Common adjustments to improve read rates include
- Placing readers in locations with less interference
- Placing a buffer or shield between the tag and the interfering object
- Adjusting the position and angle of the RFID antennae on readers
- Changing reader or tag type/manufacturer to suit the facility or product
- Regular maintenance and testing.

Sometimes processes may have to be redesigned. For example, a major airline found that it could increase the accuracy of luggage read rates to more than 90 percent, but it would need to change how its operators loaded baggage into the metal luggage carts to get that accuracy level.

**Topic 3: Unit Loads**

**Unitization and unit loads**

Unitization—the formation of unit loads—is one way in which packaging facilitates efficient and effective storage and movement of goods. The *APICS Dictionary*, 15th edition, defines **unitization** as “in warehousing, the consolidation of several units into larger units for fewer handlings.”

Although pallets are very common in materials handling, many other types of nonpalletized unit loads are used, such as drums, bundles (e.g., of lumber or copper pipes), or two or more master cartons taped together for shipping. The main idea of a unit load is that it should make materials handling as efficient as it can be while forming another layer of packaging to protect against damage. Poor design of unit loads can increase inventory handling and storage costs, transportation costs, and product damage.

A key benefit of unit loads is faster truck loading and unloading. A unit load can be moved from a truck about five times faster than a load of loose master cartons. Receiving can scan the bar code or RFID for each unit load rather than scanning each master carton. Unit loads facilitate materials handling in warehouses since they can be staged for order selection.

The main challenge with unitization is the “cube out” or “weigh out” question. Unit loads that cube out a vehicle are straightforward, but unit loads that weigh out will leave a lot of empty space. An alternative in some cases can be a unit load made up of dense and heavy objects on the bottom with lighter products on top. For example, cases of soda on the bottom and rolls of paper towels on top. In other cases, packaging can be reduced to ship more product. For example, Hewlett-Packard ships shrink-wrapped bundles of printers by air to Europe, and the final assembly and
consumer packaging are done there. The unit load needs little packaging due to the use of air freight.

**Carrier unit load requirements**

Carriers publish freight classification documents for commodities, listing tariffs based on the type of packaging that is used. For example, there will be a different rate for SU (setup) than for KD (knocked down) because the carriers have calculated in advance the relative density or efficiency of the unit load and adjust their rates accordingly. Other standard terms will differ by commodity but could include “in machine-pressed bales,” “in barrels,” and so on, sometimes specifying how much compression was done if there are alternate standard packaging methods. The rates are lower for denser packaging to encourage more compact loads.

Carriers may also specify required protective packaging when contracts make them liable for damages, such as “celluloid, covered, in boxes” or a specific cardboard box strength. This is specified to minimize risks of freight claims and to void them of liability if the instruction is not followed.

**Master cartons**

A master carton is a sturdy, perhaps semi-reusable, container used to hold multiple units in their consumer packaging. Labeling on the outside of the master carton indicates the contents. While most master cartons are used for multiple quantities of the same item, they can also be used to hold related SKUs, such as different sizes and styles of shoes. In the latter case, the carton may have a line item list or packing list on the outside for ease of locating specific goods in the back room of the retail establishment.

Various criteria affect the size of a master carton.

- **Ease of handling.** Master cartons should ideally be light enough to be handled by an individual without using handling equipment.
  
- **Economies of scale in transportation.** The number of units in a master carton should facilitate economies of scale in movement while adhering to the aforementioned weight and bulk restrictions.
  
- **Customer preference.** It is important that retailers buy in master carton quantities, so distributors and manufacturers should consult with retailers to determine ideal carton sizes.
  
- **Packaging efficiency.** Efficiency decreases in direct relation to unit size. This is why smaller containers of a product generally cost more than the same quantity in bulk form. Packaging efficiency is measured by dividing the amount of cubic
space actually occupied by product by the amount of cubic space the master carton occupies. For example, if four circular containers of bleach occupy 5,653 cubic centimeters and fit snugly in a box that is 20 × 20 × 20 centimeters (8,000 cubic centimeters), then $5,653/8,000 = 0.7066 = 70.7$ percent carton efficiency. However, if eight smaller bottles of bleach occupy 5,024 cubic centimeters and fit snugly in the same box in two tiers with a cardboard divider, then $5,024/8,000 = 0.628 = 62.8$ percent carton efficiency.

♦ **Sales velocity.** Items that sell slowly might be placed in smaller master cartons than materials handling might otherwise desire, thus minimizing inventory holding costs at the tradeoff of having more materials handling expense. The alternative is to ship individual units in assortment packages.

### Designing a master carton

Master cartons would ideally be identical in size so that they could be stacked interchangeably. However, this is usually impossible, as the master carton would be too large and leave empty space for some items or be too small for others and require multiple cartons. Therefore, master cartons usually come in different sizes for different products.

The principle of modular packaging can be used, however, to ensure that the various sizes all stack together neatly within the master carton. When other tradeoffs allow, the smallest carton size can be increased by using multiples of the smallest carton’s height, width, and/or length to ensure that the cartons can be stacked at even layer heights.

Another goal for master cartons is that they fit on the organization’s standard-size pallet when stacked with other master cartons. This is done by ensuring that the heights, lengths, and widths of one or more cartons sum to a standard-size pallet height, length, and width. In the prior example, a $6 \times 4$ configuration of $20 \times 20$-centimeter boxes would fit the particular pallet design of $120 \times 80$ centimeters (and the height limit of 160 centimeters also works out to exactly eight 20-centimeter tiers).

Exhibit 4-69 shows how modular master cartons might be designed using multiples of the smallest carton.
Sometimes a larger carton is the main carton and the smaller cartons are designated as half or quarter cartons and so on, but the principle is the same.

Master cartons for direct-to-customer business models often use this modular carton design because it is preferable to have a limited number of box sizes. However, because a wide variety of items are shipped, the box sizes will not be ideal for minimizing cube space. In many cases the boxes will be overly large for the product and filled with air bags. This issue is an inefficiency that some innovative logistics professional might yet solve.

**Palletization**

The *APICS Dictionary, 15th edition*, defines a **pallet** as “a platform designed to be loaded with packages and moved by a forklift.” Any goods that can be palleted probably will be, since pallets can be handled more easily by equipment, saving labor and time. Pallets (or skids) also provide greater security for goods.

Wood pallets are the most common type, because almost every commercial shipping destination will have a forklift. Less common are plastic pallets and slip sheets. Wood or plastic pallets can be designed for flexibility in access. While a two-way entry pallet can be accessed from one of two opposite sides, four-way entry pallets are constructed in a manner that allows a forklift or pallet truck to insert forks from all sides.
Wood pallets are generally made of coniferous wood that has been fumigated to kill vermin and thus avoid transporting problematic species. Many countries require the use of fumigation for all wood packing material, including virtually all North and South American countries, most Mediterranean countries, South Africa, India, China, Japan, South Korea, Malaysia, the Philippines, and Australia. Treated pallets are marked with a standard symbol of compliance, created under the International Plant Protection Convention (IPPC) and shown in Exhibit 4-70. Goods arriving on pallets without this certification may be rejected by customs agents.

Exhibit 4-70: Symbol of Compliance for Properly Fumigated or Heat-Treated Wood Pallets, etc.

Slip sheets are an alternative to pallets. They are flat sheets of plastic or fiber, ranging in thickness but generally around a millimeter. They often are shaped to have lips around their edges. Their advantage is that they are lighter and take up less room in transport; their primary disadvantage is that they require specialized forklift trucks or forklift modifications.

Exhibit 4-71 contrasts slip sheets and wood pallets. Pallets and slip sheets come in standard sizes and many industries dictate use of one of these standard sizes so that pallet storage bays and handling equipment can also be standardized.
### Pallet sizes

Ideally, pallet sizes will conform to equipment and racking capabilities. However, one of the major challenges in using pallets in international applications is the number of pallet sizes in use globally. While specific industries that operate within a nation can rely on a given standard, globally there are so many standards that there is effectively no real standard. Six pallet dimensions are sanctioned by ISO, detailed in ISO Standard 6780. Check the online Resource Center for a link to these standards.

Exhibit 4-72 lists common pallet sizes.

In the U.S., standard sizes (in inches) include:
- **40 × 48**
- **36 × 48** (most common)
- **32 × 40**
- **32 × 36**
The great disparity in global pallet sizes can cause many problems. Master cartons designed for one pallet size will not work well with another pallet size. For example, a 0.4 × 0.4-meter master carton works well on a euro pallet but leaves a lot of unused space on a U.S. 36 × 48–inch pallet. Also, different-size pallets fit better or worse in different shipping containers. This means that shippers must consider pallet size before selecting a container.

Pallet efficiency and effectiveness

Pallet sizes make a big difference in unit load efficiency. For example, a 40 × 48–inch pallet equals 1,920 square inches, while a 32 × 40–inch pallet equals 1,280 square inches, so the second pallet is only 66 percent as large as the first. Assuming the stacking height is the same for both pallets, 66 percent fewer goods will fit on the second pallet. More pallets on a truck or container mean more handling cost.

Pallet load efficiency can be calculated in the same way as master carton efficiency, so we will return to our example introduced there of eight small bleach bottles fitting in a master carton with 62.8% carton efficiency. For example, a euro pallet is 80 × 120 centimeters. If it can be stacked to 160 centimeters, it equals 1,536,000 cubic centimeters (about 90,732 cubic inches). A tier of master cartons of bleach is 24 boxes. If a given order has 7 tiers, this would be 168 boxes of bleach. Recall that each box has a volume of 8,000 cubic centimeters. The pallet load efficiency calculation would then be

\[
\frac{168 \times 8,000 \text{ cm}^3}{1,536,000 \text{ cm}^3} = 0.875 = 87.5\% \text{ Pallet Load Efficiency}
\]

An additional tier of bleach would bring this to 100 percent.
To calculate how much of a pallet load is occupied by product, multiply the two percentages together:

\[ 0.628 \times 0.875 = 0.5495 = 55\% \text{ Efficiency} \]

Note that this example uses boxes that can be stacked to form a pallet with ideal dimensions. If they do not, this indicates a significant opportunity for improvement in master carton design.

The next issue with palletization is how to stack the tiers on a pallet. Incorrectly loading a pallet can result in crushed boxes and damaged goods. Rows can be arranged in various types of brick patterns, where one stack halfway overlaps the other and rectangular corner units are turned 90 degrees from the box below. (Variations include brick, row, and pinwheel.) They can also be arranged in a block pattern, where each box is stacked directly over the box below.

Some experts believe that brick patterns are not as good at withstanding crushing damage and should not be used. The strongest parts of a cardboard box are its corners, while its weakest points are halfway between each corner. In making a brick pattern, the weight of the box above is supported by the weakest part of the box below. The benefit gained from a brick pattern is load stability of the unit. However, this can instead be achieved using shrink wrap and corner guards. This opinion runs contrary to popular belief, and brick patterns are quite commonly used. Brick patterns may also be necessary when the boxes are of different sizes rather than all being uniform. Pallet stacking of multiple different-size master cartons is often facilitated by computer programs that indicate the most efficient method of stacking.
Progress Check

The following questions are included as study aids and may not follow the format used for questions in the APICS CLTD examination. Read each question and respond in the space provided. Answers and page references appear on the page following the progress check questions.

1. What is the main risk if an organization adds some protective packaging during rather than at the end of production and assembly?
   a) The packaging can worsen cube utilization for shipping.
   b) The packaging can create a new bottleneck area.
   c) The packaging might reduce the number of material handling moves done per unit.
   d) The packaging will be redundant with what must be added later anyway.

2. An organization is considering using slip sheets instead of the wood pallets currently in use. What is a necessary prerequisite?
   a) Getting new warehouse floors that will work well with slip sheets
   b) Determining if unit loads will fit on a slip sheet
   c) Determining whether this will cost more or less than wood pallets
   d) Getting all customers to agree to get the right forklift modifications

3. What is a good way to improve the cube utilization of a product?
   a) Redesign kits to fit in the protective packaging at points of low damage vulnerability.
   b) Produce master cartons that are larger than a standard pallet.
   c) Remove all cushioning material from individual units but add some to master cartons.
   d) Avoid using master cartons in favor of shrink wrap.

4. What is the best option if truck shipments of pet fish are arriving with too many dead fish due to high water temperatures of the bags holding the fish?
   a) Ship the fish in larger amounts of water.
   b) Use thicker insulation on the master carton.
   c) Switch to refrigerated trucks.
   d) Switch to air transport.

5. A product is sturdy, and its consumer packaging is sturdy. How sturdy should the master carton be?
   a) It can be less sturdy.
   b) It should be equally sturdy.
   c) It should be sturdier.
   d) This shipment does not need a master carton.

6. What is the main reason a load of pillows might be vacuum-packed prior to shipment?
   a) To protect the pillows from humidity
   b) To protect the pillows from impact
   c) To minimize cubic space
   d) To minimize weight
7. What type of technology can provide information on the location of a container in transit?
   a) Active RFID tags
   b) Bar code
   c) Cellular network
   d) Passive RFID tags

8. What is the advantage of shipping something like peanut butter in a large pallet-sized bulk carton rather than in individual retail sale-size containers?
   a) Helps shipment weigh out before it cubes out
   b) Easier equipment handling
   c) Easier manual handling
   d) Shipping less air

9. Which is the most reliable method of capturing data on incoming products?
   a) Handheld bar code reader
   b) Visual identification of markings
   c) RFID readers for all items on a pallet
   d) RFID readers for items on a conveyor belt

10. A master carton is 40 × 40 × 40 centimeters. What would be the best carton size for smaller goods of the options provided? (All measurements are in centimeters.)
    a) 20 × 30 × 40
    b) 30 × 30 × 30
    c) 40 × 20 × 20
    d) 40 × 40 × 40 (and it should be packed with more of the smaller objects)
Progress check answers

1. b (p. 4-164)
2. d (p. 4-184)
3. a (p. 4-165)
4. b (p. 4-165)
5. a (p. 4-168)
6. c (p. 4-169)
7. a (p. 4-173)
8. d (p. 4-181)
9. d (p. 4-173)
10. c (p. 4-181)