Material Handling Systems

END 4650

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Material Handling – A Definition

The art and science of moving, storing, protecting, and controlling material throughout the process of manufacturing, distribution, consumption and disposal..

Right amount
Right material
Right time

Right sequence
Right cost
Right methods

https://www.youtube.com/watch?v=wZvWpYvXHLs
1.AMHSA-ASRS

Conventional view: Focuses on solely the movement of material from one location to another.

Contemporary: Expand the focus to overall handling decisions in the company.


Carton & tote conveyors

Traditional and Modern Views

- The traditional view:
  - MH Operations
    - non-value adding
    - Add cost instead
  - Hence MH should be avoided and minimized
- Modern View
  - Recognize the time and the place utility(?) of MHO:
    - right time,
    - right place.
  - Create a flexible system that can be used for a variety of products and processes

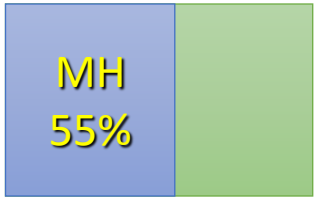
Traditional and Modern Views

- Manufacturing(i.e., fabrication and assembly)[1]:
  - creates “form utility” by changing the shape, form, and makeup of material
- Material Handling:
  - “time and place utility” through the handling, storage, and control of material, as distinct from manufacturing
    - The value added by having parts stored next to a bottleneck machine is the savings associated with the increase in machine utilization minus the cost of storing the parts at the machine.
    - The value (to the customer) added by the overnight delivery >= Regular mail service

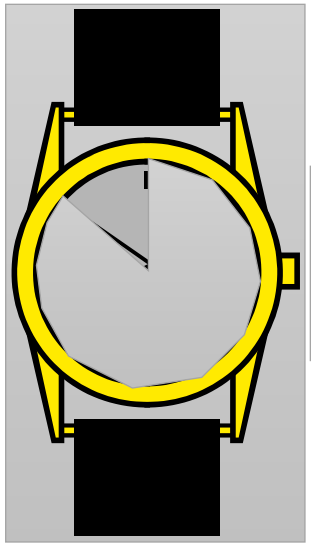
Importance of Material Handling

In a typical factory, Material Handling accounts for [ED]:

25% of Employees



Factory Space



87%
Production
time

15%

70%

Product
Cost

Material Handling Examples

Material Handling is not restricted to the manufacturing or distribution environment

Mass Transportation

Hospitals

Mail Delivery

Construction

Goals of Material Handling

- Reduce unit costs of production
- Improve (or maintain) product quality and reduce damage
- Promote safety and improve working conditions

- Promote productivity through
  - Flow in a straight line
  - Less and Less movement
  - Gravity!
  - Move more at once
  - Mechanize and automate


I A M
FUNK MASTER
22-11-08
08:10:44


I A M
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22-11-08
08:11:28

Goals of Material Handling

- Reduce tare (dead) weight
- Control inventory
- Promote increased use of facilities by:
  - Standardizing material handling equipment
  - Develop a preventive maintenance program
  - Integrate all material handling equipment into a system

Principles of Material Handling

- There are no definite “rules”
- Ten Principles of Material Handling
  - *accumulated experience and knowledge* of many *practitioners*
  - compiled by
    - the College-Industry Council on Material Handling Education (CIC-MHE)
    - Material Handling Institute (MHI),

Planning Principle

- *All material handling should be the result of a deliberate plan where the needs, performance objectives and functional specification of the proposed methods are completely defined at the beginning*.
- **Definition***:*
  - A plan is a prescribed course of action that is defined in advance of implementation.
  - In its simplest form, MHP defines
    - the material (what) and
    - the moves (when and where);
    - the method (how and who).

Planning Principle

Key points:

- should be developed in consultation between the planner(s) and all who will use and benefit from the equipment to be employed
- should reflect
  - the more immediate needs
  - the strategic objectives
- should document
  - existing methods and problems, physical and economic constraints
  - future requirements and goals.

Standardization Principle

- *Material handling methods, equipment, controls and software should be standardized within the limits of achieving overall performance objectives and without sacrificing needed flexibility , modularity and throughput*
- **Definition***:*
  - Standardization means less *variety* and *customization* in the methods and equipment employed.

Standardization Principle

Key Points:

- The planner should select methods and equipment that
  - can perform a variety of tasks under a variety of operating conditions
  - in anticipation of changing future requirements
- Standardization applies to
  - sizes of containers
  - operating procedures
  - equipment.
- Standardization
- flexibility
- modularity

} Should be compatible

Work Principle

- *Material handling work should be <u>minimized</u> without sacrificing*
  - *productivity*
  - *the level of service required*.

- **Definition**:
  - The measure of work is
    - Material Handling Flow X Distance Moved
    - Material handling Flow: volume, weight or count per unit of time

Work Principle

Key Points

- Simplify processes by reducing, combining, shortening or eliminating unnecessary moves
  - each pickup and set-down,
  - placing material in and out of storage
- Following should support the work minimization objective.
  - operation sequences
  - process/equipment layouts
- Use *Gravity* where possible but be careful for
  - safety
  - product damage
- The shortest distance between two points is a straight line!

Ergonomic Principle

- *Human capabilities and limitations must be recognized and respected in the design of material handling tasks and equipment to ensure safe and effective operations*

- **Definition**:
  - Ergonomics is the science that seeks to adapt work or working conditions to suit the abilities of the worker

Ergonomic Principle

Key Points

- Ergonomics covers both
  - physical tasks
  - mental tasks.
- Workplace should be safe for people
- Equipments should
  - eliminate repetitive and strenuous manual labor.

Unit Load Principle

- *Unit loads shall be appropriately sized and configured in a way which achieves the material flow and inventory objectives at each stage in the supply chain.*

- **Definition**:
  - A unit load is one that can be stored or moved as a *single* entity at *one time*, such as a pallet, container or tote, regardless of the number of individual items that make up the load.

Unit Load Principle

Key Points

- Less effort and work is required to collect and move
  - many individual items as a single load

  than to move
  - many items one at a time.

- Load size and composition may change as material and product moves through stages of
  - manufacturing
  - distribution channels.

- Large Unit Loads
  - common both pre and post manufacturing
  - in the form of raw materials and finished goods.

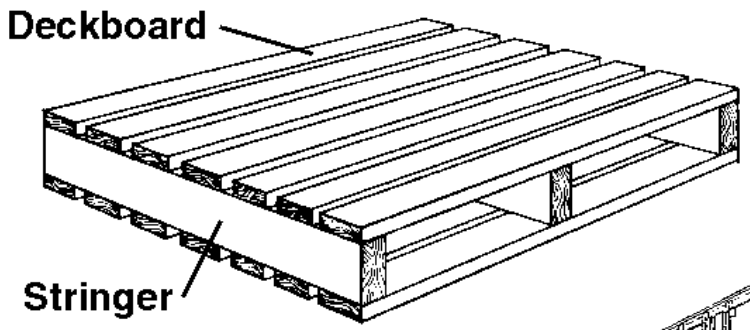
- Small Unit Loads
  - During manufacturing,
  - including as few as one item
  - Results in
    - less in-process inventory
    - shorter item throughput times
  - Good for
    - flexibility,
    - continuous flow
    - just-in-time delivery

Unit Load Principle

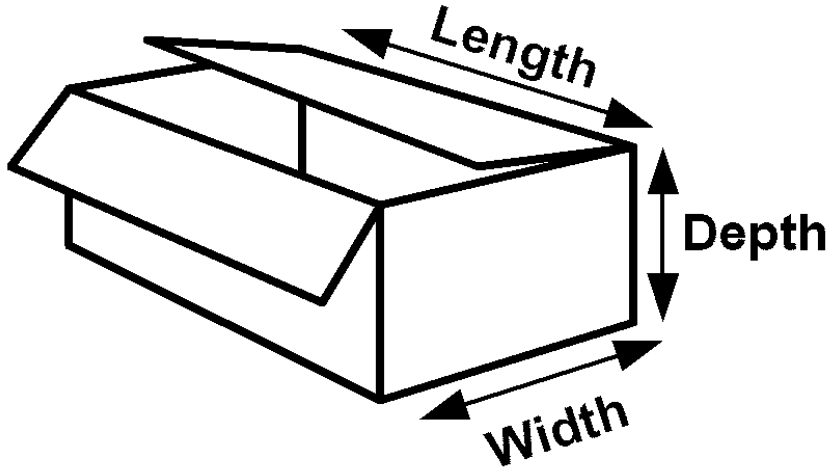
- Unit loads composed of a mix of different items are consistent with
  - JIT
  - customized supply strategies

Unit Load Examples

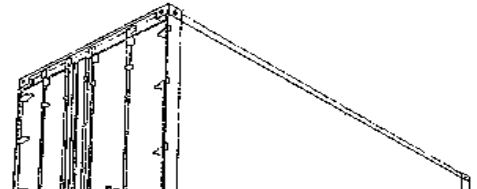
Pallet

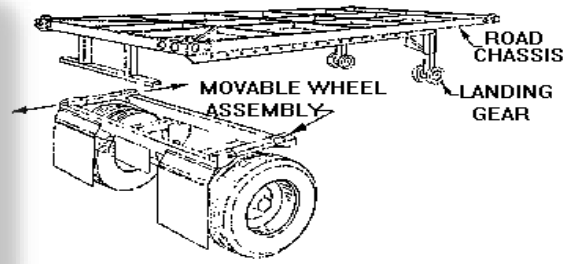


Carton

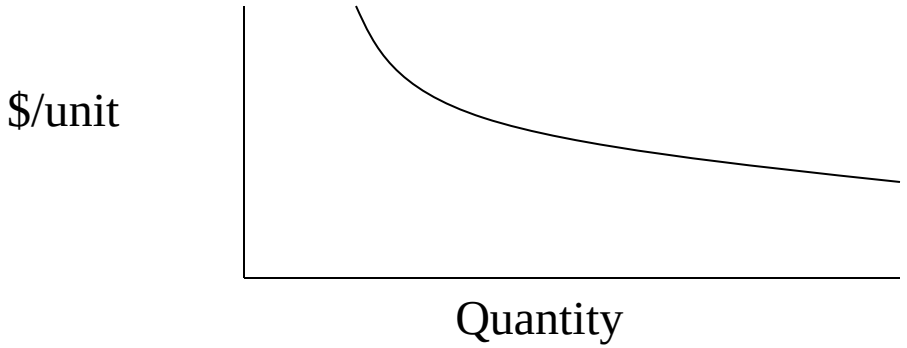


Intermodal Container





Unit Load Principle



The greater the amount moved per trip,
the less the cost per unit moved

↓

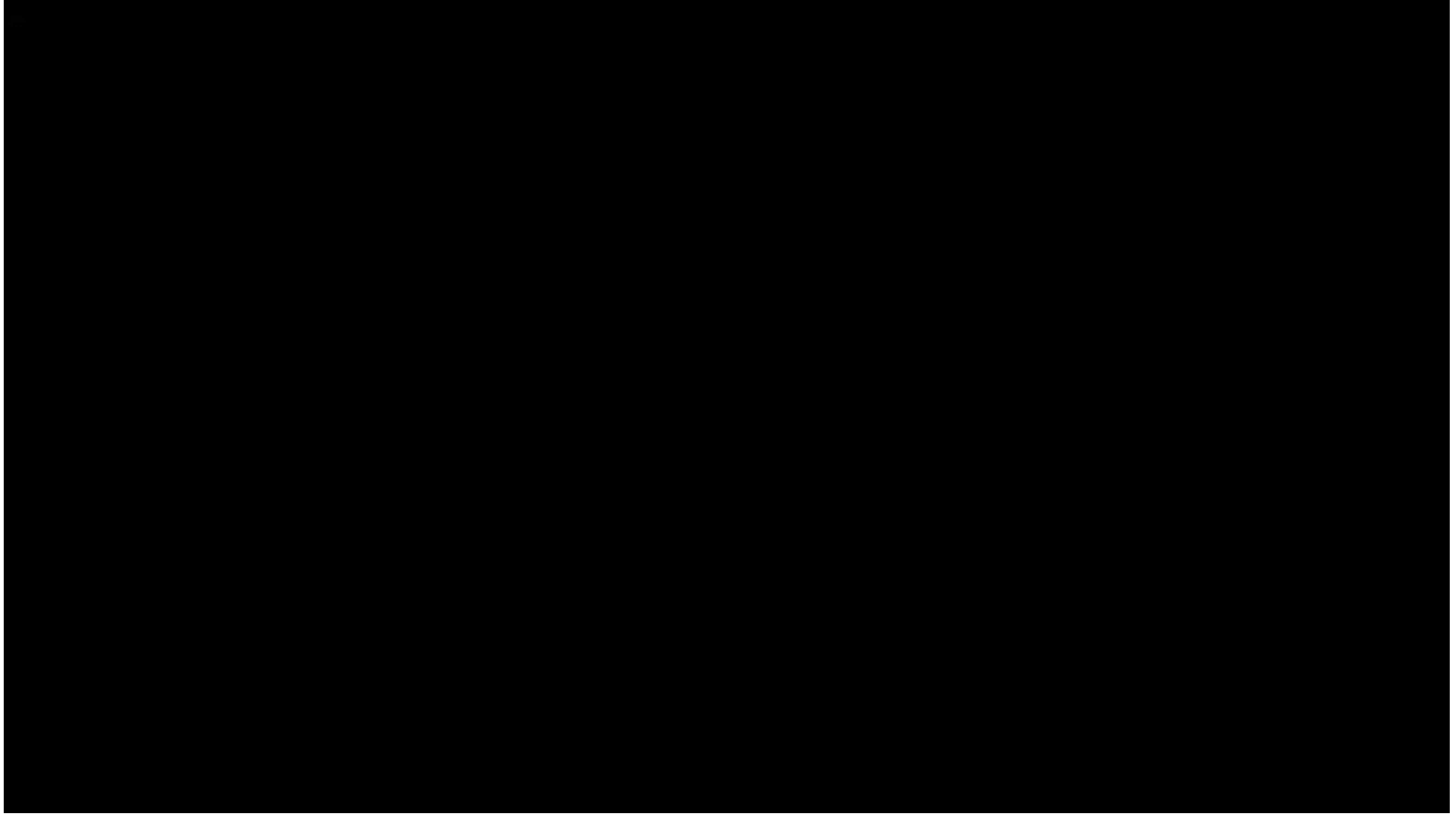
Maximize Unit Load

Unit Load – Pros and Cons

- Advantages of unit loads:
  - More items can be handled at the same time, thereby reducing
    - the number of trips required
    - handling costs,
    - loading and unloading times,
    - product damage.
  - Enables the use of standardized material handling equipment.

Unit Load – Pros and Cons (burada kaldım)

- Disadvantages of unit loads
  - Time spent forming and breaking down the unit load.
  - Empty containers/pallets may need to be returned to their point of origin.
  - Cost of containers/pallets and other load restraining materials
  - https://www.youtube.com/watch?v=q6SazdN5YjU S1.V4 Stretch



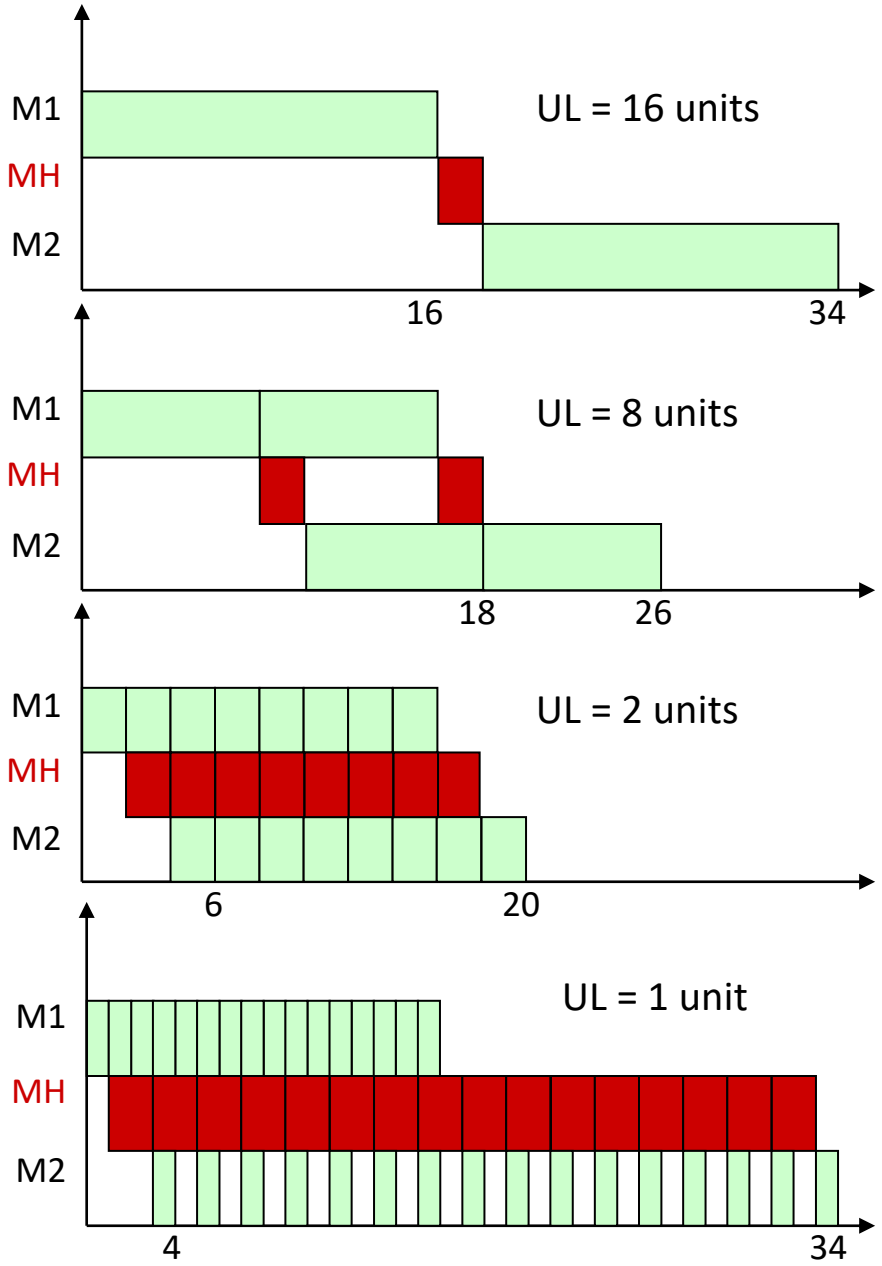

Bottom revolutions should wrap pallet and boxes

Small load? / Large load?

Large Loads:
Bigger and heavier equipment
wider aisles
higher floor load capacities
Large WIP
BUT: Fewer moves

Small Loads:
Support JIT
Decrease in job completion time
Increase material handling time
Increase transportation requirement
Less WIP
Simple material handling

Unit Load and Cycle Time



Lot size = 16 units
Machining = 1 min/unit
Operations 1 and 2 @ M1 and M2
MH = 2 min/trip

Large unit loads:
longer cycle times, fewer moves

Small unit loads:
lower cycle time*, lower WIP, more frequent handling

(only if MH time for one unit is less than processing time for one unit. WHY?)

How to Determine the Unit Load

Space Issues:

- Size of carrier
- Size and weight of items
- Space for storing loaded/unloaded container
- Aisle widths, door sizes, and clear stacking heights

Overhead Issues:

- Cost, supply and maintenance
- Equipment used for moving
- Environmental regulations

Determining Unit Load Size

- ULs can be used both for
  - in-process handling
  - distribution (receiving, storing, and shipping).

- Production Batch Size:
  - the number of items that will be produced after a machine has been setup.
  - Read https://en.wikipedia.org/wiki/Batch_production

- Transfer Batch Size:
  - the number of units that move as a group from operation to operation

Determining Unit Load Size

- **<u>Selecting UL size for in-process handling:</u>**
  - Single part, UL size, Transfer Batch Size, Production Batch Size
  - **Single part ≤ UL size ≤ Transfer batch size ≤ Production batch size**
  - When parts are transferred between adjacent operations,
    - UL may be a single part
  - When operations are not adjacent,:
    - short distance moves ⇒ smaller UL sizes,
    - long distance moves ⇒ larger UL sizes.
  - The practical size of a UL may be limited by
    - the equipment and aisle space available
    - the need for safe material handling (in accord with the Safety Principle).

Determining Unit Load Size

- **Selecting unit load size for distribution**:
  - Containers/pallets
    - are usually available only in standard sizes and configurations.
  - Truck trailers, rail boxcars, and airplane cargo bays
    - Are limited in width, length, and height.
  - Following may limit the number of feasible container/pallet sizes for a load
    - The existing warehouse layout and storage rack configuration
    - Customer package/carton sizes and retail store shelf restrictions

Space Utilization Principle

- *Effective and efficient use must be made of all available space*.

- **Definition**:
  - Space in MH is three dimensional and therefore is counted as cubic space.

Space Utilization

Key Points

- Should be eliminated:
  - Unorganized spaces
  - blocked aisles.

- Trade-off and balance in storage areas::
  - maximizing storage density
  - accessibility and selectivity.

System Principle

- *Material movement and storage activities should be fully integrated to form a coordinated, operational system which spans*
  - *receiving, inspection, storage, production, assembly, packaging, unitizing, order selection, shipping, transportation and the handling of returns.*

- **Definition**:
  - A system is a collection of interacting and/or interdependent entities that form a unified whole

System Principle

Key Points

- Systems integration should encompass the entire supply chain including reverse logistics:
  - It should include suppliers, manufacturers, distributors and customers.

- Inventory levels should be minimized at all stages of production and distribution while respecting considerations of
  - process variability (read https://www.linkedin.com/pulse/process-variability-affects-inventory-levels-lucas-jerden)
  - customer service.

System Principle

- Information flow and physical material flow should be integrated

- Methods should be provided for
  - identify
  - locate
  - Control movement
- Customer requirements and expectations should be met without exception regarding
  - quantity,
  - quality,
  - on-time delivery.


LIFTRONIC EASY

Automation Principle

- *Material handling operations should be mechanized and/or automated where feasible to*
  - *improve operational efficiency,*
  - *increase responsiveness,*
  - *improve consistency and predictability,*
  - *decrease operating costs and*
  - *to eliminate repetitive or potentially unsafe manual labor.*
- **Definition:**
  - Automation is a technology concerned with the application of electro-mechanical devices, electronics and computer-based systems to operate and control, production and service activities. *It suggests the linking of multiple mechanical operations to create a system that can be controlled by programmed instructions*.

Automation Principle

Key Points

- Before installing automation existing processes and methods should be re-evaluated
  - Simplified
  - Re-engineered

- All items expected to be handled automatically must have features that accommodate/suitable for mechanized and automated handling


INSIDE AN AMAZON
SHIPPING WAREHOUSE
YT

Environmental Principle

- *Environmental impact and energy consumption should be considered as criteria when designing or selecting alternative equipment and material handling systems.*

- **Definition**:
  - Environmental consciousness stems from a desire not to waste natural resources and to predict and eliminate the possible negative effects of our daily actions on the environment.

Environmental Principle

Key Points

- Containers, pallets and other products for UL formation and protection
  - **reusability**
  - **biodegradability**

- Materials specified as hazardous have special needs with regard to
  - spill/fall protection,
  - combustibility
  - other risks.

Life Cycle Cost Principle

- *A thorough economic analysis should account for the entire life cycle of all material handling equipment and resulting systems.*

- **Definition**:
  - Life cycle costs include all cash flows that will occur between
    - the time the first dollar is spent to plan or procure a new piece of equipment,
    - until that method and/or equipment is totally replaced.

Life Cycle Cost Principle

Key Points:

- Life cycle costs include
  - capital investment,
  - installation,
  - setup and equipment programming,
  - training,
  - system testing and acceptance,
  - operating (labor, utilities, etc.),
  - maintenance and repair,
  - reuse value,
  - ultimate disposal.

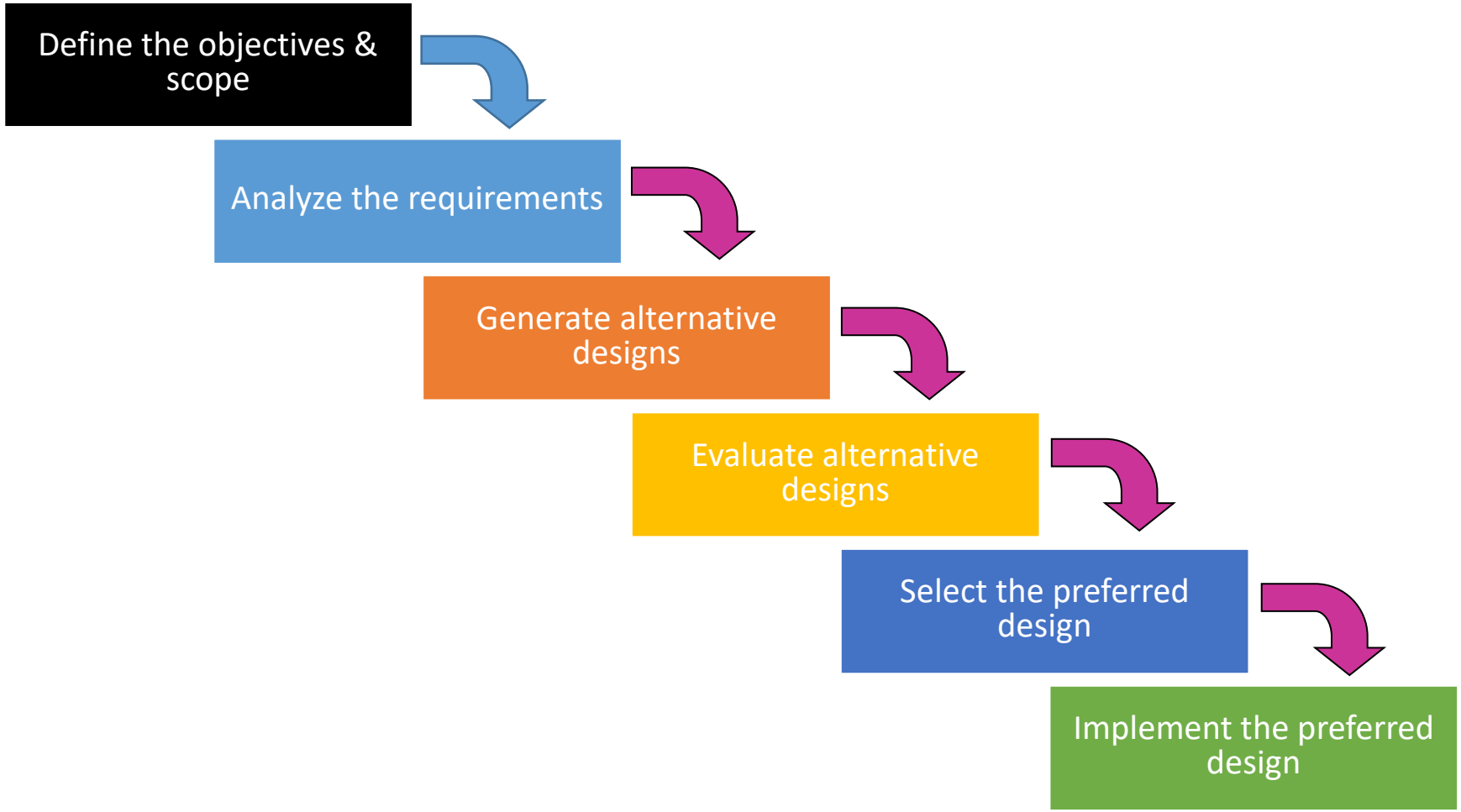
Life Cycle Cost Principle

- A plan for preventive and predictive maintenance should be prepared for the equipment,
- The estimated cost of maintenance and spare parts should be included in the economic analysis
- Cost is a primary factor, not the only one!
  - Factors that are strategic and form the basis for competition should be considered.

Principles of Material Handling

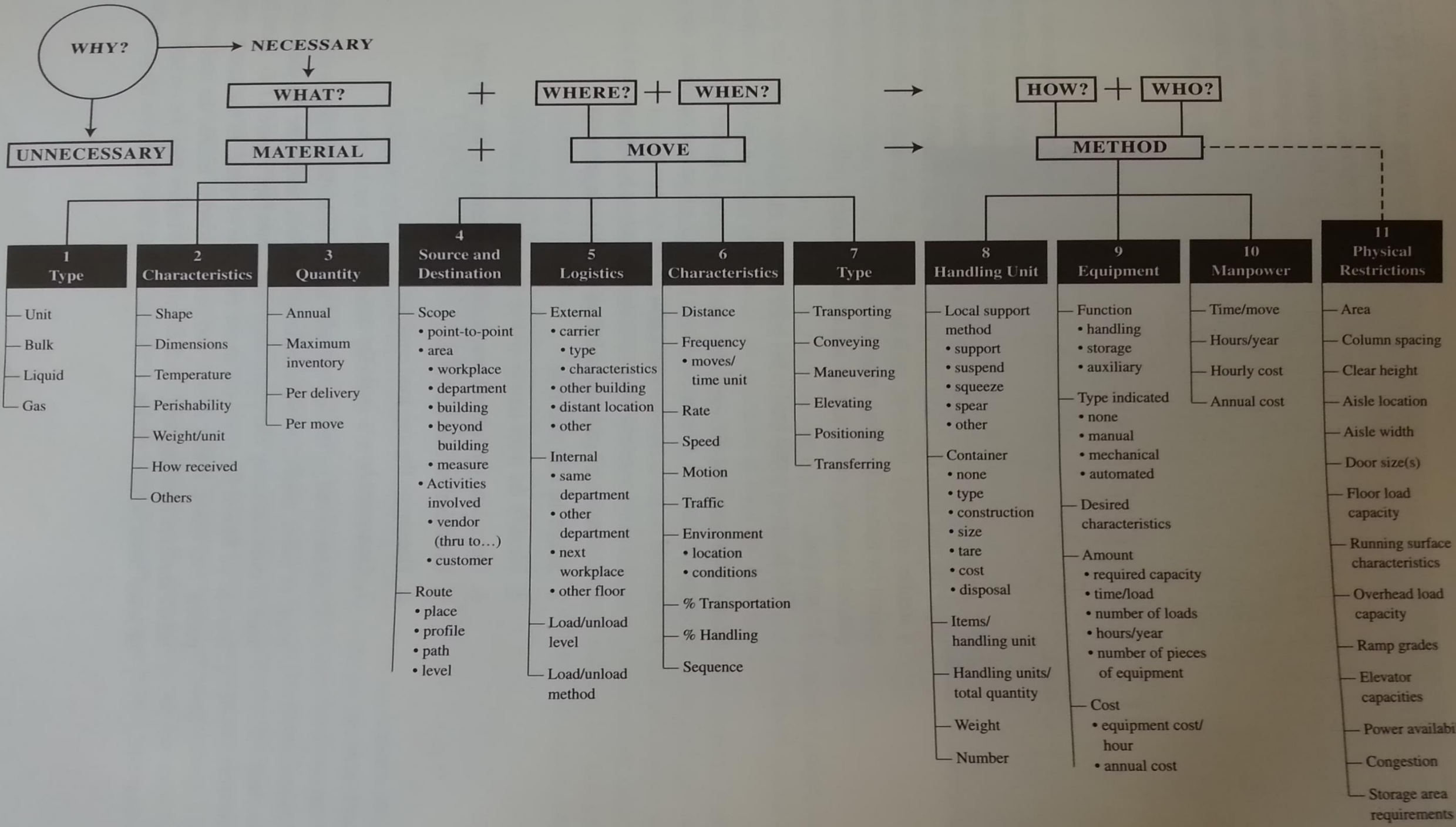
- **Planning Principle**
- **Standardization Principle**
- **Work Principle**
- **Ergonomic Principle:**
- **Unit Load Principle**
- **Space Utilization Principle**
- **System Principle**
- **Automation Principle**
- **Environmental Principle:**
- **Life Cycle Cost Principle**

Material Handling Systems Design



Material Handling Systems Equation

- Apple (1997)
  - ‘’MH equation’ should be used to arrive at a MH solution
- The process involves seeking thorough answers to six major questions
  - Why select material handling equipment
  - What is the material to be moved
  - Where and when is the move to be made
  - How will the move be made
  - Who will make the move


WHY?
NECESSARY
UNNECESSARY
WHAT?
MATERIAL
WHERE?
WHEN?
MOVE
HOW?
WHO?
METHOD
1 Type
Unit
Bulk
Liquid
Gas
2 Characteristics
Shape
Dimensions
Temperature
Perishability
Weight/unit
How received
Others
3 Quantity
Annual
Maximum inventory
Per delivery
Per move
4 Source and Destination
Scope
• point-to-point
• area
• workplace
• department
• building
• beyond building
• measure
• Activities involved
• vendor (thru to…)
• customer
Route
• place
• profile
• path
• level
5 Logistics
External
• carrier
• type
• characteristics
• other building
• distant location
• other
Internal
• same department
• other department
• next workplace
• other floor
Load/unload level
Load/unload method
6 Characteristics
Distance
Frequency
• moves/ time unit
Rate
Speed
Motion
Traffic
Environment
• location
• conditions
% Transportation
% Handling
Sequence
7 Type
Transporting
Conveying
Maneuvering
Elevating
Positioning
Transferring
8 Handling Unit
Local support method
• support
• suspend
• squeeze
• spear
• other
Container
• none
• type
• construction
• size
• tare
• cost
• disposal
Items/ handling unit
Handling units/ total quantity
Weight
Number
9 Equipment
Function
• handling
• storage
• auxiliary
Type indicated
• none
• manual
• mechanical
• automated
Desired characteristics
Amount
• required capacity
• time/load
• number of loads
• hours/year
• number of pieces of equipment
Cost
• equipment cost/ hour
• annual cost
10 Manpower
Time/move
Hours/year
Hourly cost
Annual cost
11 Physical Restrictions
Area
Column spacing
Clear height
Aisle location
Aisle width
Door size(s)
Floor load capacity
Running surface characteristics
Overhead load capacity
Ramp grades
Elevator capacities
Power availability
Congestion
Storage area requirements

An example: Characteristics of Materials

- Following characteristics affect MH
  - Size: width, depth, height
  - Weight: weight per item, per unit volume
  - Shape: round, square, long, rectangular, irregular
  - Other: slippery, fragile, sticky, explosive, frozen

	Physical State		
Material Category	Solid	Liquid	Gas
Individual units	Part, subassembly	—	—
Containerized items	Carton, bag, tote, box, pallet, bin	Barrel	Cylinder
Bulk materials	Sand, cement, coal, granular products	Liquid chemicals, solvents, gasoline	Oxygen, nitrogen, carbon dioxide

Characteristics of Materials

- The impact of the material category listed in Table 1 on the type of MH equipment is as follows:
  - Individual units and containerized items

  ⇒ discrete material flow

  ⇒ unit loads

  ⇒ unit handling equipment
  - Bulk materials

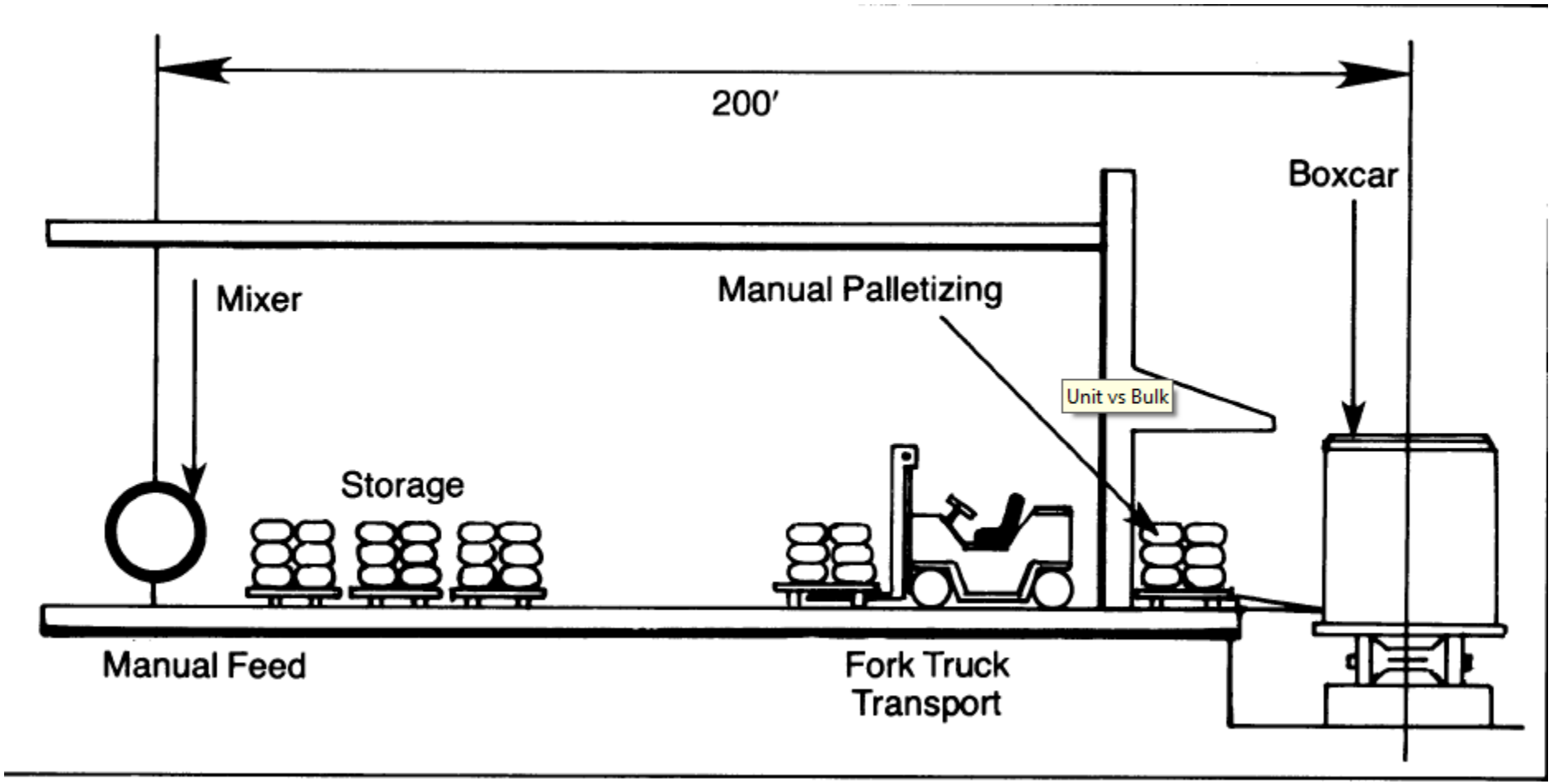
  ⇒ continuous material flow

  ⇒ bulk handling equipment

Characteristics of Materials

- Figure 1 shows an example of alternate ways of handling a dry bulk material:
  - as containerized (bagged) items on pallets handled using unit handling equipment (boxcar, pallet, fork truck), or
  - as bulk material handled using bulk handling equipment (hopper car, pneumatic conveyor, bulk storage bin).

Characteristics of Materials



Characteristics of Materials