Receiving and Shipping

- Consider handling, storing, and control requirements to provide the proper combination of space, equipment, and people.
- Receiving and shipping functions interface with the outside environment.

Facility Requirements

- Receiving
  - Stage and spot carriers
    - Waiting
    - Maneuvering
    - Unloading
  - Dockboards
  - Receiving area
  - Staging area
  - Office area

- Shipping
  - Staging area (may include accumulate and pack)
  - Office area
  - Stage and spot carriers
  - Dockboards

Desirable Attributes

- Directed flow paths (watch out for double handling)
- Continuous flow of effort (try to schedule inbound shipments)
- Concentrated area that minimizes material handling
- Efficient material handling (try to influence unit load configuration)
- Providing safe operations
- Minimizing damage
- Providing good housekeeping

Other Considerations

- Smooth interface between vendor's and receiver's (or shipper's and customer's) information system
- Returnable containers (including attrition and replacement)
- Returned goods
- Returning carriers, i.e., backhaul (maximize utilization of shipper owned carriers)
- Coordination of Receiving and Shipping
  - Common space, equipment, and/or personnel might be used
  - Return of slave pallets for manufacturing
  - Possible centralization of the functions (i.e., receive in the morning and ship in the afternoon)

Space Planning

- What is to be receiving and shipped?
- Number and type of docks
- Space requirements for receiving and shipping area

Receiving and Shipping Analysis Chart
Receiving and Shipping

Docks
- Number
  - Estimate with
    » Queuing analysis
    » Simulation
- Configuration
  - Carrier approaches
  - Carrier traffic flow
  - Carrier waiting area
  - Apron Depth
  - Bay Width

90 degree versus finger docks

Receiving and Shipping

Internal Area Requirements
- Space Allocations For
  - Personnel convenience
  - Offices
  - Material handling equipment maintenance
  - Trash disposal
  - Pallet and packaging material storage
  - Truckers' lounge
  - Buffer or staging area
  - Material handling equipment maneuvering

Receiving and Shipping

Area Requirement Example

Plant

Truck Waiting 24'

Dock Face

Dock Shelter

Dock Levelers
- Portable ramp
- Permanent ramp
- Yard ramp
- Scissor lift
- Bumper pads
- Dock shelters

Receiving and Shipping

Conclusion
- Receiving and shipping are important, but often overlooked, functions.
- They deserve the same systematic planning procedure that is afforded the rest of the manufacturing process.

Storage and Warehousing

- Storage Function
  - Activity of storing raw materials, supplies, and in process material.

- Warehousing Function
  - Activity of storing finished goods.
Storage and Warehousing

• Basic Functions
  – Receiving
  – Identification and sorting
  – Dispatching to storage
  – Placing in storage
  – Storage
  – Removing from storage
  – Order accumulation
  – Packing
  – Shipping
  – Record keeping

• Additional Functions
  – Inbound inspection
  – Parts preparation
  – Kitting
  – Item packaging

Storage and Warehousing

• Goal:
  – Maximize resource utilization while satisfying customer requirements, or
  – Maximize customer service subject to resource constraints

• Resources:
  – Space
  – Equipment
  – Personnel

• Objectives:
  – Maximize space utilization
  – Maximize equipment utilization
  – Maximize labor utilization
  – Maximize accessibility of all materials
  – Maximize protection of all materials

Storage Location Methods

• Randomized Storage
  – An individual stock keeping unit (SKU) can be stored in any available storage location.
  – An inbound load is assigned to the closest available storage location.
  – Retrievals are first-in, first-out (FIFO).

• Dedicated Storage
  – Each SKU is assigned to a specific storage location or set of locations.
  – Storage locations can be arbitrarily determined, such as part number sequence, or they can be determined based on the SKU's activity level and inventory level.
  – Number of storage locations is the sum of the maximum inventory level for each SKU.

• Class Based Storage
  – Hybrid configuration which assigns SKUs to classes based on their activity-to-space ratios, but uses randomized storage within the classes.
  – Yields some of the throughput benefits of dedicated storage and the space benefits of randomized storage.

• Supermarket Storage
  – Combination of random and assigned storage.

Storage Location Methods

• Example

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</tbody>
</table>

Maximum of aggregate inventory level = 105 pallet loads
Sum of individual maximum inventory levels = 140
Average inventory level = 77.5
Minimum of aggregate inventory level = 51

Space Planning

Storage Analysis Chart

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Storage and Warehousing

• Loss of Cube Utilization
  – Aisle Example
  
  Main Aisle
  18' Clear Stack Height
  
  Total Cube = 30,636 cubic feet
  Aisle Cube = 19,620 cubic feet
  Percentage of total volume allocated to aisles = 64%

• Loss of Cube Utilization
  – Honeycombing
  » Wasted space that results because a partial row or stack cannot be utilized because adding materials would result in blocked storage.

• Space Standard
  – Volume requirement per unit load stored to include allocated space for aisles and honeycombing.

Storage and Warehousing

Equipment Planning

• Storage Equipment Types
  – Bulk Storage  – includes block and tight-blocking stacking
  – Portable Racks or Stackable Racks
  – Pallet Rack
  – Cantilever Racks  – provide long uninterrupted spans
  – Drive-In or Drive-Through Racks
  – Flow-Through Rack
  – Bin Racks or Shelving
  – Sliding Racks

Storage and Warehousing

Layout Planning

• Objectives
  – To utilize space effectively
  – To provide efficient materials handling
  – To minimize storage cost while providing the required levels of service
  – To provide maximum flexibility
  – To provide good housekeeping

• Principles
  – Popularity
  – Similarity
  – Size
  – Characteristics
  – Space Utilization

Storage and Warehousing

• Popularity

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity per Receipt</th>
<th>Trips to Receive</th>
<th>Average Customer Order Size</th>
<th>Trips to Ship</th>
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<td>0.4 cartons</td>
<td>125</td>
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</tbody>
</table>

Storage and Warehousing

• Layout Principles
  – Similarity
    » Items that are received and shipped together should be stored together.
  – Size
    » Provide a variety of storage location sizes to accommodate a variety of products.
    » Utilize adjustable racks or shelves if product and unit load sizes are uncertain or change periodically.
  – Characteristics
    » Perishable materials
    » Oddly shaped items
    » Crushable items
    » Hazardous materials
    » Security of items from pilferage
    » Compatibility between items
Space Utilization

- Conservation of Space
  - Maximizing concentration
  - Maximizing cube utilization
  - Minimizing honeycombing

- Limitations of Space
  - Clear height
  - Stacking height
  - Floor loading
  - Columns

- Materials Accessibility
  - Each storage face has aisle access
  - Majority of items stored along the long axis of the area
  - Aisles should not be placed along walls without doors
  - Avoid locked stock by using a two-bin system

Warehouse Layout Models

- Determine the optimal dedicated storage layout

  - Notation
    - \( q \) = number of storage locations
    - \( n \) = number of products
    - \( m \) = number of I/O points
    - \( S_j \) = number of storage locations required for product \( j \)
    - \( T_j \) = number of trips in/out of storage for product \( j \) (throughput)
    - \( p_j \) = percentage of travel through I/O point \( i \) for product \( j \)
    - \( d_{ik} \) = distance (or time) required to travel from I/O point \( i \) to storage location \( k \)
    - \( x_{jk} \) = 1 if product \( j \) is assigned to storage location \( k \); = 0, otherwise

Warehouse Layout Formulation

-  \( f_{jk} \) = expected distance traveled between storage location \( k \) and the docks for product \( j \)
  
  \[
  f_{jk} = \frac{m}{j=1} p_j d_{ik} x_{jk}
  \]

- Minimize
  
  \[
  \min \sum_{j=1}^{q} \sum_{k=1}^{S_j} \frac{T_j}{S_j} p_j d_{ik} x_{jk}
  \]

  \[
  \text{s.t.}\:
  \sum_{j=1}^{q} x_{jk} = 1 \quad k = 1, \ldots, q
  \]

  \[
  \sum_{k=1}^{S_j} x_{jk} = S_j \quad j = 1, \ldots, n
  \]

  \[x_{jk} \in \{0,1\} \quad \forall j, k\]

- Rewritten in this form, this problem looks like a transportation problem
  - Can use any standard procedure to solve or specialized algorithms like WHAP

Warehouse Layout Algorithm

- If probabilities of using the I/O points are independent of the product types, that is
  - \( p_i = p_j \) for all \( i \)

- Then we can use the following algorithm to minimize the total distance travelled
  - Number the products in non-increasing order of their \( T_j/S_j \) values
  
  \[
  \frac{T_1}{S_1} \geq \frac{T_2}{S_2} \geq \cdots \geq \frac{T_q}{S_q}
  \]

  - Compute the \( f_{jk} \) value for each storage location
  
  - Assign product 1 to the \( S_1 \) storage locations having the lowest \( f_{jk} \) values; assign product 2 to the \( S_2 \) locations having the next lowest \( f_{jk} \) values;...
Storage Models

- Determine best design for each storage subsystem
- Unit loads stored and retrieved with lift trucks
- Four conventional storage methods analyzed
  - Block stacking
  - Deep lane storage
  - Single-deep rack
  - Double-deep rack
- Tradeoff between density of storage and accessibility
  - Have different types of space losses due to rack design and honeycombing
  - Minimize average amount of floor space required