E99+D100	=E100/$E$300	=A100/$A$300
101	198	Product CR	260	=E100+D101	=E101/$E$300	=A101/$A$300
102	135	Product CS	258	=E101+D102	=E102/$E$300	=A102/$A$300
103	130	Product CT	256	=E102+D103	=E103/$E$300	=A103/$A$300
104	85	Product CU	255	=E103+D104	=E104/$E$300	=A104/$A$300
105	216	Product CV	223	=E104+D105	=E105/$E$300	=A105/$A$300
106	193	Product CW	222	=E105+D106	=E106/$E$300	=A106/$A$300
107	285	Product CX	220	=E106+D107	=E107/$E$300	=A107/$A$300
108	288	Product CY	200	=E107+D108	=E108/$E$300	=A108/$A$300
109	26	Product CZ	199	=E108+D109	=E109/$E$300	=A109/$A$300
110	176	Product DA	199	=E109+D110	=E110/$E$300	=A110/$A$300
111	186	Product DB	194	=E110+D111	=E111/$E$300	=A111/$A$300
112	173	Product DC	189	=E111+D112	=E112/$E$300	=A112/$A$300
113	81	Product DD	188	=E112+D113	=E113/$E$300	=A113/$A$300
114	172	Product DE	188	=E113+D114	=E114/$E$300	=A114/$A$300
115	144	Product DF	186	=E114+D115	=E115/$E$300	=A115/$A$300
116	12	Product DG	186	=E115+D116	=E116/$E$300	=A116/$A$300
117	141	Product DH	186	=E116+D117	=E117/$E$300	=A117/$A$300
118	15	Product DI	185	=E117+D118	=E118/$E$300	=A118/$A$300
119	227	Product DJ	185	=E118+D119	=E119/$E$300	=A119/$A$300
120	191	Product DK	184	=E119+D120	=E120/$E$300	=A120/$A$300
121	272	Product DL	178	=E120+D121	=E121/$E$300	=A121/$A$300
122	279	Product DM	156	=E121+D122	=E122/$E$300	=A122/$A$300
123	247	Product DN	150	=E122+D123	=E123/$E$300	=A123/$A$300

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
124	89	Product DO	144	=E123+D124	=E124/$E$300	=A124/$A$300
125	174	Product DP	143	=E124+D125	=E125/$E$300	=A125/$A$300
126	118	Product DQ	133	=E125+D126	=E126/$E$300	=A126/$A$300
127	27	Product DR	116	=E126+D127	=E127/$E$300	=A127/$A$300
128	34	Product DS	116	=E127+D128	=E128/$E$300	=A128/$A$300
129	169	Product DT	116	=E128+D129	=E129/$E$300	=A129/$A$300
130	178	Product DU	113	=E129+D130	=E130/$E$300	=A130/$A$300
131	84	Product DV	105	=E130+D131	=E131/$E$300	=A131/$A$300
132	204	Product DW	103	=E131+D132	=E132/$E$300	=A132/$A$300
133	273	Product DX	102	=E132+D133	=E133/$E$300	=A133/$A$300
134	24	Product DY	101	=E133+D134	=E134/$E$300	=A134/$A$300
135	114	Product DZ	100	=E134+D135	=E135/$E$300	=A135/$A$300
136	57	Product EA	100	=E135+D136	=E136/$E$300	=A136/$A$300
137	168	Product EB	99	=E136+D137	=E137/$E$300	=A137/$A$300
138	187	Product EC	99	=E137+D138	=E138/$E$300	=A138/$A$300
139	214	Product ED	99	=E138+D139	=E139/$E$300	=A139/$A$300
140	220	Product EE	98	=E139+D140	=E140/$E$300	=A140/$A$300
141	29	Product EF	98	=E140+D141	=E141/$E$300	=A141/$A$300
142	98	Product EG	98	=E141+D142	=E142/$E$300	=A142/$A$300
143	261	Product EH	97	=E142+D143	=E143/$E$300	=A143/$A$300
144	180	Product EI	97	=E143+D144	=E144/$E$300	=A144/$A$300
145	289	Product EJ	96	=E144+D145	=E145/$E$300	=A145/$A$300
146	146	Product EK	96	=E145+D146	=E146/$E$300	=A146/$A$300
147	299	Product EL	94	=E146+D147	=E147/$E$300	=A147/$A$300
148	68	Product EM	92	=E147+D148	=E148/$E$300	=A148/$A$300
149	41	Product EN	91	=E148+D149	=E149/$E$300	=A149/$A$300
150	38	Product EO	90	=E149+D150	=E150/$E$300	=A150/$A$300
151	140	Product EP	89	=E150+D151	=E151/$E$300	=A151/$A$300
152	16	Product EQ	89	=E151+D152	=E152/$E$300	=A152/$A$300
153	128	Product ER	88	=E152+D153	=E153/$E$300	=A153/$A$300
154	25	Product ES	88	=E153+D154	=E154/$E$300	=A154/$A$300
155	45	Product ET	87	=E154+D155	=E155/$E$300	=A155/$A$300
156	1	Product EU	86	=E155+D156	=E156/$E$300	=A156/$A$300
157	246	Product EV	85	=E156+D157	=E157/$E$300	=A157/$A$300
158	108	Product EW	85	=E157+D158	=E158/$E$300	=A158/$A$300
159	231	Product EX	85	=E158+D159	=E159/$E$300	=A159/$A$300
160	21	Product EY	84	=E159+D160	=E160/$E$300	=A160/$A$300
161	183	Product EZ	84	=E160+D161	=E161/$E$300	=A161/$A$300
162	248	Product FA	84	=E161+D162	=E162/$E$300	=A162/$A$300
163	199	Product FB	84	=E162+D163	=E163/$E$300	=A163/$A$300
164	120	Product FC	80	=E163+D164	=E164/$E$300	=A164/$A$300
165	224	Product FD	80	=E164+D165	=E165/$E$300	=A165/$A$300
166	256	Product FE	76	=E165+D166	=E166/$E$300	=A166/$A$300

A	B	C	D	E	F	G
Line No.	**Part No.**	**Description**	**Annual Usage**	**Cumulative Usage**	**% Total Usage**	**% Total Items**
167	281	Product FF	76	=E166+D167	=E167/$E$300	=A167/$A$300
168	157	Product FG	76	=E167+D168	=E168/$E$300	=A168/$A$300
169	5	Product FH	75	=E168+D169	=E169/$E$300	=A169/$A$300
170	56	Product FI	75	=E169+D170	=E170/$E$300	=A170/$A$300
171	44	Product FJ	74	=E170+D171	=E171/$E$300	=A171/$A$300
172	76	Product FK	74	=E171+D172	=E172/$E$300	=A172/$A$300
173	267	Product FL	74	=E172+D173	=E173/$E$300	=A173/$A$300
174	262	Product FM	72	=E173+D174	=E174/$E$300	=A174/$A$300
175	225	Product FN	68	=E174+D175	=E175/$E$300	=A175/$A$300
176	276	Product FO	67	=E175+D176	=E176/$E$300	=A176/$A$300
177	43	Product FP	66	=E176+D177	=E177/$E$300	=A177/$A$300
178	10	Product FQ	66	=E177+D178	=E178/$E$300	=A178/$A$300
179	126	Product FR	65	=E178+D179	=E179/$E$300	=A179/$A$300
180	296	Product FS	64	=E179+D180	=E180/$E$300	=A180/$A$300
181	277	Product FT	63	=E180+D181	=E181/$E$300	=A181/$A$300
182	42	Product FU	63	=E181+D182	=E182/$E$300	=A182/$A$300
183	197	Product FV	62	=E182+D183	=E183/$E$300	=A183/$A$300
184	284	Product FW	61	=E183+D184	=E184/$E$300	=A184/$A$300
185	22	Product FX	61	=E184+D185	=E185/$E$300	=A185/$A$300
186	39	Product FY	61	=E185+D186	=E186/$E$300	=A186/$A$300
187	82	Product FZ	58	=E186+D187	=E187/$E$300	=A187/$A$300
188	237	Product GA	56	=E187+D188	=E188/$E$300	=A188/$A$300
189	69	Product GB	56	=E188+D189	=E189/$E$300	=A189/$A$300
190	62	Product GC	56	=E189+D190	=E190/$E$300	=A190/$A$300
191	213	Product GD	56	=E190+D191	=E191/$E$300	=A191/$A$300
192	109	Product GE	55	=E191+D192	=E192/$E$300	=A192/$A$300
193	149	Product GF	55	=E192+D193	=E193/$E$300	=A193/$A$300
194	159	Product GG	55	=E193+D194	=E194/$E$300	=A194/$A$300
195	113	Product GH	54	=E194+D195	=E195/$E$300	=A195/$A$300
196	110	Product GI	54	=E195+D196	=E196/$E$300	=A196/$A$300
197	218	Product GJ	54	=E196+D197	=E197/$E$300	=A197/$A$300
198	46	Product GK	53	=E197+D198	=E198/$E$300	=A198/$A$300
199	112	Product GL	52	=E198+D199	=E199/$E$300	=A199/$A$300
200	179	Product GM	52	=E199+D200	=E200/$E$300	=A200/$A$300
201	100	Product GN	52	=E200+D201	=E201/$E$300	=A201/$A$300
202	37	Product GO	52	=E201+D202	=E202/$E$300	=A202/$A$300
203	282	Product GP	50	=E202+D203	=E203/$E$300	=A203/$A$300
204	116	Product GQ	48	=E203+D204	=E204/$E$300	=A204/$A$300
205	8	Product GR	46	=E204+D205	=E205/$E$300	=A205/$A$300
206	254	Product GS	45	=E205+D206	=E206/$E$300	=A206/$A$300
207	148	Product GT	45	=E206+D207	=E207/$E$300	=A207/$A$300
208	66	Product GU	44	=E207+D208	=E208/$E$300	=A208/$A$300
209	18	Product GV	43	=E208+D209	=E209/$E$300	=A209/$A$300

A	B	C	D	E	F	G
Line No.	Part No.	Description	Annual Usage	Cumulative Usage	% Total Usage	% Total Items
210	119	Product GW	43	=E209+D210	=E210/$E$300	=A210/$A$300
211	52	Product GX	42	=E210+D211	=E211/$E$300	=A211/$A$300
212	123	Product GY	41	=E211+D212	=E212/$E$300	=A212/$A$300
213	55	Product GZ	41	=E212+D213	=E213/$E$300	=A213/$A$300
214	147	Product HA	37	=E213+D214	=E214/$E$300	=A214/$A$300
215	161	Product HB	36	=E214+D215	=E215/$E$300	=A215/$A$300
216	127	Product HC	34	=E215+D216	=E216/$E$300	=A216/$A$300
217	74	Product HD	34	=E216+D217	=E217/$E$300	=A217/$A$300
218	250	Product HE	33	=E217+D218	=E218/$E$300	=A218/$A$300
219	260	Product HF	32	=E218+D219	=E219/$E$300	=A219/$A$300
220	263	Product HG	32	=E219+D220	=E220/$E$300	=A220/$A$300
221	20	Product HH	28	=E220+D221	=E221/$E$300	=A221/$A$300
222	229	Product HI	26	=E221+D222	=E222/$E$300	=A222/$A$300
223	58	Product HJ	25	=E222+D223	=E223/$E$300	=A223/$A$300
224	31	Product HK	25	=E223+D224	=E224/$E$300	=A224/$A$300
225	50	Product HL	24	=E224+D225	=E225/$E$300	=A225/$A$300
226	217	Product HM	24	=E225+D226	=E226/$E$300	=A226/$A$300
227	232	Product HN	23	=E226+D227	=E227/$E$300	=A227/$A$300
228	234	Product HO	23	=E227+D228	=E228/$E$300	=A228/$A$300
229	257	Product HP	22	=E228+D229	=E229/$E$300	=A229/$A$300
230	280	Product HQ	21	=E229+D230	=E230/$E$300	=A230/$A$300
231	80	Product HR	21	=E230+D231	=E231/$E$300	=A231/$A$300
232	88	Product HS	20	=E231+D232	=E232/$E$300	=A232/$A$300
233	49	Product HT	19	=E232+D233	=E233/$E$300	=A233/$A$300
234	212	Product HU	18	=E233+D234	=E234/$E$300	=A234/$A$300
235	226	Product HV	18	=E234+D235	=E235/$E$300	=A235/$A$300
236	97	Product HW	18	=E235+D236	=E236/$E$300	=A236/$A$300
237	166	Product HX	18	=E236+D237	=E237/$E$300	=A237/$A$300
238	293	Product HY	18	=E237+D238	=E238/$E$300	=A238/$A$300
239	36	Product HZ	18	=E238+D239	=E239/$E$300	=A239/$A$300
240	249	Product IA	17	=E239+D240	=E240/$E$300	=A240/$A$300
241	143	Product IB	16	=E240+D241	=E241/$E$300	=A241/$A$300
242	145	Product IC	16	=E241+D242	=E242/$E$300	=A242/$A$300
243	167	Product ID	15	=E242+D243	=E243/$E$300	=A243/$A$300
244	268	Product IE	15	=E243+D244	=E244/$E$300	=A244/$A$300
245	181	Product IF	14	=E244+D245	=E245/$E$300	=A245/$A$300
246	292	Product IG	14	=E245+D246	=E246/$E$300	=A246/$A$300
247	19	Product IH	14	=E246+D247	=E247/$E$300	=A247/$A$300
248	185	Product II	14	=E247+D248	=E248/$E$300	=A248/$A$300
249	102	Product IJ	13	=E248+D249	=E249/$E$300	=A249/$A$300
250	269	Product IK	12	=E249+D250	=E250/$E$300	=A250/$A$300
251	270	Product IL	12	=E250+D251	=E251/$E$300	=A251/$A$300
252	158	Product IM	12	=E251+D252	=E252/$E$300	=A252/$A$300

A	B	C	D	E	F	G
Line No.	**Part No.**	**Description**	**Annual Usage**	**Cumulative Usage**	**% Total Usage**	**% Total Items**
253	228	Product IN	12	=E252+D253	=E253/$E$300	=A253/$A$300
254	205	Product IO	11	=E253+D254	=E254/$E$300	=A254/$A$300
255	223	Product IP	11	=E254+D255	=E255/$E$300	=A255/$A$300
256	17	Product IQ	10	=E255+D256	=E256/$E$300	=A256/$A$300
257	156	Product IR	10	=E256+D257	=E257/$E$300	=A257/$A$300
258	171	Product IS	10	=E257+D258	=E258/$E$300	=A258/$A$300
259	137	Product IT	9	=E258+D259	=E259/$E$300	=A259/$A$300
260	203	Product IU	9	=E259+D260	=E260/$E$300	=A260/$A$300
261	106	Product IV	9	=E260+D261	=E261/$E$300	=A261/$A$300
262	209	Product IW	8	=E261+D262	=E262/$E$300	=A262/$A$300
263	244	Product IX	8	=E262+D263	=E263/$E$300	=A263/$A$300
264	99	Product IY	8	=E263+D264	=E264/$E$300	=A264/$A$300
265	60	Product IZ	8	=E264+D265	=E265/$E$300	=A265/$A$300
266	71	Product JA	8	=E265+D266	=E266/$E$300	=A266/$A$300
267	93	Product JB	8	=E266+D267	=E267/$E$300	=A267/$A$300
268	150	Product JC	7	=E267+D268	=E268/$E$300	=A268/$A$300
269	215	Product JD	7	=E268+D269	=E269/$E$300	=A269/$A$300
270	294	Product JE	7	=E269+D270	=E270/$E$300	=A270/$A$300
271	236	Product JF	6	=E270+D271	=E271/$E$300	=A271/$A$300
272	86	Product JG	6	=E271+D272	=E272/$E$300	=A272/$A$300
273	32	Product JH	6	=E272+D273	=E273/$E$300	=A273/$A$300
274	129	Product JI	5	=E273+D274	=E274/$E$300	=A274/$A$300
275	164	Product JJ	5	=E274+D275	=E275/$E$300	=A275/$A$300
276	283	Product JK	5	=E275+D276	=E276/$E$300	=A276/$A$300
277	252	Product JL	5	=E276+D277	=E277/$E$300	=A277/$A$300
278	259	Product JM	5	=E277+D278	=E278/$E$300	=A278/$A$300
279	152	Product JN	5	=E278+D279	=E279/$E$300	=A279/$A$300
280	78	Product JO	4	=E279+D280	=E280/$E$300	=A280/$A$300
281	251	Product JP	4	=E280+D281	=E281/$E$300	=A281/$A$300
282	73	Product JQ	4	=E281+D282	=E282/$E$300	=A282/$A$300
283	194	Product JR	4	=E282+D283	=E283/$E$300	=A283/$A$300
284	107	Product JS	3	=E283+D284	=E284/$E$300	=A284/$A$300
285	196	Product JT	3	=E284+D285	=E285/$E$300	=A285/$A$300
286	177	Product JU	3	=E285+D286	=E286/$E$300	=A286/$A$300
287	221	Product JV	3	=E286+D287	=E287/$E$300	=A287/$A$300
288	105	Product JW	3	=E287+D288	=E288/$E$300	=A288/$A$300
289	72	Product JX	2	=E288+D289	=E289/$E$300	=A289/$A$300
290	286	Product JY	2	=E289+D290	=E290/$E$300	=A290/$A$300
291	291	Product JZ	2	=E290+D291	=E291/$E$300	=A291/$A$300
292	54	Product KA	2	=E291+D292	=E292/$E$300	=A292/$A$300
293	163	Product KB	2	=E292+D293	=E293/$E$300	=A293/$A$300
294	271	Product KC	1	=E293+D294	=E294/$E$300	=A294/$A$300
295	4	Product KD	1	=E294+D295	=E295/$E$300	=A295/$A$300

A	B	C	D	E	F	G
Line No.	**Part No.**	**Description**	**Annual Usage**	**Cumulative Usage**	**% Total Usage**	**% Total Items**
296	153	Product KE	1	=E295+D296	=E296/$E$300	=A296/$A$300
297	91	Product KF	1	=E296+D297	=E297/$E$300	=A297/$A$300
298	151	Product KG	0	=E297+D298	=E298/$E$300	=A298/$A$300
299	61	Product KH	0	=E298+D299	=E299/$E$300	=A299/$A$300
300	165	Product KI	0	=E299+D300	=E300/$E$300	=A300/$A$300

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