Chapter 5

Material Handling

Material Handling Defined

- The *layout design* and *material handling system* design are inseparable.

- Material handling accounts for
  - 25% of all employees
  - 55% of all factory space
  - 87% of production time
  - 15 to 70% of the total cost of a manufactured product

- Cost reduction can be achieved not by eliminating material handling but by more efficient material flow

Material Handling Defined

Definitions:

1. Material handling is the art and science of moving, storing, protecting, and controlling material.

The Right Definition:

2. Providing the right amount of the right material, in the right condition, at the right place, at the right time, in the right position, in the right sequence, and for the right cost, by using the right method(s).

Material Handling Defined

a. <u>Right amount</u>

i. just in time vs. just in case inventory management.

ii. Small load size is preferred

iii. Match production lot size with transfer batch

b. <u>Right material</u>

i. Automatic identification system is key to accurate identification

ii. Simplify the part numbering system

iii. Maintain good database system

Material Handling Defined

c. Right condition
   i. Delivery to customer requirements (packed or unpacked…)
   ii. The absence of damage
d. Right sequence
   i. Simplify work (eliminate unnecessary operations, and improve the remaining)
   ii. Change sequence of operations, or combine operations.
e. Right Orientation
   i. Position for ease of handling (critical in automated systems)
   ii. Changing the design (by including handling tabs)
f. Right Place
   i. For transportation or storage
   ii. Central storage vs. distributed storage

Material Handling Defined

g. Right time
   i. Not early neither tardy
   ii. Use low variance transportation (forklift vs. AGV’s)
   iii. Cycle time reductions not lower delivery time
   iv. The emphasis is on the right time, not the fastest time.

h. Right cost
   i. The right cost is not necessarily the lowest cost
   ii. On-time delivery increases customer satisfaction

Material Handling Defined

i. Right methods

i. Requirements-driven materials handling systems over solution-driven system.

- Solution-driven systems are those in which technologies are chosen without consideration for how the technologies match requirements; instead of defining requirements and matching technology options to requirements, the solution-driven approach force-fits a technology on the system.

ii. Equipments should be the last step

Material handling principles

Provide guidance and perspective to material handling system designers.

1. Planning principle: define in advance what material when and where to move and how to move it
2. Standardization process: less variation in methods and equipments.
3. Work principle: material flow (volume, weight..) *distance
4. Ergonomic principle: fit task to man
5. Unit load principle: that can be stored or moved as a single entity such as pallet or container
6. Space utilization principle: utilize the 3-D space (cubic space)

Principles…continue

7. System principle: collection of interacting entities that form a unified whole.
8. Automation principle
9. Environmental principle: Not to waste natural resources, and reduce negative effects on the environment.
10. Life Cycle Cost principle:

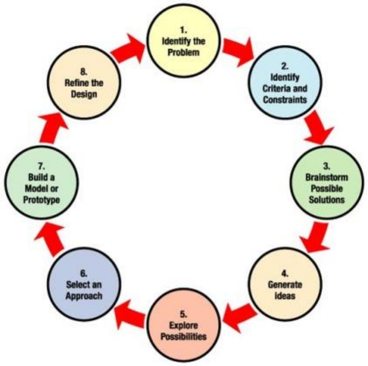
See table 5.1 for checklist (to facilitate the identification of opportunities to improve existing material handling systems, or to serve in designing new systems)

Material Handling System Design

Factors to be considered in analyzing material handling problems include:

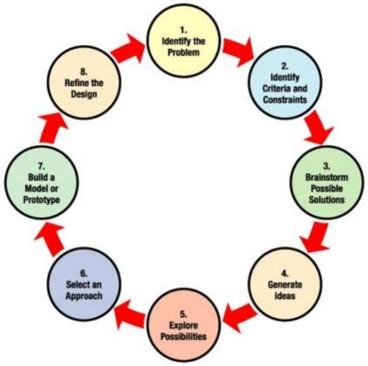
- Types of materials
- Their physical characteristics
- Quantities to be moved
- Sources and destinations for each move
- Frequencies or rates at which moves must be made
- Equipment alternatives
- Units to be handled

Designing Material Handling Systems



1. Define the objectives and scope for the material handling system.
2. Analyze the requirements for moving, storing, protecting, and controlling material.
3. Generate alternative designs for meeting material handling system requirements.
4. Evaluate alternative material handling system designs.

Designing Material Handling Systems

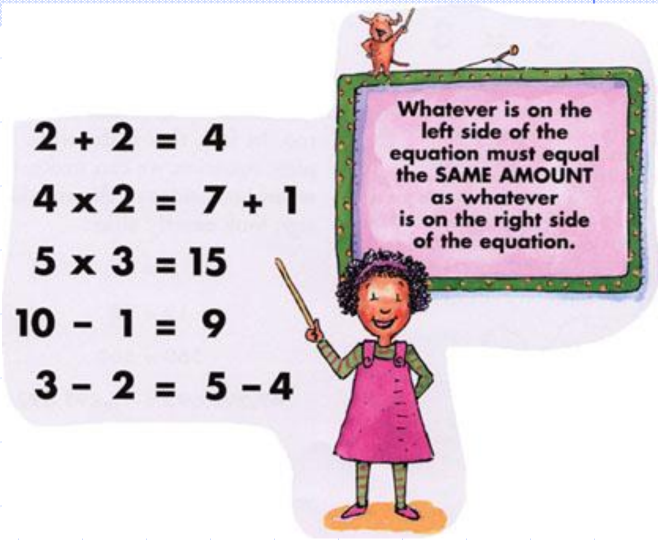


5. Select the preferred design for moving, storing, protecting, and controlling material.

6. Implement the preferred design, including the selection of suppliers, training of personnel, installation, debug and startup of equipment, and periodic audits of system performance.

Material Handling System Equation

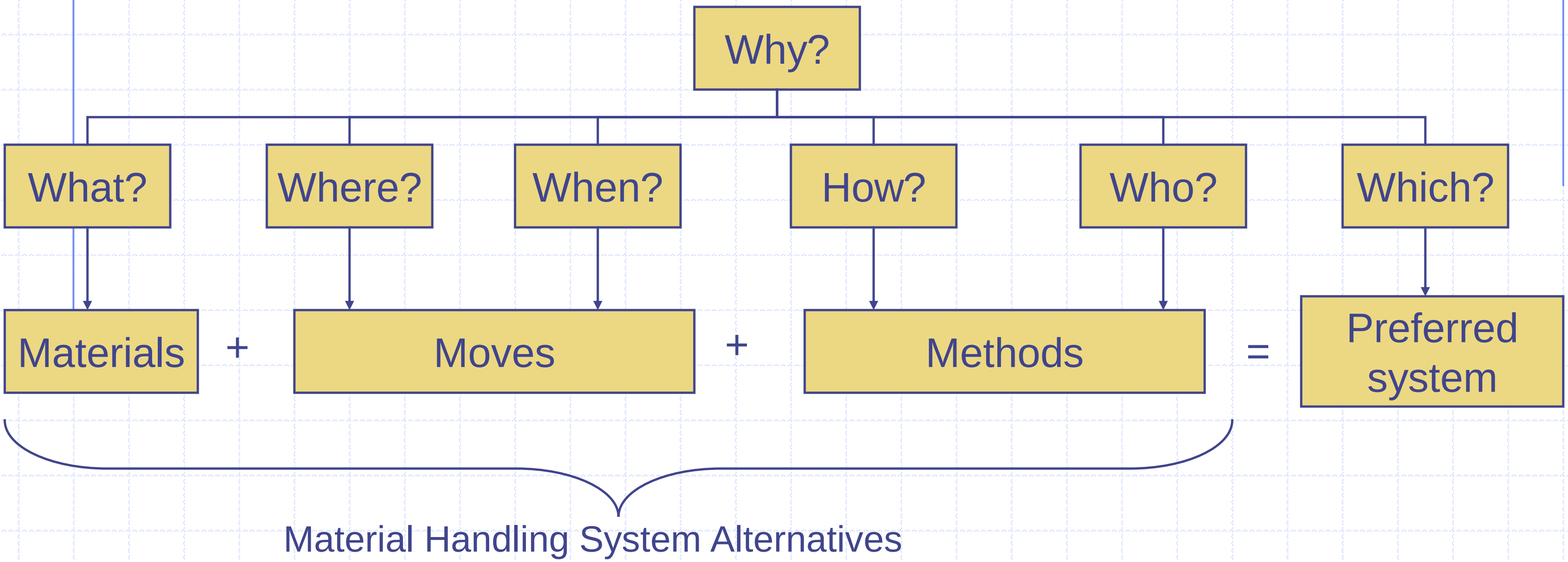
- ➢ Provides means to identify opportunities for improvement.
- ➢ It gives us a framework for identifying solutions to material handling problems.



- The what defines the type of materials moved, the where and when identify the place and time requirements, the how and who point to the material handling methods. Leads us to:

Materials (what)+ Moves (where, when) + Methods (how, who) = Recommended System (which)

Material Handling System Equation



Material Handling System Equation

- The What Question:
  1. What are the types of material to be moved?
  2. What are their characteristics?
  3. What are the amounts moved and stored?

- The Where Question:
  1. Where is the material coming from? Where should it come from?
  2. Where is the material delivered? Where should it be delivered?
  3. Where is the material stored? Where should it be stored?
  4. Where can material handling be tasks be eliminated, combined, and simplified?
  5. Where you can apply mechanization, or automation?

See other Questions in the Text Book.

For each question we ask *Why* it is necessary or not.

Material Handling Planning Chart

- A material handling planning chart can be used to gather information pertaining to a specific material handling problem and to provide a preliminary examination of the alternative solution.
- The result from analyses using this chart can then be used to further refine solution strategies using methods such as the simulation of alternative solutions. P.185

Step #	O	T	S	I	Description	Depart.	Size	Wt.	Freq.	Dis.	Method of MH

Unit Loads

Unit load Definition:

A single item, a number of items or bulk material which is arranged so that the load can be stored, and picked up and moved between two locations as a single mass.

- This definition suggests that the nature of the unit load could change each time an item, or a number of items, or bulk material is moved.
- Primary advantage of using unit loads is the capability of handling more items at a time and reducing the number of trips, handling cost, loading and unloading times, and product damage.

Unit Loads (contd.)

- Examples of unit load:
  - A single item picked and moved manually between two locations.
  - One pallet load of nonuniform-size cartons with different products picked and moved by a lift truck from packaging area to the shipping dock.
  - One full load of products delivered by a truck-trailer from warehouse to customer store.
  - If the trailer is half full, it is still one unit load. It is the move that defines the unit load.

Unit Loads (contd.)

- The unit load size specification has a major impact on the specification and operation of the material handling system.
- Large unit load:
  - Required bigger and heavier equipments, wider aisles.
  - Increase work-in-process (WIP) inventory.
  - Major advantage is fewer moves
- Small unit load:
  - Required simple MH methods (such as push carts).
  - Reduce work-in-process
  - Support JIT production
  - But increase the transportation requirements.
- The Optimal Unit Load is the quantity where system idle time, WIP and transportation cost are minimized

Unit Loads (contd.)

- Two important elements in determining the size of the unit load are:
  - "Cube" limit.
  - Weight limit.
  - Example: a cartoon with outside dimension 16"X12"X6" and a gross weight limit of 65 lbs)
- The integrity of the unit load can be maintained in a variety of ways:
  - Boxes, cartons, pallets (wooden)
  - Strapping, shrink wrapping, and stretch wrapping.

Unit Loads (contd.)

Pallet

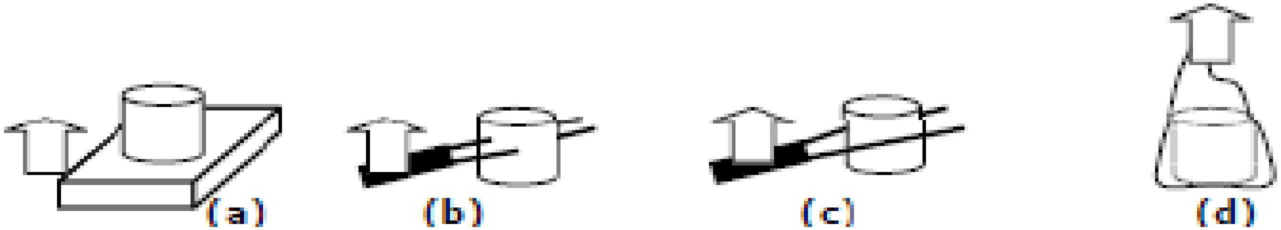
Skids

Stretch wrapping

Shrink wrapping

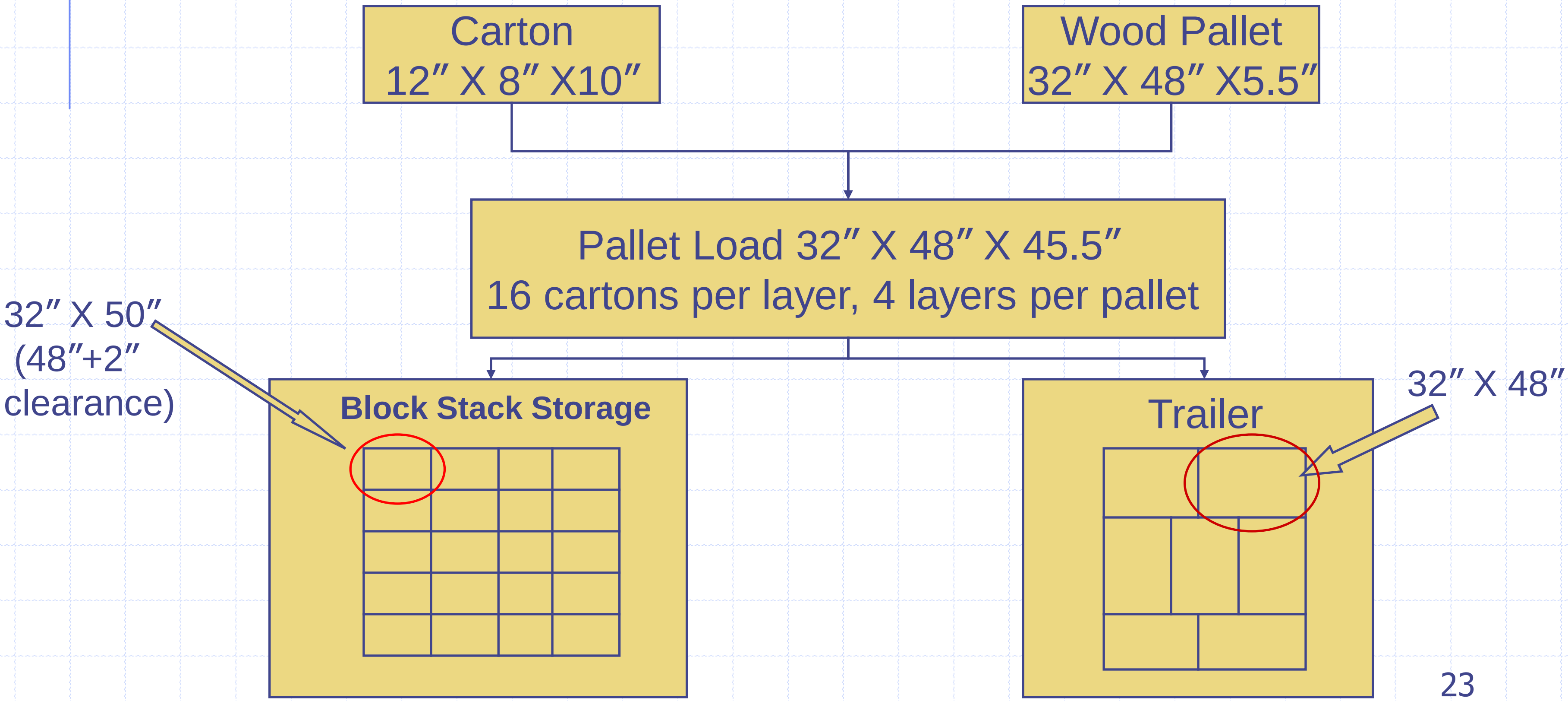
Unit Loads (contd.)

- The methods by which the unit load can be moved:
  A. Lifting under the mass
  B. Inserting the lifting element into the body of the unit load.
  C. Squeezing the load between two lifting surfaces.
  D. Suspending the load.



Unit Loads (contd.)

- The dimensional relationships between the various forms the unit load takes.
- The cartoons are stacked on pallets, and the full pallet loads are loaded to a trailer or staked in a warehouse

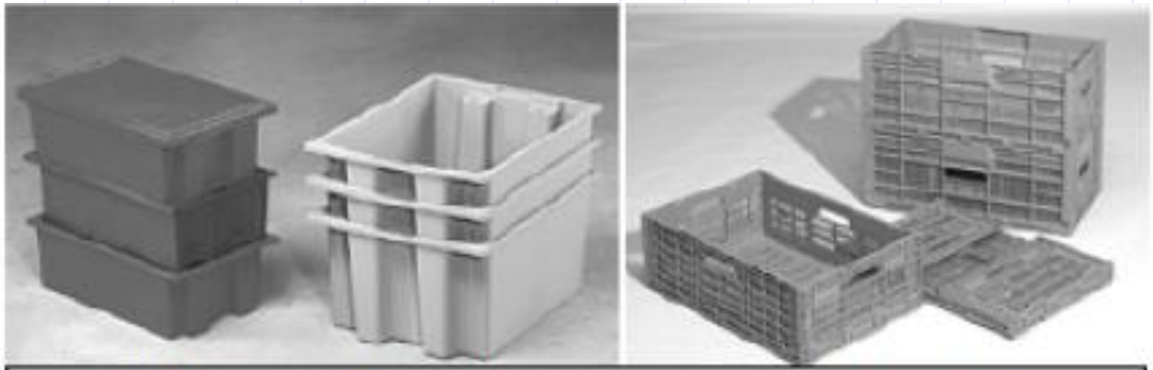


Unit Loads (contd.)

Efficiency of containers

- Returnable containers should have good *stacking* and *nesting* features can provide significant reduction in material handling costs

- *Stackability* means that a full container can be stacked on top of another full container in the same orientation.
- *Nestability* means that the shape of the containers permits an empty container to be inserted into another empty container.



Stackable Nestable Collapsible

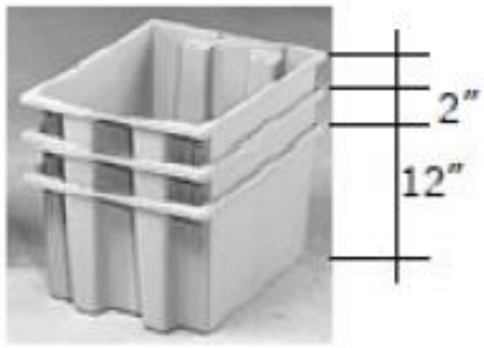
Unit Loads (contd.)

Efficiency of containers

- Efficiency of Returnable Containers:

  Example:

- Given the following dimensions of a particular type of plastic reusable containers:
  - Inside dimensions 18”x 11”x11”
  - Outside dimensions 20”x12”x12”
  - Each nested container 20”x12”x2”
  - A trailer inside dimension 240”x120”x120”
  - Containers are not palletized. Assume no clearance is needed between containers, and between containers and the walls of the trailer.



Unit Loads (contd.)

Efficiency of containers

Example (contd.):

- Determine the following:

1. Container space utilization.
2. Container nesting ratio.
3. Trailer space utilization (if all containers stacked vertically in only one orientation).
4. Trailer return ratio.

Unit Loads (contd.)

Efficiency of containers

Example (contd.)

- Container space utilization:
  - Divide the usable cube by the exterior envelope of the container. The container efficiency is:
  - (18″x11″x11″)/(20″x12″x12″)=0.76 or **76%**

- The container nesting ratio:
  - Divide the overall container height by the nested height:
  - 12″/2″=6 (the ratio is **6:1**). Six nested containers use the same space as one closed container.

Unit Loads (contd.)

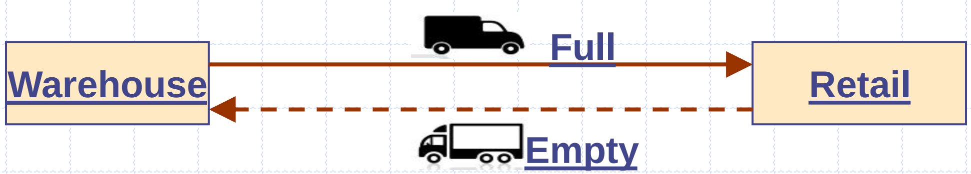
Efficiency of containers

- **The trailer space utilization:**
  - Number of loaded containers that the trailer can take:

    240″/20″=12 container along the length, 120″/12″=10 containers along the width, and 120″/12″=10 containers stacked vertically. The total number is 12x10x10=1200.
  - The trailer space utilization is:

    (18″x11″x11″)(1200)/(240″x120″x120″)= 0.76 or **76%**
- **The trailer return ratio:**
  - One stack of loaded containers has 120″/12″=10 containers
  - One stack of empty containers has: 1+(120″-12″)/2″=55
  - The total number of empty containers per trailer is:

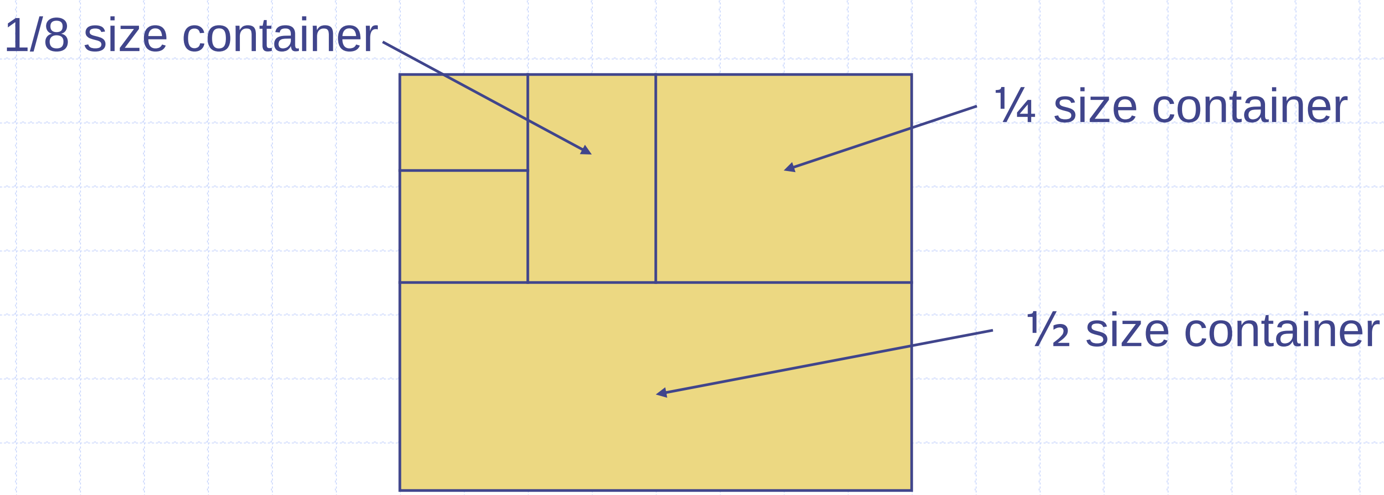
    55x12x10=6600 containers
  - The trailer return ratio: 6600/1200 = **5.5**



Unit Loads (contd.)

Efficiency of containers

- In selecting containers, size progression is one of the important consideration (e.g. a smaller container is half the size of the larger container: 1, 0.5, 0.25, 0.125,and so on).
- These types of containers allows the efficient utilization of the load deck of an automated guided vehicle , also simplify the pallet loading of mixed-sized containers.



Unit Loads (contd.)

<u>Pallets and Pallet Sizes:</u>

- Another common method of containing the unit load.
- Common pallet sizes: 32 in x 40 in , 36 in x 48 in
  40 in x 48 in , 42 in x 42 in, 48 in x 40 in, 48 in x 48 in
  - The first dimension corresponds to the length of the stringer board , and the second dimension to the length of deck-board of the pallet.

- Two-way pallet: the fork entry can be only on two opposite sides of the pallet and is parallel to the stringer side.
- Four-way pallet: the fork entry can be on any side.

Pallet

Unit Loads (contd.)

- Pallets and Pallet Sizes:
- Table 5.2 shows a comparison of various types of pallets (wood, plastic ,metal, etc.).
- The relationship between the container and the pallet, referred to as the *pallet loading problem*.
  - The objective is to maximize the use of space.
  - Another objectives are load stability and low cost.

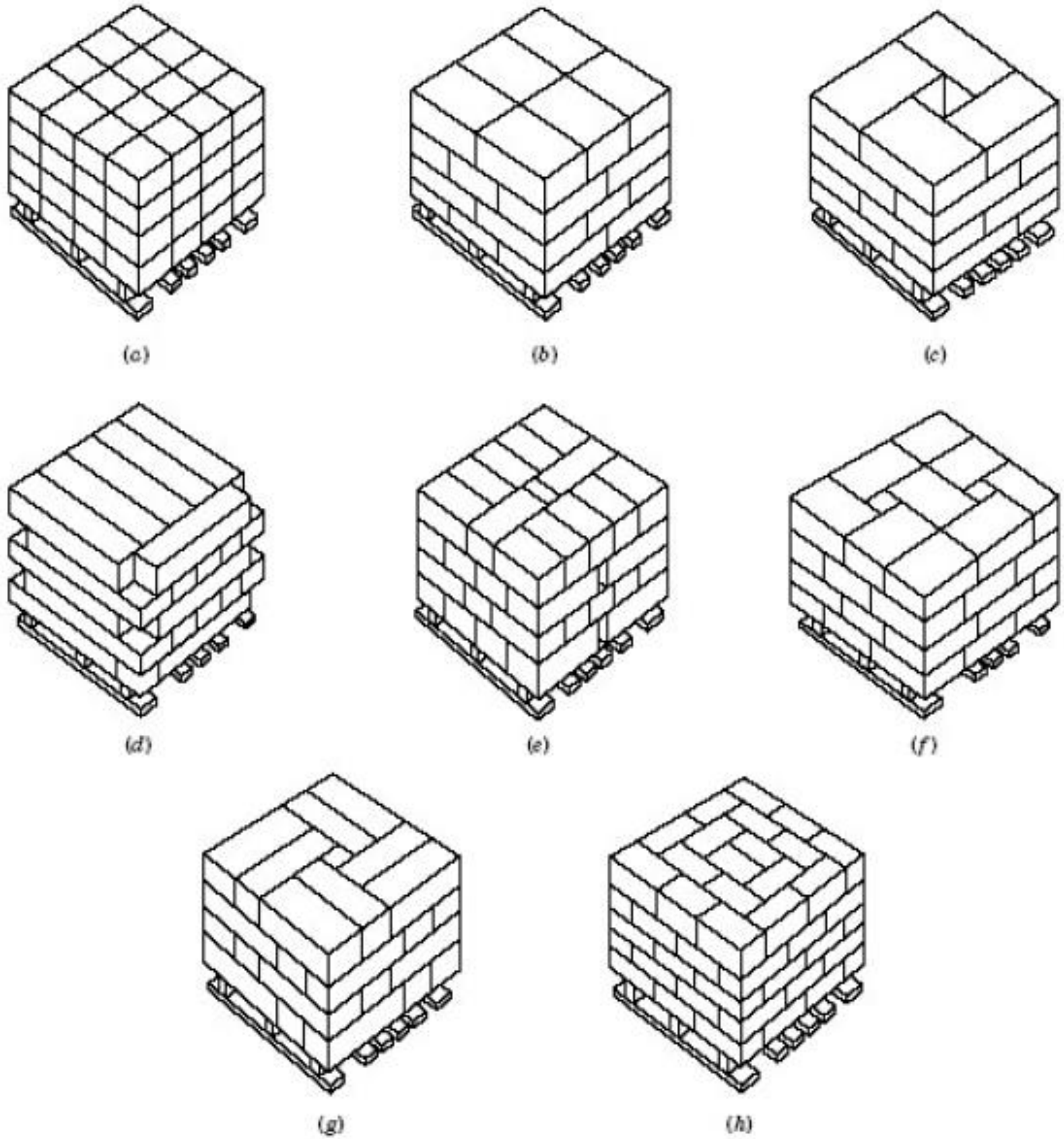


Figure 5.9 Stacking patterns for different pallet sizes. (*a*) Block pattern. (*b*) Row pattern. (*c*) Pinwheel pattern. (*d*) Honeycomb pattern. (*e*) Split-row pattern. (*f*) Split-pinwheel pattern. (*g*) Split-pinwheel pattern for narrow boxes. (*h*) Brick pattern. (*From [7] with permission.*)

Unit Loads (contd.)

Unit Load Interaction with Warehouse Components:

- The purpose is to illustrate the relationship between the unit load size and configuration and certain other system factors.
- Warehouse components include:
  - the packaging, palletizing, storing, and shipping operations.
- Critical factors in this interaction are:
  - the specifications of the carton used, and the pallet size.
- These factors affect the selection of:
  - the material handling equipment, the physical configuration of the storage facility, and the utilization of both the warehouse and highway trailer.

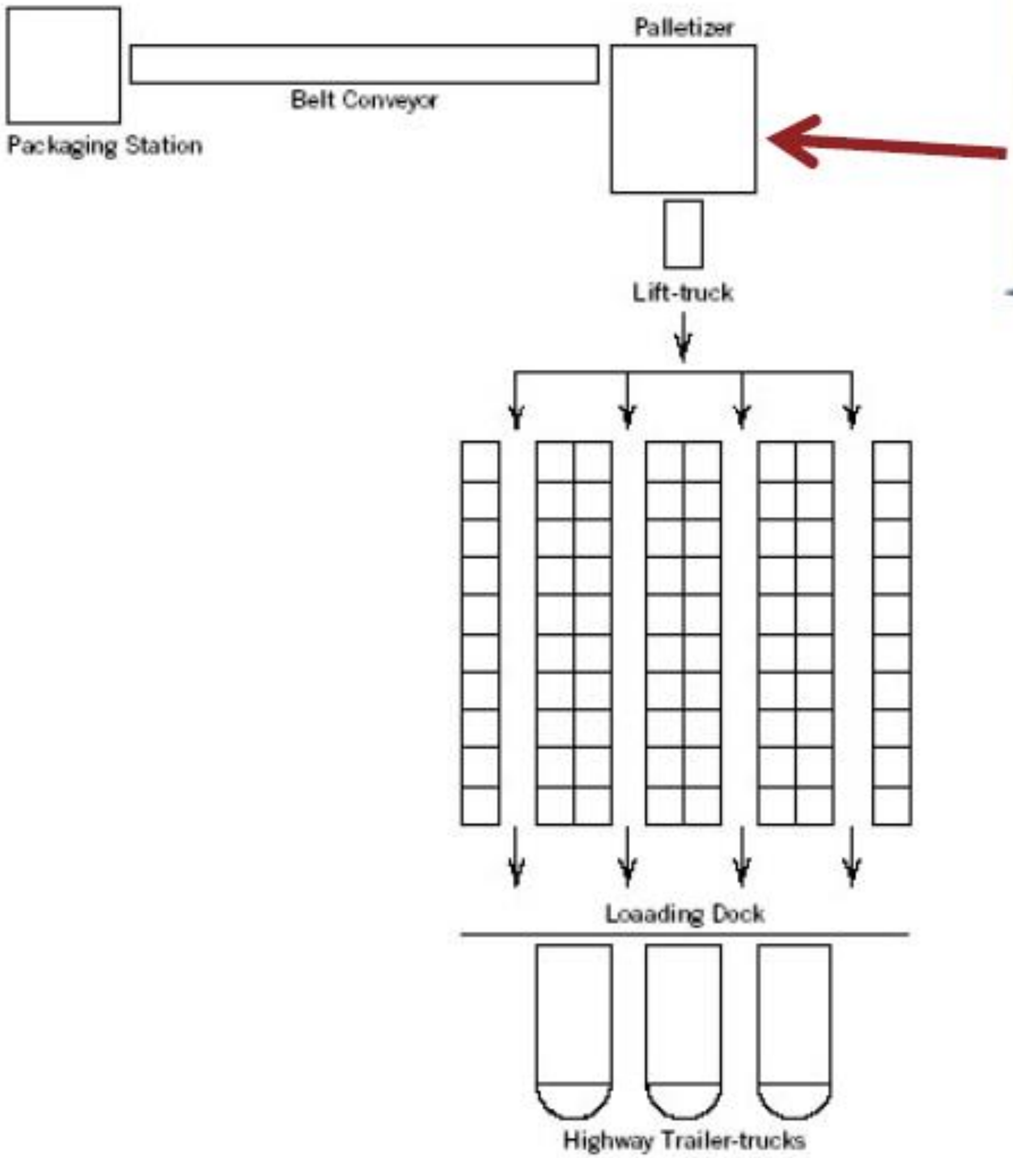
Unit Loads

Unit Load Interaction with Warehouse Components:

Example:

The operations included in this example are :

1. Finished goods are packaged using closed-top cartoons.
2. The cartons are transported to a palletizer.
3. The pallet loads are formed using a mechanized palletizer.
4. The full pallet loads are then stored in the finished goods warehouse using a powered lift truck.
5. Upon receipt of customer orders, full pallet loads are retrieved from the warehouse by a powered lift truck.
6. The pallets are then loaded on highway trailer trucks.



- Manufacturing subsystem of
  - packaging
  - palletization
  - storage
  - shipping

Unit Loads

Unit Load Interaction with Warehouse Components:

Example (contd.):

- The specifications of the carton size is the most critical element in the design of the unit load system.
- The carton size dictates:
  - the number of parts contained in each carton, and total number of cartons that may be packaged and transported to the palletizer.
- The carton flow rate to the palletizer depends on:
  - the parts flow rate to packaging stations, and the time required to package each carton.
- The rate at which full pallet loads are formed is a function of:
  - the capacity of the palletizer, the carton size, and pallet size.

Unit Loads

Unit Load Interaction with Warehouse Components:

Example (contd.):

- A powered lift truck is used to pick up loads from the palletizer to warehouse, and from warehouse to delivery location. Hence, the type of material handling equipment will dictate the floor space requirements for the warehouse.
  - For instance, the use of a narrow-aisle truck can reduce the floor space requirements.
- The next step is loading of the pallet loads into highway trailer-truck for delivery to customers.
- The number of pallet loads delivered per truckload is constrained by:
  - the inside dimensions of the trailer, and the dimensions and capability of the dock lift truck to maneuver the load inside the trailer.

Unit Loads

Unit Load Interaction with Warehouse Components:

Example (contd.)

- Further tradeoffs must be considered between warehouse storage space utilization and the trailer-truck utilization. (Number of the trips).

- The above example highlighted the many interactions possible between unit load and warehouse components.

- See the numerical example that given in the text book page 197 to illustrate some of the interactions.

Unit Loads (contd.)

Container and Pallet Pooling:

- Instead of buying, rent containers and pallets for a fee per day per container or pallet.
- Advantages:
  - Minimize the movement of empty pallets.
  - Utilization is increased.
  - No need for allocating extra space to store them.
  - Reduce maintenance.
  - Much better quality, less product damage, and efficient interfacing with material handling equipment.

Should the material handling system be designed around the unit load or should The unit load system be designed to fit the material handling system?

Material Handling Equipment

MH equipments are classified into the following categories:

1. Containers and Unitizing Equipment
2. Material Transport Equipment
3. Storage and Retrieval Equipment
4. Automatic Data Collection and Communication Equipment